Test Solutions - Programming Manual

Programming Examples & Troubleshooting Guide

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Important Notice

Trademarks

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1 - Conversion Tables

1.1 - ASCII Character Codes

Decimal	Binary	Symbol
32	00100000	
33	00100001	!
34	00100010	"
35	00100011	#
36	00100100	$
37	00100101	%
38	00100110	&
39	00100111	'
40	00101000	(
41	00101001	)
42	00101010	*
43	00101011	+
44	00101100	,
45	00101101	-
46	00101110	.
47	00101111	/
48	00110000	0
49	00110001	1
50	00110010	2
51	00110011	3
52	00110100	4
53	00110101	5
54	00110110	6
55	00110111	7
56	00111000	8
57	00111001	9
58	00111010	:
59	00111011	;
60	00111100	<
61	00111101	=
62	00111110	>
63	00111111	?
64	01000000	@

Decimal	Binary	Symbol
65	01000001	A
66	01000010	B
67	01000011	C
68	01000100	D
69	01000101	E
70	01000110	F
71	01000111	G
72	01001000	H
73	01001001	I
74	01001010	J
75	01001011	K
76	01001100	L
77	01001101	M
78	01001110	N
79	01001111	O
80	01010000	P
81	01010001	Q
82	01010010	R
83	01010011	S
84	01010100	T
85	01010101	U
86	01010110	V
87	01010111	W
88	01011000	X
89	01011001	Y
90	01011010	Z
91	01011011	[
92	01011100	\
93	01011101	]
94	01011110	^
95	01011111	_
96	01100000	`

Decimal	Binary	Symbol
97	01100001	a
98	01100010	b
99	01100011	c
100	01100100	d
101	01100101	e
102	01100110	f
103	01100111	g
104	01101000	h
105	01101001	i
106	01101010	j
107	01101011	k
108	01101100	l
109	01101101	m
110	01101110	n
111	01101111	o
112	01110000	p
113	01110001	q
114	01110010	r
115	01110011	s
116	01110100	t
117	01110101	u
118	01110110	v
119	01110111	w
120	01111000	x
121	01111001	y
122	01111010	z
123	01111011	{
124	01111100	|
125	01111101	}
126	01111110	~

2 - Programming Examples

2.1 - Python Programming

2.1.1 - USB Control Using the .Net DLL

Mini-Circuits' USB controlled equipment can be automated using the Python.Net library (`pip install pythonnet`) to interact with the relevant .Net DLL from Mini-Circuits.

2.1.1 (a) - Programmable Attenuators

```
# Control Mini-Circuits' RUDAT or RCDAT series programmable attenuators via USB
# Requirements:
#   1: Python.Net (pip install pythonnet)
#   2: Mini-Circuits' DLL API file (mcl_RUDAT_NET45.dll)
#      https://www.minicircuits.com/softwaredownload/mcl_RUDAT64_DLL.zip
#      Note: - Windows may block the DLL file after download as a precaution
#            - Right-click on the file, select properties, click "Unblock" (if shown)

import clr # pythonnet
clr.AddReference('mcl_RUDAT_NET45')      # Reference the DLL

from mcl_RUDAT_NET45 import USB_RUDAT
att = USB_RUDAT()   # Create an instance of the USB control class

Status = att.Connect()       # Connect (pass the serial number as an argument if required)

if Status > 0:              # The connection was successful

    Responses = att.Send_SCPI(":SN?", "")        # Read serial number
    print (str(Responses[1]))   # Python interprets the response as a tuple [function return
(0 or 1), command parameter, response parameter]

    Responses = att.Send_SCPI(":MN?", "")        # Read model name
    print (str(Responses[1]))

    # Set and then read attenuation
    Status = att.Send_SCPI(":SETATT=12.75", "")    # Set attenuation
    Responses = att.Send_SCPI(":ATT?", "")   # Read attenuation
    print (str(Responses[1]))

    att.Disconnect()             # Disconnect at the end of the program

else:
    print ("Could not connect.")
```

2.1.1 (b) - Mechanical Switch Boxes

```
# Control Mini-Circuits' RC or USB series mechanical switches via USB
# Requirements:
#   1: Python.Net (pip install pythonnet)
#   2: Mini-Circuits' DLL API file (mcl RF Switch ControllerNET45.dll)
#      https://www.minicircuits.com/softwaredownload/mcl RF Switch Controller64 dll.zip
#      Note: - Windows may block the DLL file after download as a precaution
#            - Right-click on the file, select properties, click "Unblock" (if shown)

import clr # pythonnet
clr.AddReference('mcl_RF_Switch_ControllerNET45')      # Reference the DLL

from mcl_RF_Switch_ControllerNET45 import USB_RF_SwitchBox
sw = USB_RF_SwitchBox()      # Create an instance of the switch class

Status = sw.Connect()        # Connect the switch (pass the serial number as an argument if
required)

if Status > 0:               # The connection was successful

    Responses = sw.Send_SCPI(":SN?", "")            # Read serial number
    print (str(Responses[2]))   # Python interprets the response as a tuple [function return
(0 or 1), command parameter, response parameter]

    Responses = sw.Send_SCPI(":MN?", "")            # Read model name
    print (str(Responses[2]))

    # SP6T switches (specify the switch channel A to B, model dependent)
    Status = sw.Send_SCPI("SP6TA:STATE:6", "")      # Set switch state (SW A, COM<>6)
    Responses = sw.Send_SCPI("SP6TA:STATE?", "")    # Read switch state (SP6TA)
    print (str(Responses[2]))

    # SP4T switches (specify the switch channel A to B, model dependent)
    #Status = sw.Send_SCPI("SP4TA:STATE:4", "")      # Set switch state (SW A, COM<>4)
    #Responses = sw.Send_SCPI("SP4TA:STATE?", "")    # Read switch state (SP4TA)
    #print (str(Responses[2]))

    # SPDT & transfer switches (specify the switch channel A to H, model dependent)
    #Status = sw.Send SCPI("SETA=1", "")             # Set switch state (SW A, COM<>2)
    #Responses = sw.Send_SCPI("SWPORT?", "")         # Read switch state, returns a byte value
of all switch states (1 bit per switch)
    #print (str(Responses[2]))

    sw.Disconnect()             # Disconnect at the end of the program

else:
    print ("Could not connect.")
```

2.1.1 (c) - Solid-State Switches (H-Series)

```
# Control Mini-Circuits' USB "H series" solid-state switches via USB
# Requirements:
#   1: Python.Net (pip install pythonnet)
#   2: Mini-Circuits' DLL API file (mcl SolidStateSwitch NET45.dll)
#      https://www.minicircuits.com/softwaredownload/MCL SolidStateSwitch64 DLL.zip
#      Note: - Windows may block the DLL file after download as a precaution
#            - Right-click on the file, select properties, click "Unblock" (if shown)

import clr # pythonnet
clr.AddReference('mcl_SolidStateSwitch_NET45')      # Reference the DLL

from MCL_SolidStateSwitch_NET45 import USB_Digital_Switch
sw = USB_Digital_Switch()   # Create an instance of the switch class

Status = sw.Connect()       # Connect the switch (pass the serial number as an argument if
required)

if Status > 0:              # The connection was successful

    Responses = sw.Send_SCPI(":SN?", "")        # Read serial number
    print (str(Responses[2]))   # Python interprets the response as a tuple [function return
(0 or 1), command parameter, response parameter]

    Responses = sw.Send_SCPI(":MN?", "")        # Read model name
    print (str(Responses[2]))

    # SP16T switches
    Status = sw.Send_SCPI(":SP16T:STATE:16", "")    # Set switch state (COM<>16)
    Responses = sw.Send_SCPI(":SP16T:STATE?", "")   # Read switch state
    print (str(Responses[2]))

    # SP8T switches
    #Status = sw.Send_SCPI(":SP8T:STATE:8", "")      # Set switch state (COM<>8)
    #Responses = sw.Send_SCPI(":SP8T:STATE?", "")    # Read switch state
    #print (str(Responses[2]))

    # SP4T switches (specify the switch channel A or B for modules with dual SP4T switches)
    #Status = sw.Send SCPI(":SP4T:A:STATE:4", "")    # Set switch state (COM<>4)
    #Responses = sw.Send_SCPI(":SP4T:A:STATE?", "")  # Read switch state
    #print (str(Responses[2]))

    # SP2T switches (specify the switch channel A, B, C or D for modules with multiple SP2T
switches)
    #Status = sw.Send SCPI(":SP2T:A:STATE:2", "")    # Set switch state (COM<>2)
    #Responses = sw.Send_SCPI(":SP2T:A:STATE?", "")  # Read switch state
    #print (str(Responses[2]))

    sw.Disconnect()             # Disconnect at the end of the program

else:
    print ("Could not connect.")
```

2.1.1 (d) - Solid-State Switches (USB-SP4T-63)

```
# Control Mini-Circuits' USB-SP4T-63 solid-state switch via USB
# Requirements:
#   1: Python.Net (pip install pythonnet)
#   2: Mini-Circuits' DLL API file (mcl SolidStateSwitch NET45.dll)
#      https://www.minicircuits.com/softwaredownload/MCL SolidStateSwitch64 DLL.zip
#      Note: - Windows may block the DLL file after download as a precaution
#            - Right-click on the file, select properties, click "Unblock" (if shown)

import clr # pythonnet
clr.AddReference('mcl_SolidStateSwitch_NET45')      # Reference the DLL

from MCL_SolidStateSwitch_NET45 import USB_Digital_Switch
sw = USB_Digital_Switch()   # Create an instance of the switch class

Status = sw.Connect()       # Connect the switch (pass the serial number as an argument if
required)

if Status > 0:              # The connection was successful

    Status = sw.Set_SP4T_COM_To(4)      # Set switch to port 4
    Sw_State = sw.Get_SP4T_State()      # Get switch state
    print ('Switch State:', str(Sw_State))

    sw.Disconnect()             # Disconnect at the end of the program

else:
    print ("Could not connect.")
```

2.1.2 - USB Control for Linux

USB control in a Linux environment makes use of USB interrupt codes. The examples below for specific models / model families can be adapted to any other of Mini-Circuits USB controlled test devices, by adjusting the interrupt codes used according to the relevant program manual for your device.

2.1.2 (a) - Frequency Counters

This example relates to Mini-Circuits' UFC-6000 switch box but the same process can be applied to other Mini-Circuits switch families by adapting the functions / interrupt codes used, per the respective programming manuals.

```
# Python interface for the Minicircuits UFC-6000 frequency counter
# 2019-05-06, version 1
# Ryan Zazo & Amar Vutha
# https://github.com/vuthalab/UFC-6000-Frequency-Counter

import os
import time

#Frequency Counter Class meant to operate the Mini-Circuits RF Frequency
Counter UFC-6000
class FrequencyCounter:
    def __init__(self,address="/dev/hidraw1"):
        """Initializes the Frequency Counter Class, takes an adress as
input and prints out a confirmation message"""
        self.fc = os.open(address, os.O_RDWR|os.O_NONBLOCK)
        print("Connected to:",self.get_model_name(), "with serial
number",self.get_serial_number())


    def get_model_name(self):
        """ Returns the model name of the device, expected return: UFC-6000
"""
        os.write(self.fc,b'(\r')
        time.sleep(1)
        return os.read(self.fc,64).decode('UTF-8').split("\x00")[0][1:]


    def get_serial_number(self):
        """ Returns the serial number of the device, expected return:
11812200037 """
        os.write(self.fc,b')\r')
        time.sleep(1)
        return os.read(self.fc,64).decode('UTF-8').split("\x00")[0][1:]

    def get_frequency_and_range(self):
        """ Returns a tuple containing the operating range (1 to 4) and the
frequency (MHz) """
        os.write(self.fc,b'\x02\r')
        time.sleep(1)
        returned_string = os.read(self.fc,64).decode('UTF-
8').split("\x00")[0][1:].strip().split()
        range = returned_string[1]
        frequency = returned_string[2]    # MHz
        return range, frequency
```

```
    def set_range(self,range_value):
        """ Set the range of the device, from 1 to 4; 1 is from 1 to 40
MHz, 2 40-190, 3 190-1400 and 4 1400-6000 """
        os.write(self.fc,b'\x04' + bytes([range_value]) + b'\r')
        time.sleep(5)
        os.read(self.fc,64).decode('UTF-8').split("\x00")[0][1:]
        return None

    def set_sample_time(self,sample_time):
        """ Sample time of the device in units of 100 ms """
        if (sample_time < 1) or (sample_time > 30): sample_time = 1
        os.write(self.fc,b'\x03' + bytes([sample_time]) + b'\r')
        time.sleep(1)
        os.read(self.fc,64).decode('UTF-8').split("\x00")[0][1:]
        return None

        def get_sample_time(self):
        """ Returns the sample time of the device """
        os.write(self.fc,b'!\r')
        time.sleep(1)
        rval = os.read(self.fc,64).decode('UTF-8').split("\x00")[0]
        val = rval.encode(encoding='UTF-8') #Encode the value again to
"fix" the return value as to add a binary "b" to it.
        return val[1]

frequency_counter = FrequencyCounter()
```

2.1.2 (b) - Power Sensors

```
"""
Minimalist Linux interface to Mini Circuits USB power meter.
Copyright (C) 2017, Rigetti & Co. Inc.

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even the implied warranty of MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE.  See the GNU
General Public License for more details.

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Usage:
  from MiniCircuits_PWR import MiniCircuits_PWR
  ...
  pwr = MiniCircuits PWR()
  ...
  pwr.get_power()

Installation instructions:
  In a terminal session
    sudo su
    pip install --upgrade libusb1
    echo 'ACTION=="add", SUBSYSTEM=="usb", ATTRS{idVendor}=="20ce", MODE="0666"' >
/etc/udev/rules.d/70-MiniCircuits-PWR.rules
    udevadm control --reload
    exit
  Disconnect and reconnect the USB cord for the power meter.
"""

import string
import sys
import threading
import time

try:
    import libusb1
    import usb1
except:
    print(__doc__[__doc__.index["Installation"]:-1])
    raise RuntimeError('libusb1 and/or usb1 not installed -- resolve using the preceding
instructions')
```

```
################################################################################
#
# Class to operate the MiniCircuits power meter.
#
################################################################################

class MiniCircuits_PWR():
    """
    Operate a Mini Circuits Power Meter.
    """

    _VENDOR_ID = 0x20CE
    _PRODUCT_ID = 0x0011

    _MSG_LEN = 64

    _SET_MEASUREMENT_MODE       =  15
    _GET_FIRMWARE               =  99
    _READ_POWER                 = 102
    _GET_INTERNAL_TEMPERATURE   = 103
    _GET_DEVICE_MODEL_NAME      = 104
    _GET_DEVICE_SERIAL_NUMBER   = 105

    def __init__(self):
        """
        Connect to the power meter.
        """
        # Configure threading
        self.lock = threading.Lock()
        # Configure the USB target
        self.context = usb1.USBContext()
        self.handle = self.context.openByVendorIDAndProductID(0x20CE,0x0011)
        if self.handle is None:
            raise RuntimeError('No USB Power meter found')
        if self.handle.kernelDriverActive(0):
            self.handle.detachKernelDriver(0)
        self.handle.resetDevice()
        self.handle.claimInterface(0)
        # Get the model number and serial number
        self.model = self._query_string([MiniCircuits_PWR._GET_DEVICE_MODEL_NAME,])
        self.sernum = self._query_string([MiniCircuits_PWR._GET_DEVICE_SERIAL_NUMBER,])
        # Set to low noise measurement mode.
        self._query([MiniCircuits_PWR._SET_MEASUREMENT_MODE, 0,])
        # Get the device temperature
        self.temperature = self._query_string([MiniCircuits_PWR._GET_INTERNAL_TEMPERATURE,],
7)
        # Get the firmware version
        resp = self._query([MiniCircuits_PWR._GET_FIRMWARE,])[4:6]
        if not all([chr(c) in string.printable for c in resp]):
            raise RuntimeError('Response to _GET_FIRMWARE malformed : %s' % resp[0:6])
        self.firmware = str(resp)

    def _query(self, cmd):
        """
        Issue the provided command, get and validate the response, and return the rest of the
        response.
        """
        self.cmd = bytearray([0]*MiniCircuits_PWR._MSG_LEN)
        self.cmd[:len(cmd)] = cmd
        self.lock.acquire()
        threading.Thread(target=self._write).start()
        while self.lock.locked():
            time.sleep(10e-6)
        if self.nsent != len(self.cmd):
            sys.exit(1)
        self.lock.acquire()
        threading.Thread(target=self._read).start()
        while self.lock.locked():
            time.sleep(10e-6)
        if len(self.response) != MiniCircuits_PWR._MSG_LEN:
            sys.exit(1)
        return self.response
```

```
def _query_string(self, cmd, response_length=None):
        """
        Issue the provided command and return the string response from the device.
        If the response length is not provided, use a terminating null character to extract
the
        string.
        """
        resp = self._query(cmd)
        if response_length is None:
            try:
                response_length = resp.index(bytearray([0]))
            except:
                raise RuntimeError('No terminating null character in response: %s' % resp)
        resp = resp[1:response_length-1]
        if not all([chr(c) in string.printable for c in resp]):
            raise RuntimeError('Response to command %s is not all printable: %s' % (cmd,
resp,))
        return str(resp)

    def _read(self):
        """
        Interrupt task required to read from the USB device.
        """
        self.response = ''
        try:
            self.response = self.handle.interruptRead(endpoint=1,
length=MiniCircuits_PWR._MSG_LEN, timeout=1000)
        finally:
            self.lock.release()

    def _write(self):
        """
        Interrupt task required to write to the USB device.
        """
        self.nsent = -1
        try:
            self.nsent = self.handle.interruptWrite(endpoint=1, data=str(self.cmd),
timeout=50)
        finally:
            self.lock.release()

    def get_power(self, freq_MHz):
        """
        Read the power meter configured for the specified frequency.
        """
        freq_MHz = int(round(freq_MHz))
        resp = self._query_string([MiniCircuits_PWR._READ_POWER, freq_MHz//256, freq_MHz %
256, ord('M'),], 7)
        try:
            return float(resp)
        except:
            raise RuntimeError('power readout not valid: "%s"' % resp)
```

2.1.2 (c) - Mechanical Switch Boxes

This example relates to Mini-Circuits RC-2SP6T-A12 switch box but the same process can be applied to other Mini-Circuits switch families by adapting the functions / interrupt codes used, per the respective programming manuals.

```
"""
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General Public License as published by the Free Software Foundation, either version 3 of the
License, or (at your option) any later version.

This program is distributed in the hope that it will be useful, but WITHOUT ANY WARRANTY;
without
even the implied warranty of MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE.  See the GNU
General Public License for more details.

The GNU General Public License can be found at <http://www.gnu.org/licenses/>.
"""


"""
Linux interface to Mini-Circuits matrix switch RC-2SP6T-A12.
Written by: Tim Dunker
E-mail: tdu [at] justervesenet [dot] no
OpenPGP key: 0x4FDBC497

This programme is based on the script 'Minimalist Linux interface to Mini Circuits USB power
meter', copyright (C) 2017, Rigetti & Co. Inc., distributed with a GPL licence.


Basic usage:
  from MiniCircuits_Switch import MiniCircuits_Switch
  sw = MiniCircuits_Switch()
  # Switch to channel 6 on switch A:
  sw.switch(1,6)
  # Switch to channel 3 on switch B:
  sw.switch(2,3)
  # De-energize switch A:
  sw.switch(1,0)
"""


import string
import sys
import threading
import time
import numpy as np
import libusb1
import usb1
```

```
################################################################################
#
# Class to operate a Mini-Circuits RC-2SP6T-A12 switch.
#
################################################################################

class MiniCircuits_Switch():
    """
    Operate a Mini Circuits matrix switch RC-2SP6T-A12.
    """
    # Vendor ID of Mini Circuits:
    _VENDOR_ID = 0x20CE
    # Product ID of the RF switch box:
    _PRODUCT_ID = 0x0022
    # Length of a message in bytes:
    _MSG_LEN = 64


    _GET_DEVICE_MODEL_NAME      =  40
    _GET_DEVICE_SERIAL_NUMBER   =  41
    _GET_FIRMWARE               =  99
    _SET_SP6T_SWITCH            =  12


    def __init__(self):
        """
        Connect to the USB RF matrix switch.
        """
        # Configure threading
        self.lock = threading.Lock()
        # Configure the USB target:
        self.context = usb1.USBContext()
        self.handle = self.context.openByVendorIDAndProductID(0x20CE,0x0022)
        if self.handle is None:
            raise RuntimeError('No USB RF matrix switch found.')
        if self.handle.kernelDriverActive(0):
            self.handle.detachKernelDriver(0)
        self.handle.resetDevice()
        self.handle.claimInterface(0)
        self.model = self._query_string([MiniCircuits_Switch._GET_DEVICE_MODEL_NAME,])
        self.sernum = self._query_string([MiniCircuits_Switch._GET_DEVICE_SERIAL_NUMBER,])


    def _query(self, cmd):
        """
        Issue the provided command, get and validate the response, and return the rest of the
        response.
        """
        self.cmd = bytearray([0]*MiniCircuits_Switch._MSG_LEN)
        self.cmd[:len(cmd)] = cmd
        self.lock.acquire()
        threading.Thread(target=self._write).start()
        while self.lock.locked():
            time.sleep(1e-6)
        if self.nsent != len(self.cmd):
            sys.exit(1)
        self.lock.acquire()
        threading.Thread(target=self._read).start()
        while self.lock.locked():
            time.sleep(10e-6)
        if len(self.response) != MiniCircuits_Switch._MSG_LEN:
            sys.exit(1)
        return self.response
```

```
    def _query_string(self, cmd, response_length=None):
        """
        Issue the provided command and return the string response from the device.
        If the response length is not provided, use a terminating null character to extract
the
        string.
        """
        resp = self._query(cmd)
        if response_length is None:
            try:
                response_length = resp.index(bytearray([0]))
            except:
                raise RuntimeError('No terminating null character in response: %s' % resp)
        resp = resp[1:response_length-1]
        return str(resp)


    def _read(self):
        """
        Interrupt task required to read from the USB device.
        """
        self.response = ''
        try:
            self.response = self.handle.interruptRead(endpoint=1,
length=MiniCircuits_Switch._MSG_LEN, timeout=1000)
        finally:
            self.lock.release()


    def _write(self):
        """
        Interrupt task required to write to the USB device.
        """
        self.nsent = -1
        try:
            self.nsent = self.handle.interruptWrite(endpoint=1, data=self.cmd, timeout=50)
        finally:
            self.lock.release()


    def get_device_model_name(self):
        """
        Read the device model name of the RF matrix switch.
        """
        resp = self._query_string([MiniCircuits_Switch._GET_DEVICE_MODEL_NAME,])
        try:
            return str(resp)
        except:
            raise RuntimeError('Device model name readout not valid: "%s"' % resp)


    def get_device_serial_number(self):
        """
        Read the serial number of the RF matrix switch.
        """
        resp = self._query_string([MiniCircuits_Switch._GET_DEVICE_SERIAL_NUMBER,])
        try:
            return str(resp)
        except:
            raise RuntimeError('Serial number readout not valid: "%s"' % resp)


    def get_firmware(self):
        """
        Read the firmware of the RF matrix switch.
        """
        resp = self._query([MiniCircuits_Switch._GET_FIRMWARE,])[5:7]
        try:
            return resp
        except:
            raise RuntimeError('Firmware readout not valid: "%s"' % resp)
```

```
    def switch(self, switch, state):
        """
        Set the switch "sw" to channel "state".
        """
        resp = self._query_string([MiniCircuits_Switch._SET_SP6T_SWITCH, switch, state,])
        try:
            return str(resp)
        except:
            raise RuntimeError('Switch state readout not valid: "%s"' % resp)
```

2.1.2 (d) - Solid-State Switches (H Series)

This example demonstrates how to send SCPI commands to Mini-Circuits' H Series USB controlled solid-state switches on a Linux system using Python. The same processes can be applied to other Mini-Circuits products by adapting the functions / interrupt codes used, per the respective programming manuals.

```
import usb.core
import usb.util

#find our device
dev = usb.core.find(idVendor=0x20ce, idProduct=0x0022)

if dev is None:
   raise ValueError('Device not found')

for configuration in dev:
   for interface in configuration:
      ifnum = interface.bInterfaceNumber
      if not dev.is_kernel_driver_active(ifnum):
         continue
      try:
         dev.detach_kernel_driver(ifnum)
      except usb.core.USBError, e:
         pass

#set the active configuration. with no args we use first config.
dev.set_configuration()
SerialN=""
ModelN=""
Fw=""

dev.write(1,"*:SN?")
sn=dev.read(0x81,64)
i=1
while (sn[i]<255 and sn[i]>0):
   SerialN=SerialN+chr(sn[i])
   i=i+1

dev.write(1,"*:MN?")
mn=dev.read(0x81,64)
i=1
while (mn[i]<255 and mn[i]>0):
   ModelN=ModelN+chr(mn[i])
   i=i+1

dev.write(1,"*:FIRMWARE?")
sn=dev.read(0x81,64)
i=1
while (sn[i]<255 and sn[i]>0):
   Fw=Fw+chr(sn[i])
   i=i+1

print (ModelN)
print (SerialN)
print (Fw)

# Set switch A to state 2
dev.write(1,"*:SP2T:A:STATE:2;")
```

```
resp=dev.read(0x81,64)
i=1
AttResp=""
while (resp[i]<255 and resp[i]>0):
    AttResp=AttResp+chr(resp[i])
    i=i+1
print AttResp

# Set switch B to state 1
dev.write(1,"*:SP2T:B:STATE:1;")
resp=dev.read(0x81,64)
i=1
AttResp=""
while (resp[i]<255 and resp[i]>0):
    AttResp=AttResp+chr(resp[i])
    i=i+1
print AttResp

# Read switch A state
dev.write(1,"*:SP2T:A:STATE?")
resp=dev.read(0x81,64)
i=1
AttResp=""
while (resp[i]<255 and resp[i]>0):
    AttResp=AttResp+chr(resp[i])
    i=i+1
print AttResp
```

2.1.2 (e) - Solid-State Switches (USB-SP4T-63)

This example creates a simple GUI for control of Mini-Circuits' USB-SP4T-63 solid-state switch on a Linux system using Python. The same processes can be applied to other Mini-Circuits products by adapting the functions / interrupt codes used, per the respective programming manuals.

```
import time
import usb.core
import usb.util
import Tkinter as tk

def ApplySwitching():
        v11=int(V1.get())
        dev.write(1,chr(v11)) # v11=1 switch port 1; v11=2 switch port 2...

root = tk.Tk()
root.title("Mini Circuits   USB-SP4T  ver 1.0")
tk.Label(root, text="    ").grid(row=2, column=1)
V1=tk.IntVar()
tk.Button(root,text="Apply
Switching",width=10,height=1,command=ApplySwitching).grid(row=4,column=1)
tk.Spinbox(root,values=(1,2,3,4),width=5,textvariable=V1).grid(row=3,column
=2)
tk.Label(root, text="Comm -> Switch: ").grid(row=3, column=1)

#find our device
dev = usb.core.find(idVendor=0x20ce, idProduct=0x0022)

#was it found?
if dev is None:
        raise ValueError('Device not found')

for configuration in dev:
        for interface in configuration:
                ifnum = interface.bInterfaceNumber
                if not dev.is_kernel_driver_active(ifnum):
                        continue
                try:
                        #print "detach kernel driver from device %s:
interface %s" % (dev, ifnum)
                        dev.detach_kernel_driver(ifnum)
                except usb.core.USBError, e:
                        pass

#set the active configuration. with no args we use first config.
dev.set_configuration()

root.geometry("500x300+0+0")
root.mainloop()
```

2.1.2 (f) - Solid-State Switches - (Control of 2 x USB-SP4T-63)

This example creates a simple GUI for control of a pair of Mini-Circuits' USB-SP4T-63 solid-state switch on a Linux system using Python. The same processes can be applied to other Mini-Circuits products by adapting the functions / interrupt codes used, per the respective programming manuals.

```
import time
import usb.core
import usb.util
import Tkinter as tk

def ApplySwitching():
    v11=int(V1.get())
        v22=int(V2.get())
        dev[0].write(1,chr(v11))  # v11=1 switch port 1; v11=2 switch port
2 ...
        dev[1].write(1,chr(v22))  # v22=1 switch port 1; v22=2 switch port
2 ...
        print v11,v22

root = tk.Tk()
root.title("Mini Circuits   USB-SP4T  ver 1.0")
tk.Label(root, text="    ").grid(row=2, column=1)
V1=tk.IntVar()
V2=tk.IntVar()

tk.Button(root,text="Apply
Switching",width=10,height=1,command=ApplySwitching).grid(row=4,column=1)
tk.Spinbox(root,values=(1,2,3,4),width=5,textvariable=V1).grid(row=3,column
=2)
tk.Spinbox(root,values=(1,2,3,4),width=5,textvariable=V2).grid(row=3,column
=3)

tk.Label(root, text="Comm -> Switch: ").grid(row=3, column=1)

#find our device
dev = usb.core.find(find_all=True,idVendor=0x20ce, idProduct=0x0022)

#dev = usb.core.find(idVendor=0x20ce, idProduct=0x0022)
print usb.util.get_string (dev[0] ,256, dev[0].iSerialNumber)
print usb.util.get_string (dev[1] ,256, dev[1].iSerialNumber)

#was it found?
if dev is None:
   raise ValueError('Device not found')

# Detach kernal driver
for configuration in dev[0]:
        for interface in configuration:
                ifnum = interface.bInterfaceNumber
                if not dev[0].is_kernel_driver_active(ifnum):
                        continue
                try:
                        #print "detach kernel driver from device %s:
interface %s" % (dev, ifnum)
                        dev[0].detach_kernel_driver(ifnum)
                except usb.core.USBError, e:
                        pass
```

```
for configuration in dev[1]:
        for interface in configuration:
                ifnum = interface.bInterfaceNumber
                if not dev[1].is_kernel_driver_active(ifnum):
                        continue
                try:
                        #print "detach kernel driver from device %s:
interface %s" % (dev, ifnum)
                        dev[1].detach_kernel_driver(ifnum)
                except usb.core.USBError, e:
                        pass

#set the active configuration. with no args we use first config.
dev[0].set_configuration()
dev[1].set_configuration()

root.geometry("500x300+0+0")
root.mainloop()
```

2.1.2 (g) - Multi-Channel Programmable Attenuators

This example demonstrates control of Mini-Circuits' RC4DAT multi-channel attenuators on a Linux system using Python. The same processes can be applied to other Mini-Circuits products by adapting the functions / interrupt codes used, per the respective programming manuals.

```
import usb.core
import usb.util

#find our device
dev = usb.core.find(idVendor=0x20ce, idProduct=0x0023)

if dev is None:
   raise ValueError('Device not found')

for configuration in dev:
   for interface in configuration:
      ifnum = interface.bInterfaceNumber
      if not dev.is_kernel_driver_active(ifnum):
         continue
      try:
         dev.detach_kernel_driver(ifnum)
      except usb.core.USBError, e:
         pass

#set the active configuration. with no args we use first config.
dev.set_configuration()
SerialN=""
ModelN=""
Fw=""

dev.write(1,"*:SN?")
sn=dev.read(0x81,64)
i=1
while (sn[i]<255 and sn[i]>0):
   SerialN=SerialN+chr(sn[i])
   i=i+1
dev.write(1,"*:MN?")
mn=dev.read(0x81,64)
i=1

while (mn[i]<255 and mn[i]>0):
   ModelN=ModelN+chr(mn[i])
   i=i+1
dev.write(1,"*:FIRMWARE?")
sn=dev.read(0x81,64)
i=1

while (sn[i]<255 and sn[i]>0):
   Fw=Fw+chr(sn[i])
   i=i+1

print (ModelN)
print (SerialN)
print (Fw)

dev.write(1,"*:CHAN:1:SETATT:11.25;")
resp=dev.read(0x81,64)
i=1
AttResp=""
```

```
while (resp[i]<255 and resp[i]>0):
   AttResp=AttResp+chr(resp[i])
   i=i+1
print AttResp

dev.write(1,"*:CHAN:2:SETATT:22.5;")
resp=dev.read(0x81,64)
i=1
AttResp=""
while (resp[i]<255 and resp[i]>0):
   AttResp=AttResp+chr(resp[i])
   i=i+1
print AttResp

dev.write(1,"*:CHAN:3:SETATT:27;")
resp=dev.read(0x81,64)
i=1
AttResp=""
while (resp[i]<255 and resp[i]>0):
   AttResp=AttResp+chr(resp[i])
   i=i+1
print AttResp

dev.write(1,"*:CHAN:4:SETATT:9.25;")
resp=dev.read(0x81,64)
i=1
AttResp=""
while (resp[i]<255 and resp[i]>0):
   AttResp=AttResp+chr(resp[i])
   i=i+1
print AttResp

dev.write(1,"*:ATT?") # return all channels attenuation
resp=dev.read(0x81,64)
i=1
AttResp=""
while (resp[i]<255 and resp[i]>0):
   AttResp=AttResp+chr(resp[i])
   i=i+1
print AttResp
```

2.1.3 - Ethernet Control Using HTTP

These examples demonstrate control of Mini-Circuits' PTE products over a TCP/IP network by making use of Python's *urllib2* library.

2.1.3 (a) - SPDT Switch Boxes (Set/Read Switch States)

Send HTTP commands to execute a pre-defined switching sequence.

```
import urllib2
import sys

########################################
# Define a function to send an HTTP command and get the result
########################################

def Get_HTTP_Result(CmdToSend):

    # Specify the IP address
    CmdToSend = "http://192.168.9.61/:" + CmdToSend

    # Send the HTTP command and try to read the result
    try:
        HTTP_Result = urllib2.urlopen(CmdToSend)
        PTE_Return = HTTP_Result.read()

        # The switch displays a web GUI for unrecognised commands
        if len(PTE_Return) > 100:
            print "Error, command not found:", CmdToSend
            PTE_Return = "Invalid Command!"

    # Catch an exception if URL is incorrect (incorrect IP or disconnected)
    except:
        print "Error, no response from device; check IP address and connections."
        PTE_Return = "No Response!"
        sys.exit()      # Exit the script

    # Return the response
    return PTE_Return

########################################
# Define a function to interpret the switch port values
########################################

def Interpret_Switch_Port(Sw_Port, NoSwitches):

    # Converts decimal switch port value into bits, each indicating a switch state
    # NoSwitches should be set to the number of switches available (eg: 3 for RC-3SPDT-A18)

    # Set the initial values
    Last_Remainder = int(Sw_Port)
    Sw_State = int(0)
    This_Remainder = int(0)
    First_Loop = True
    Sw_State_List = []

    # Loop for each switch
    for n in range(int(NoSwitches), -1, -1):

        # Calculate each switch state by comparing to the byte value and the previous
states
        This_Remainder = Last_Remainder - (Sw_State * (2**(n+1)))
        Sw_State = int(This_Remainder / 2**n)
        Last_Remainder = This_Remainder
```

```
        if First_Loop == False:                 # Ignore the first pass as it doesn't
relate to a switch
            Sw_State_List.append(Sw_State)      # Add each switch state to a list

        First_Loop = False

    return Sw_State_List


########################################
# Use switches below
########################################

# Print the model name and serial number
sn = Get_HTTP_Result("SN?")
mn = Get_HTTP_Result("MN?")
print "Switch", mn, "/", sn

# Set switches
Get_HTTP_Result('SETA=1')
Get_HTTP_Result('SETB=1')
Get_HTTP_Result('SETC=1')

# Check and output switch states
Switch_States = Interpret_Switch_Port(Get_HTTP_Result("SWPORT?"), 3)
print "Switch A =", Switch_States[2], "Switch B =", Switch_States[1], "Switch C =",
Switch_States[0]

# Set switches
Get_HTTP_Result('SETA=0')

# Check and output switch states
Switch_States = Interpret_Switch_Port(Get_HTTP_Result("SWPORT?"), 3)
print "Switch A =", Switch_States[2], "Switch B =", Switch_States[1], "Switch C =",
Switch_States[0]

# Set switches
Get_HTTP_Result('SETB=0')
Get_HTTP_Result('SETC=0')

# Check and output switch states
Switch_States = Interpret_Switch_Port(Get_HTTP_Result("SWPORT?"), 3)
print "Switch A =", Switch_States[2], "Switch B =", Switch_States[1], "Switch C =",
Switch_States[0]
```

The program output should be as below:

```
>>>
        Switch MN=RC-2SPDT-A18 / SN=11308050024
        Switch A = 1 Switch B = 1 Switch C = 1
        Switch A = 0 Switch B = 1 Switch C = 1
        Switch A = 0 Switch B = 0 Switch C = 0
>>>
```

2.1.3 (b) - SP6T Switch Boxes (Set/Read Switch States)

Send HTTP commands to execute a pre-defined switching sequence.

```
import urllib2
import sys

########################################
# Define a function to send an HTTP command and get the result
########################################

def Get_HTTP_Result(CmdToSend):

    # Specify the IP address
    CmdToSend = "http://192.168.9.61/:" + CmdToSend

    # Send the HTTP command and try to read the result
    try:
        HTTP_Result = urllib2.urlopen(CmdToSend)
        PTE_Return = HTTP_Result.read()

        # The switch displays a web GUI for unrecognised commands
        if len(PTE_Return) > 100:
            print "Error, command not found:", CmdToSend
            PTE_Return = "Invalid Command!"

    # Catch an exception if URL is incorrect (incorrect IP or disconnected)
    except:
        print "Error, no response from device; check IP address and connections."
        PTE_Return = "No Response!"
        sys.exit()      # Exit the script

    # Return the response
    return PTE_Return

########################################
# Send some commands to the switch box
########################################

print Get_HTTP_Result("MN?")        # Print model name
print Get_HTTP_Result("SN?")        # Print serial number

status = Get_HTTP_Result("SP6TA:STATE:6")   # Set switch A to position 6
print "Sw A connected, Com =>", Get_HTTP_Result("SP6TA:STATE?")  # Print switch A position

status = Get_HTTP_Result("SP6TB:STATE:4")   # Set switch B to position 4
print "Sw B connected, Com =>", Get_HTTP_Result("SP6TB:STATE?")  # Print switch B position

status = Get_HTTP_Result("SP6TA:STATE:0")   # Set switch A to position 0
print "Sw A connected, Com =>", Get_HTTP_Result("SP6TA:STATE?")  # Print switch A position

status = Get_HTTP_Result("SP6TB:STATE:0")   # Set switch B to position 0
print "Sw B connected, Com =>", Get_HTTP_Result("SP6TB:STATE?")  # Print switch B position

print "Done."
```

The program output should be as below:

```
>>>
        MN=RC-2SPDT-A18
        SN=11308050024
        Sw A connected, Com => 6
        Sw B connected, Com => 4
        Sw A connected, Com => 0
        Sw B connected, Com => 0
        Done
>>>
```

2.1.3 (c) - Signal Generators (Set RF Output)

Sends HTTP commands to configure a pre-defined RF output.

```
import urllib2
import sys

########################################
# Define a function to send an HTTP command and get the result
########################################

def Get_HTTP_Result(CmdToSend):

    # Specify the IP address for the signal generator
    CmdToSend = "http://192.168.9.59/:" + CmdToSend

    # Send the HTTP command and try to read the result
    try:
        HTTP_Result = urllib2.urlopen(CmdToSend)
        SSG_Return = HTTP_Result.read()

        # The generator returns "-99..." for unrecognised commands
        if SSG_Return[0:3] == "-99":
            print "Error, command not found:", CmdToSend
            SSG_Return = "SSG: Invalid Command!"

    # Catch an exception if URL is incorrect (incorrect IP or generator disconnected)
    except:
        print "Error, no response from device; check IP address and connections."
        SSG_Return = "SSG: No Response!"
        sys.exit()      # Exit the script

    # Return the generator's response
    return SSG_Return

########################################
# Use signal generator below
########################################

# Print the model name and serial number
sn = Get_HTTP_Result("SN?")
mn = Get_HTTP_Result("MN?")
print "Generator", mn, "/", sn

# Set frequency and power
Get_HTTP_Result('FREQ:3000MHZ')
Get_HTTP_Result('PWR:-5.5')

# Check frequency and power
freq = Get_HTTP_Result("FREQ?")
pwr = Get_HTTP_Result("PWR?")

# Turn on RF output and confirm
Get_HTTP_Result("PWR:RF:ON")
status = Get_HTTP_Result("PWR:RF?")

# Output status
print "Freq", freq, "power", pwr, "set"
print "Output is", status

########################################
# Pause the program with generator on until user terminates
########################################

final_status = raw_input("Hit Enter to turn off the RF output and end program:")
Get_HTTP_Result("PWR:RF:OFF")
print "Program ended."
```

The program output should be as below:

```
>>>
        Generator MN=SSG-6000RC / SN=11402040043
        Freq 3000.000000 power -5.50 set
        Output is ON
        Hit Enter to turn off the RF output and end program:
        Program ended.
>>>
```

2.1.3 (d) - Programmable Attenuator (Set/Read Attenuation with User Input)

Continuously set and read the attenuation based on user inputs.

```
import urllib2
import sys

########################################
# Define a function to send an HTTP command and get the result
########################################

def Get_HTTP_Result(CmdToSend):

    # Specify the IP address
    CmdToSend = "http://192.168.9.63/:" + CmdToSend

    # Send the HTTP command and try to read the result
    try:
        HTTP_Result = urllib2.urlopen(CmdToSend)
        PTE_Return = HTTP_Result.read()

        # The switch displays a web GUI for unrecognised commands
        if len(PTE_Return) > 100:
            print "Error, command not found:", CmdToSend
            PTE_Return = "Invalid Command!"

    # Catch an exception if URL is incorrect (incorrect IP or disconnected)
    except:
        print "Error, no response from device; check IP address and connections."
        PTE_Return = "No Response!"
        sys.exit()      # Exit the script

    # Return the response
    return PTE_Return


########################################
# Create a loop to request and set attenuation values
########################################

print Get_HTTP_Result("MN?")        # Print model name
print Get_HTTP_Result("SN?")        # Print serial number

run_loop = True
Attenuation = input ("Please enter attenuation value: ")

# Loop the following code while run loop = True
while run_loop:

    Set_1 = Get_HTTP_Result("SETATT=" + str(Attenuation))    # Set attenuation
    print "Set Attenuation:", str(Set_1)

    Read_1 = Get_HTTP_Result("ATT?")                         # Read attenuation
    print "Read Attenuation: ", str(Read_1)

    # Request next attenuation (or 999 to exit the loop)
    Attenuation = input("Please enter attenuation value (or 999 to finish): ")

    # Set run_loop to false to exit the loop if 999 entered
    if Attenuation == 999:
        run_loop = False
        print "Program finished."
```

2.1.3 (e) - Integrated Frequency & Power Sensor

Read frequency and power from FCPM-6000RC.

```
import urllib2
import sys

########################################
# Define a function to send an HTTP command and get the result
########################################

def Get_HTTP_Result(CmdToSend):

    # Specify the IP address
    CmdToSend = "http://192.168.9.69/:" + CmdToSend

    # Send the HTTP command and try to read the result
    try:
        HTTP_Result = urllib2.urlopen(CmdToSend)
        PTE_Return = HTTP_Result.read()

        # Look for the default response to an invalid command
        if "Model:" in PTE_Return:
            print "Error, command not found:", CmdToSend
            PTE_Return = "Invalid Command!"

    # Catch an exception if URL is incorrect (incorrect IP or disconnected)
    except:
        print "Error, no response from device; check IP address and connections."
        PTE_Return = "No Response!"
        sys.exit()      # Exit the script

    # Return the response
    return PTE_Return


########################################
# Send some commands to the FCPM
########################################

print Get_HTTP_Result("MN?")        # Print model name
print Get_HTTP_Result("SN?")        # Print serial number

Freq = Get_HTTP_Result("FREQ?")     # Read frequency
print "Measured Frequency:", str(Freq)

Pwr = Get_HTTP_Result("POWER?")       # Read power
print "Measured Power: ", str(Pwr)
```

The program output should be as below:

```
>>>
        MN=FCPM-6000RC
        SN=11412110017
        Measured Frequency: 1.000000 MHz
        Measured Power:  -99.00 dBm
>>>
```

2.1.4 - Ethernet Device Discovery Using UDP

Mini-Circuits' test products support UDP queries for the purpose of "discovering" any device connected and available on the network.

2.1.4 (a) - Identifying Connected Devices on the Network

Each product family within Mini-Circuits' test equipment range has an identification query that can be sent to the broadcast IP address using UDP on port 4950. The command is detailed in the respective programming manuals. Any relevant connected PTE devices will respond on port 4951 with identification details including model name, serial number and IP address.

The below example summarises the process of searching for any connected Mini-Circuits programmable attenuators on the network. The only details to change from one system to another are the broadcast IP address and subnet mask of the sending PC / server and the broadcast command for the particular PTE family to be searched.

```
import socket

# broadcast address is the bitwise OR between IP and bit-complement of the subnet mask
addr_SND = ('192.168.9.255', 4950)  # broadcast address / MCL test equipment listens on
port 4950
addr_RCV = ('', 4951)               # MCL test equipment replies on port 4951

UDPSock_SND = socket.socket(socket.AF_INET, socket.SOCK_DGRAM) # Create socket
UDPSock_RCV = socket.socket(socket.AF_INET, socket.SOCK_DGRAM) # Create socket

UDPSock_RCV.bind(addr_RCV)
UDPSock_RCV.settimeout(1)
Data_RCV=""

Data_SND = "MCLDAT?"                # Query for the relevant product family

print "Sending message '%s'..." % Data_SND
UDPSock_SND.sendto(Data_SND, addr_SND)

i=0
while i<5:                          # Search for up to 5 units

    try:
        Data_RCV,addr_RCV = UDPSock_RCV.recvfrom(4951)
        print Data_RCV

    except:                         # Timeout error if no more responses
        print "No data received."

    i=i+1

print "End of UDP listening..."

UDPSock_SND.close()             # Close sockets
UDPSock_RCV.close()

print 'Client stopped.'
```

The above example will search for up to 5 connected programmable attenuators. An example output from the program is shown below where 2 devices have been found on the network:

```
>>>
        Sending message 'MCLDAT?'...

        Model Name: RCDAT-6000-110
        Serial Number: 11406170049
        IP Address=192.168.9.66  Port: 80 Telnet: 23
        Subnet Mask=255.255.255.0
        Network Gateway=192.168.9.254
        Mac Address=D0-73-7F-88-80-31

        Model Name: RCDAT-6000-90
        Serial Number: 11310090001
        IP Address=192.168.9.61  Port: 80 Telnet: 23
        Subnet Mask=255.255.255.0
        Network Gateway=192.168.9.254
        Mac Address=D0-73-7F-84-80-01

        No data received.
        No data received.
        No data received.

        End of UDP listening...
        Client stopped.
```

2.2 - C Programming

2.2.1 - USB Control in a Linux Environment

These examples demonstrate control of Mini-Circuits' PTE products using C in the following environment:

1. Host computer running a Linux operating system
2. PTE connected by the USB interface
3. Linux's libhid/libusb libraries installed

The examples use Linux's libhid and libusb libraries to allow communication with the PTE as a USB Human Interface Device. The package can be downloaded from the Mini-Circuits website with the programming example files, installation can be carried out in the following steps:

1. Download libhid-0.2.16.tar.gz
2. Extract libhid-0.2.16.tar.gz to a temporary folder
3. Open the Terminal on the temporary folder location
4. Type the following commands:
    a. *sudo apt-get install libusb-dev*
    b. *cd libhid-0.2.16*
    c. *./configure --enable-werror=no*
    d. *make*
    e. *sudo make install*
    f. *sudo ldconfig*

2.2.1 (a) - Mechanical Switch Boxes

This example relates to Mini-Circuits' mechanical switch box families only and provides a simple console program to find the connected switch, read model name/serial number and set the switch states. Please refer to the programming manual at the link below for full details:
https://www.minicircuits.com/softwaredownload/rfswitchcontroller.html

This code can also be used a starting point for Mini-Circuits' solid-state switches but a different set of commands needs to be sent. Please refer to the detailed programming manuals at the below link for full details:
https://www.minicircuits.com/softwaredownload/solidstate.html

The libusb and libhid libraries are required to enable the program to interface with the devices by USB (see USB Control in a Linux Environment).

To compile and run the program:

1. Open the terminal
2. Type "sudo su" in order to get root privilege (necessary for control over USB)
3. Type "gcc switch.c -o Switch -lusb -lhid" to compile the code
4. Type "./Switch <state>" in order to run the code (entering the required switch state)

```
#include <hid.h>
#include <stdio.h>
#include <string.h>
#include <usb.h>

#define VENDOR_ID  0x20ce   // MiniCircuits Vendor ID
#define PRODUCT_ID 0x0022   // MiniCircuits HID USB Control For RF switch Product ID
#define PATHLEN  2
#define SEND_PACKET_LEN 64

 HIDInterface* hid;
 hid_return ret;
 struct usb_device *usb_dev;
 struct usb_dev_handle *usb_handle;
 char buffer[80], kdname[80];

const int PATH_IN[PATHLEN] = { 0x00010005, 0x00010033 };
char  PACKET[SEND_PACKET_LEN];

bool match_serial_number(struct usb_dev_handle* usbdev, void* custom, unsigned int len)
{
  bool ret;
  char* buffer = (char*)malloc(len);
  usb_get_string_simple(usbdev, usb_device(usbdev)->descriptor.iSerialNumber,
      buffer, len);
  ret = strncmp(buffer, (char*)custom, len) == 0;
  free(buffer);
  return ret;
}
```

```
static struct usb_device *device_init(void)
{
    struct usb_bus *usb_bus;
    struct usb_device *dev;
    usb_init();
    usb_find_busses();
    usb_find_devices();
    for (usb_bus = usb_busses; usb_bus; usb_bus = usb_bus->next)
    {
        for (dev = usb_bus->devices; dev; dev = dev->next)
        {
            if ((dev->descriptor.idVendor == VENDOR_ID) &&
                (dev->descriptor.idProduct == PRODUCT_ID)) {
      return dev;
       }
        }
    }
    return NULL;
}
void Get_PN (char* PNstr)
{
        int i;
        char  PACKETreceive[SEND_PACKET_LEN];
        PACKET[0]=40;  //     PN code
        ret = hid_interrupt_write(hid, 0x01, PACKET, SEND_PACKET_LEN,1000);
    if (ret != HID_RET_SUCCESS) {
      fprintf(stderr, "hid_interrupt_write failed with return code %d\n", ret);
   }
        ret = hid_interrupt_read(hid, 0x01, PACKETreceive, SEND_PACKET_LEN,1000);
        if (ret == HID_RET_SUCCESS) {
              strncpy(PNstr,PACKETreceive,SEND_PACKET_LEN);
              for (i=0;PNstr[i+1]!='\0';i++) {
                       PNstr[i]=PNstr[i+1];
                                                }
              PNstr[i]='\0';
           }
          if (ret != HID_RET_SUCCESS) {
      fprintf(stderr, "hid_interrupt_read failed with return code %d\n", ret);   }

}

void Get_SN (char* SNstr)
{
       int i;
       char  PACKETreceive[SEND_PACKET_LEN];
       PACKET[0]=41;  //     SN Code
        ret = hid_interrupt_write(hid, 0x01, PACKET, SEND_PACKET_LEN,1000);
    if (ret != HID_RET_SUCCESS) {
      fprintf(stderr, "hid_interrupt_write failed with return code %d\n", ret);
   }
        ret = hid_interrupt_read(hid, 0x01, PACKETreceive, SEND_PACKET_LEN,1000);
        if (ret == HID_RET_SUCCESS) {
               strncpy(SNstr,PACKETreceive,SEND_PACKET_LEN);
             for (i=0;SNstr[i+1]!='\0';i++) {
                       SNstr[i]=SNstr[i+1];
                                                }
             SNstr[i]='\0';
           }
   if (ret != HID_RET_SUCCESS) {
      fprintf(stderr, "hid_interrupt_read failed with return code %d\n", ret);   }


}
```

```
void Set_Switch ( unsigned char **switchingCode)
{
        int i;
        char  PACKETreceive[SEND_PACKET_LEN];
        // Writing / Reading From USB
        PACKET[0]=9;          //  switching command
        PACKET[1]= atoi(switchingCode[1]);         // switching code:
                                                // 0 - de-energize all switches
                                                // 1 to energize sw 1 & de-energize sw 2
                                                // 2 to energize sw 2 & de-energize sw 1
                                                // 3 to energize sw 1 ,2
                                                // etc.

        ret = hid_interrupt_write(hid, 0x01, PACKET, SEND_PACKET_LEN,1000);
    if (ret != HID_RET_SUCCESS) {
      fprintf(stderr, "hid_interrupt_write failed with return code %d\n", ret);
   }
        ret = hid_interrupt_read(hid, 0x01, PACKETreceive, SEND_PACKET_LEN,1000);
        //  Read packet  Packetreceive[0]=1

       if (ret != HID_RET_SUCCESS) {
       fprintf(stderr, "hid_interrupt_read failed with return code %d\n", ret);   }

}

int main( int argc, unsigned char **argv)
{
  usb_dev = device_init();

  if (usb_dev == NULL)
  {
      fprintf(stderr, "Device not found!\n");
      exit(-1);
  }
  if (usb_dev != NULL)
  {
      usb_handle = usb_open(usb_dev);
      int drstatus = usb_get_driver_np(usb_handle, 0, kdname, sizeof(kdname));
      if (kdname != NULL && strlen(kdname) > 0) {
     usb_detach_kernel_driver_np(usb_handle, 0);
      }
  }
  usb_reset(usb_handle);
  usb_close(usb_handle);
  HIDInterfaceMatcher matcher = { VENDOR_ID, PRODUCT_ID, NULL, NULL, 0 };
  ret = hid_init();
  if (ret != HID_RET_SUCCESS) {
    fprintf(stderr, "hid_init failed with return code %d\n", ret);
    return 1;
  }
  hid = hid_new_HIDInterface();
  if (hid == 0) {
    fprintf(stderr, "hid_new_HIDInterface() failed, out of memory?\n");
    return 1;
  }

  ret = hid_force_open(hid, 0, &matcher, 3);
  if (ret != HID_RET_SUCCESS) {
    fprintf(stderr, "hid_force_open failed with return code %d\n", ret);
    return 1;
  }
```

```
//////////////    Switching    ////////////////

char  PNreceive[SEND_PACKET_LEN];
char  SNreceive[SEND_PACKET_LEN];

int StrLen1;

 Get_PN(PNreceive);
 fprintf(stderr," PN=  %s .\n",PNreceive);

 Get_SN(SNreceive);
 fprintf(stderr," SN=  %s .\n",SNreceive);

  Set_Switch(argv);

 ////////////////////////////////////////////

  ret = hid_close(hid);
  if (ret != HID_RET_SUCCESS) {
    fprintf(stderr, "hid_close failed with return code %d\n", ret);
    return 1;
  }

  hid_delete_HIDInterface(&hid);

  ret = hid_cleanup();
  if (ret != HID_RET_SUCCESS) {
    fprintf(stderr, "hid_cleanup failed with return code %d\n", ret);
    return 1;
  }

  return 0;
}
```

2.2.1 (b) - Synthesized Signal Generator

Find connected signal generator, read model name/serial number and set RF output.

```
/* ****************************************************************
This is an example code to communicate with USB Control Driver for RF generator.
The example use libusb and libhid libraries to connect to the USB ,
and are available to downlolad from the web (GNU GPL license ).
*****************************************************************/


#include <hid.h>
#include <stdio.h>
#include <string.h>
#include <usb.h>


#define VENDOR_ID  0x20ce   // MiniCircuits Vendor ID
#define PRODUCT_ID 0x0022   // MiniCircuits HID USB Control For RF generator Product ID
#define PATHLEN  2
#define SEND_PACKET_LEN 64


 HIDInterface* hid;
 hid_return ret;
 struct usb_device *usb_dev;
 struct usb_dev_handle *usb_handle;
 char buffer[80], kdname[80];


const int PATH_IN[PATHLEN] = { 0x00010005, 0x00010033 };
char  PACKET[SEND_PACKET_LEN];


bool match_serial_number(struct usb_dev_handle* usbdev, void* custom, unsigned int len)
{
  bool ret;
  char* buffer = (char*)malloc(len);
  usb_get_string_simple(usbdev, usb_device(usbdev)->descriptor.iSerialNumber,
      buffer, len);
  ret = strncmp(buffer, (char*)custom, len) == 0;
  free(buffer);
  return ret;
}


static struct usb_device *device_init(void)
{
    struct usb_bus *usb_bus;
    struct usb_device *dev;
    usb_init();
    usb_find_busses();
    usb_find_devices();
    for (usb_bus = usb_busses; usb_bus; usb_bus = usb_bus->next)
    {
        for (dev = usb_bus->devices; dev; dev = dev->next)
        {
            if ((dev->descriptor.idVendor == VENDOR_ID) &&
                (dev->descriptor.idProduct == PRODUCT_ID)) {
      return dev;
       }
        }
    }
    return NULL;
}
```

```
void Get_PN (char* PNstr)
{
        int i;
        char  PACKETreceive[SEND_PACKET_LEN];
        PACKET[0]=40;  //     PN code
        ret = hid_interrupt_write(hid, 0x01, PACKET, SEND_PACKET_LEN,1000);
    if (ret != HID_RET_SUCCESS) {
      fprintf(stderr, "hid_interrupt_write failed with return code %d\n", ret);
   }
        ret = hid_interrupt_read(hid, 0x01, PACKETreceive, SEND_PACKET_LEN,1000);
        if (ret == HID_RET_SUCCESS) {
              strncpy(PNstr,PACKETreceive,SEND_PACKET_LEN);
              for (i=0;PNstr[i+1]!='\0';i++) {
                       PNstr[i]=PNstr[i+1];
                                              }
              PNstr[i]='\0';
           }
          if (ret != HID_RET_SUCCESS) {
      fprintf(stderr, "hid_interrupt_read failed with return code %d\n", ret);   }

}

void Get_SN (char* SNstr)
{
       int i;
       char  PACKETreceive[SEND_PACKET_LEN];
       PACKET[0]=41;  //     SN Code
        ret = hid_interrupt_write(hid, 0x01, PACKET, SEND_PACKET_LEN,1000);
    if (ret != HID_RET_SUCCESS) {
      fprintf(stderr, "hid_interrupt_write failed with return code %d\n", ret);
   }
        ret = hid_interrupt_read(hid, 0x01, PACKETreceive, SEND_PACKET_LEN,1000);
        if (ret == HID_RET_SUCCESS) {
               strncpy(SNstr,PACKETreceive,SEND_PACKET_LEN);
             for (i=0;SNstr[i+1]!='\0';i++) {
                       SNstr[i]=SNstr[i+1];
                                              }
             SNstr[i]='\0';
           }
   if (ret != HID_RET_SUCCESS) {
      fprintf(stderr, "hid_interrupt_read failed with return code %d\n", ret);   }

}

void Set_GeneratorA ()
//  Energized generator A
{
        int i;
        char  PACKETreceive[SEND_PACKET_LEN];
        // Writing / Reading From USB
        PACKET[0]=1;          // 1 = Handle Generator A ; 2=Handle Generator B
        PACKET[1]= 1;         // 1 = energized 0=de-energized
        ret = hid_interrupt_write(hid, 0x01, PACKET, SEND_PACKET_LEN,1000);
    if (ret != HID_RET_SUCCESS) {
      fprintf(stderr, "hid_interrupt_write failed with return code %d\n", ret);
   }
        ret = hid_interrupt_read(hid, 0x01, PACKETreceive, SEND_PACKET_LEN,1000);
        //  Read packet  Packetreceive[0]=1

       if (ret != HID_RET_SUCCESS) {
       fprintf(stderr, "hid_interrupt_read failed with return code %d\n", ret);   }

}
```

```
int main( int argc, unsigned char **argv)
{
  usb_dev = device_init();

  if (usb_dev == NULL)
  {
      fprintf(stderr, "Device not found!\n");
      exit(-1);
  }
  if (usb_dev != NULL)
  {
      usb_handle = usb_open(usb_dev);
      int drstatus = usb_get_driver_np(usb_handle, 0, kdname, sizeof(kdname));
      if (kdname != NULL && strlen(kdname) > 0) {
     usb_detach_kernel_driver_np(usb_handle, 0);
      }
  }
  usb_reset(usb_handle);
  usb_close(usb_handle);
  HIDInterfaceMatcher matcher = { VENDOR_ID, PRODUCT_ID, NULL, NULL, 0 };
  ret = hid_init();
  if (ret != HID_RET_SUCCESS) {
    fprintf(stderr, "hid_init failed with return code %d\n", ret);
    return 1;
  }
  hid = hid_new_HIDInterface();
  if (hid == 0) {
    fprintf(stderr, "hid_new_HIDInterface() failed, out of memory?\n");
    return 1;
  }

  ret = hid_force_open(hid, 0, &matcher, 3);
  if (ret != HID_RET_SUCCESS) {
    fprintf(stderr, "hid_force_open failed with return code %d\n", ret);
    return 1;
  }

//////////////   Generating    ////////////////////////////////

char  PNreceive[SEND_PACKET_LEN];
char  SNreceive[SEND_PACKET_LEN];

int StrLen1;

 Get_PN(PNreceive);
 fprintf(stderr," PN=  %s .\n",PNreceive);

 Get_SN(SNreceive);
 fprintf(stderr," SN=  %s .\n",SNreceive);

 Set_GeneratorA();
 ////////////////////////////////////////////////////////////

  ret = hid_close(hid);
  if (ret != HID_RET_SUCCESS) {
    fprintf(stderr, "hid_close failed with return code %d\n", ret);
    return 1;
  }

  hid_delete_HIDInterface(&hid);

  ret = hid_cleanup();
  if (ret != HID_RET_SUCCESS) {
    fprintf(stderr, "hid_cleanup failed with return code %d\n", ret);
    return 1;
  }

  return 0;
}
```

2.2.1 (c) - Power Sensor (Single Device)

Find connected power sensor, read model name/serial number and read input power level.

```
/* ****************************************************************
This is an example code to communicate with USB Control Driver for RF sensor.
The example use libusb and libhid libraries to connect to the USB ,
and are available to downlolad from the web (GNU GPL license ).
*****************************************************************/


#include <hid.h>
#include <stdio.h>
#include <string.h>
#include <usb.h>


#define VENDOR_ID  0x20ce   // MiniCircuits Vendor ID
#define PRODUCT_ID 0x0022   // MiniCircuits HID USB Control For RF sensor Product ID
#define PATHLEN  2
#define SEND_PACKET_LEN 64


 HIDInterface* hid;
 hid_return ret;
 struct usb_device *usb_dev;
 struct usb_dev_handle *usb_handle;
 char buffer[80], kdname[80];


const int PATH_IN[PATHLEN] = { 0x00010005, 0x00010033 };
char  PACKET[SEND_PACKET_LEN];


bool match_serial_number(struct usb_dev_handle* usbdev, void* custom, unsigned int len)
{
  bool ret;
  char* buffer = (char*)malloc(len);
  usb_get_string_simple(usbdev, usb_device(usbdev)->descriptor.iSerialNumber,
      buffer, len);
  ret = strncmp(buffer, (char*)custom, len) == 0;
  free(buffer);
  return ret;
}


static struct usb_device *device_init(void)
{
    struct usb_bus *usb_bus;
    struct usb_device *dev;
    usb_init();
    usb_find_busses();
    usb_find_devices();
    for (usb_bus = usb_busses; usb_bus; usb_bus = usb_bus->next)
    {
        for (dev = usb_bus->devices; dev; dev = dev->next)
        {
            if ((dev->descriptor.idVendor == VENDOR_ID) &&
                (dev->descriptor.idProduct == PRODUCT_ID)) {
      return dev;
       }
        }
    }
    return NULL;
}
```

```
void Get_PN (char* PNstr)
{
        int i;
        char  PACKETreceive[SEND_PACKET_LEN];
        PACKET[0]=40;  //     PN code
        ret = hid_interrupt_write(hid, 0x01, PACKET, SEND_PACKET_LEN,1000);
    if (ret != HID_RET_SUCCESS) {
      fprintf(stderr, "hid_interrupt_write failed with return code %d\n", ret);
   }
        ret = hid_interrupt_read(hid, 0x01, PACKETreceive, SEND_PACKET_LEN,1000);
        if (ret == HID_RET_SUCCESS) {
              strncpy(PNstr,PACKETreceive,SEND_PACKET_LEN);
              for (i=0;PNstr[i+1]!='\0';i++) {
                       PNstr[i]=PNstr[i+1];
                                              }
              PNstr[i]='\0';
           }
          if (ret != HID_RET_SUCCESS) {
      fprintf(stderr, "hid_interrupt_read failed with return code %d\n", ret);   }

}

void Get_SN (char* SNstr)
{
       int i;
       char  PACKETreceive[SEND_PACKET_LEN];
       PACKET[0]=41;  //     SN Code
        ret = hid_interrupt_write(hid, 0x01, PACKET, SEND_PACKET_LEN,1000);
    if (ret != HID_RET_SUCCESS) {
      fprintf(stderr, "hid_interrupt_write failed with return code %d\n", ret);
   }
        ret = hid_interrupt_read(hid, 0x01, PACKETreceive, SEND_PACKET_LEN,1000);
        if (ret == HID_RET_SUCCESS) {
               strncpy(SNstr,PACKETreceive,SEND_PACKET_LEN);
             for (i=0;SNstr[i+1]!='\0';i++) {
                       SNstr[i]=SNstr[i+1];
                                              }
             SNstr[i]='\0';
           }
   if (ret != HID_RET_SUCCESS) {
      fprintf(stderr, "hid_interrupt_read failed with return code %d\n", ret);   }

}

void Set_SensorA ()
//  Energized sensor A
{
        int i;
        char  PACKETreceive[SEND_PACKET_LEN];
        // Writing / Reading From USB
        PACKET[0]=1;          // 1 = Handle Sensor A ; 2=Handle Sensor B
        PACKET[1]= 1;         // 1 = energized 0=de-energized
        ret = hid_interrupt_write(hid, 0x01, PACKET, SEND_PACKET_LEN,1000);
    if (ret != HID_RET_SUCCESS) {
      fprintf(stderr, "hid_interrupt_write failed with return code %d\n", ret);
   }
        ret = hid_interrupt_read(hid, 0x01, PACKETreceive, SEND_PACKET_LEN,1000);
        //  Read packet  Packetreceive[0]=1

       if (ret != HID_RET_SUCCESS) {
       fprintf(stderr, "hid_interrupt_read failed with return code %d\n", ret);   }

}
```

```
int main( int argc, unsigned char **argv)
{
  usb_dev = device_init();

  if (usb_dev == NULL)
  {
      fprintf(stderr, "Device not found!\n");
      exit(-1);
  }
  if (usb_dev != NULL)
  {
      usb_handle = usb_open(usb_dev);
      int drstatus = usb_get_driver_np(usb_handle, 0, kdname, sizeof(kdname));
      if (kdname != NULL && strlen(kdname) > 0) {
     usb_detach_kernel_driver_np(usb_handle, 0);
      }
  }
  usb_reset(usb_handle);
  usb_close(usb_handle);
  HIDInterfaceMatcher matcher = { VENDOR_ID, PRODUCT_ID, NULL, NULL, 0 };
  ret = hid_init();
  if (ret != HID_RET_SUCCESS) {
    fprintf(stderr, "hid_init failed with return code %d\n", ret);
    return 1;
  }
  hid = hid_new_HIDInterface();
  if (hid == 0) {
    fprintf(stderr, "hid_new_HIDInterface() failed, out of memory?\n");
    return 1;
  }

  ret = hid_force_open(hid, 0, &matcher, 3);
  if (ret != HID_RET_SUCCESS) {
    fprintf(stderr, "hid_force_open failed with return code %d\n", ret);
    return 1;
  }

//////////////   Sensoring    ////////////////////////////////

char  PNreceive[SEND_PACKET_LEN];
char  SNreceive[SEND_PACKET_LEN];

int StrLen1;

 Get_PN(PNreceive);
 fprintf(stderr," PN=  %s .\n",PNreceive);

 Get_SN(SNreceive);
 fprintf(stderr," SN=  %s .\n",SNreceive);

 Set_SensorA();
 ////////////////////////////////////////////////////////////

  ret = hid_close(hid);
  if (ret != HID_RET_SUCCESS) {
    fprintf(stderr, "hid_close failed with return code %d\n", ret);
    return 1;
  }

  hid_delete_HIDInterface(&hid);

  ret = hid_cleanup();
  if (ret != HID_RET_SUCCESS) {
    fprintf(stderr, "hid_cleanup failed with return code %d\n", ret);
    return 1;
  }

  return 0;
}
```

2.2.1 (d) - Power Sensors (Controlling Multiple Devices)

This example (MCL_PM2.c) demonstrates how to control 2 or more power sensors simultaneously. The source code is below and the files can be downloaded from the Mini-Circuits website.

After extracting the download files, the user can run from a Linux terminal using the following commands:
sudo su (for administrator privileges)
gcc -o MCL_PM2 MCL_PM2.c libhid/.c libusb/*.c* (to compile)
./MCL_PM2 10 (to run, after 2 power sensors have been connected by USB)

The output will show 2 different power readings along with the serial number and model name for each device.

```
#include <hid.h>
#include <stdio.h>
#include <string.h>
#include <usb.h>

#define VENDOR_ID  0x20ce   // MiniCircuits Vendor ID
#define PRODUCT_ID 0x0011   // MiniCircuits HID Power Sensor Product ID
#define PATHLEN  2
#define SEND_PACKET_LEN 64

hid_return ret;

char buffer[80], kdname[80];
const int PATH_IN[PATHLEN] = { 0x00010005, 0x00010033 };
char  PACKET[SEND_PACKET_LEN];


bool match_serial_number(struct usb_dev_handle* usbdev, void* custom, unsigned int len)
{
  bool ret;
  char* buffer = (char*)malloc(len);
  usb_get_string_simple(usbdev, usb_device(usbdev)->descriptor.iSerialNumber,
      buffer, len);
  ret = strncmp(buffer, (char*)custom, len) == 0;
  free(buffer);
  return ret;
}


void Get_PN (char* PNstr, HIDInterface* hid)
{
        int i;
        char  PACKETreceive[SEND_PACKET_LEN];
        PACKET[0]=104;  //     PN code
        ret = hid_interrupt_write(hid, 0x01, PACKET, SEND_PACKET_LEN,1000);
    if (ret != HID_RET_SUCCESS) {
        fprintf(stderr, "hid_interrupt_write failed with return code %d\n", ret);
    }
        ret = hid_interrupt_read(hid, 0x01, PACKETreceive, SEND_PACKET_LEN,1000);
        if (ret == HID_RET_SUCCESS) {
              strncpy(PNstr,PACKETreceive,SEND_PACKET_LEN);
              for (i=0;PNstr[i+1]!='\0';i++) {
                        PNstr[i]=PNstr[i+1];
                                              }
              PNstr[i]='\0';
           }
        if (ret != HID_RET_SUCCESS) {
        fprintf(stderr, "hid_interrupt_read failed with return code %d\n", ret);    }

}
```

```
void Get_SN (char* SNstr, HIDInterface* hid)
{
       int i;
       char  PACKETreceive[SEND_PACKET_LEN];
       PACKET[0]=105;  //     SN Code
        ret = hid_interrupt_write(hid, 0x01, PACKET, SEND_PACKET_LEN,1000);
    if (ret != HID_RET_SUCCESS) {
        fprintf(stderr, "hid_interrupt_write failed with return code %d\n", ret);
    }
        ret = hid_interrupt_read(hid, 0x01, PACKETreceive, SEND_PACKET_LEN,1000);
        if (ret == HID_RET_SUCCESS) {
               strncpy(SNstr,PACKETreceive,SEND_PACKET_LEN);
             for (i=0;SNstr[i+1]!='\0';i++) {
                       SNstr[i]=SNstr[i+1];
                                              }
             SNstr[i]='\0';
           }
    if (ret != HID_RET_SUCCESS) {
        fprintf(stderr, "hid_interrupt_read failed with return code %d\n", ret);    }
}


void Get_Power (unsigned char **Freq1,char* Pwr, HIDInterface* hid)
//  Freq1 = input frequency ,  Pwr = output Power
{
        int i;
        char  PACKETreceive[SEND_PACKET_LEN];
    // Writing / Reading From USB
        PACKET[0]=102;          // 102 = code to get power
        PACKET[1]= atoi(Freq1[1])/256;
        PACKET[2]= atoi(Freq1[1])%256;
        //  Frequency   to Hex   Packet[1]=hi  packet[2]=lo
        ret = hid_interrupt_write(hid, 0x01, PACKET, SEND_PACKET_LEN,1000);
    if (ret != HID_RET_SUCCESS) {
        fprintf(stderr, "hid_interrupt_write failed with return code %d\n", ret);
    }
        ret = hid_interrupt_read(hid, 0x01, PACKETreceive, SEND_PACKET_LEN,1000);
        //  Read packet  Packetreceive[0]=102 get power  Packetreceive[1]-Packetreceive[6]
Ascii of Power ex: -10.05

        if (ret == HID_RET_SUCCESS)
        {
             strncpy(Pwr,PACKETreceive,SEND_PACKET_LEN);
            for (i=0;Pwr[i+1]!='\0';i++) {
                       Pwr[i]=Pwr[i+1];
                                             }
            Pwr[i]='\0';
        }

    if (ret != HID_RET_SUCCESS) {
        fprintf(stderr, "hid_interrupt_read failed with return code %d\n", ret);    }

}
```

```
int main( int argc, unsigned char **argv)
{
   char  PNreceive[SEND_PACKET_LEN];
   char  SNreceive[SEND_PACKET_LEN];
   char  SNreceive1[SEND_PACKET_LEN];
   char  RFpower[SEND_PACKET_LEN];

   int StrLen1;
   int CountUSB=0;

     HIDInterface* hid1;    // Declare power sensor 1 (repeat for multiple sensors)
     HIDInterface* hid2;    // Declare power sensor 2

    usb_init();
    usb_find_busses();
    usb_find_devices();
    ret = hid_init();
    HIDInterfaceMatcher matcher = { VENDOR_ID, PRODUCT_ID, NULL, NULL, 0 };
    ++CountUSB;

    // Use power sensor 1 (repeat this block of code for multiple sensors)
    hid1 = hid_new_HIDInterface();
    ret = hid_force_open(hid1, 0, &matcher, 0);
    Get_PN(PNreceive,hid1);          // Get part number
    fprintf(stderr," PN=  %s .\n",PNreceive);
    Get_SN(SNreceive,hid1);          // Get serial number
    fprintf(stderr," SN=  %s .\n",SNreceive);
    Get_Power(argv,RFpower,hid1);    // Read power
    fprintf(stderr," Power=  %s dBm.\n",RFpower);

    // Use power sensor 2
    hid2 = hid_new_HIDInterface();
    ret = hid_force_open(hid2, 0, &matcher, 0);
    Get_PN(PNreceive,hid2);          // Get part number
    fprintf(stderr," PN=  %s .\n",PNreceive);
    Get_SN(SNreceive,hid2);          // Get serial number
    fprintf(stderr," SN=  %s .\n",SNreceive);
    Get_Power(argv,RFpower,hid2);    // Read power
    fprintf(stderr," Power=  %s dBm.\n",RFpower);

    ret = hid_close(hid1);
    hid_delete_HIDInterface(&hid1);

    ret = hid_close(hid2);
    hid_delete_HIDInterface(&hid2);

    ret = hid_cleanup();
    return 0;

}
```

2.2.1 (e) - Frequency Counter

Find connected frequency counter, read frequency and write to a text file.

Sudo rights are needed to compile and run the code, type:

- *sudo gcc FC.c -o FC -lusb -lhid* (to compile)
- *sudo ./FC* (to run)

The text file output ("FreqCounter.txt") will be created in the project folder.

```
/* ****************************************************************
The example use libusb and libhid libraries to connect to the USB ,
and are available to downlolad from the web (GNU GPL license ).
*****************************************************************/

#include <usb.h>
#include <hid.h>
#include <stdio.h>
#include <sys/types.h>
#include <sys/stat.h>
#include <fcntl.h>
#include <unistd.h>
#include <string.h>
#define VENDOR_ID  0x20ce   // MiniCircuits Vendor ID
#define PRODUCT_ID 0x0010   // MiniCircuits HID USB Freq Counter Product ID
#define PATHLEN  2
#define SEND_PACKET_LEN 64

 HIDInterface* hid;
 hid_return ret;
 struct usb_device *usb_dev;
 struct usb_dev_handle *usb_handle;
 char buffer[80], kdname[80];

const int PATH_IN[PATHLEN] = { 0x00010005, 0x00010033 };
char  PACKET[SEND_PACKET_LEN];

bool match_serial_number(struct usb_dev_handle* usbdev, void* custom, unsigned int len)
{
  bool ret;
  char* buffer = (char*)malloc(len);
  usb_get_string_simple(usbdev, usb_device(usbdev)->descriptor.iSerialNumber,
      buffer, len);
  ret = strncmp(buffer, (char*)custom, len) == 0;
  free(buffer);
  return ret;
}

static struct usb_device *device_init(void)
{
    struct usb_bus *usb_bus;
    struct usb_device *dev;
    usb_init();
    usb_find_busses();
    usb_find_devices();
    for (usb_bus = usb_busses; usb_bus; usb_bus = usb_bus->next)
    {
        for (dev = usb_bus->devices; dev; dev = dev->next)
        {
            if ((dev->descriptor.idVendor == VENDOR_ID) &&
                (dev->descriptor.idProduct == PRODUCT_ID)) {
      return dev;
       }
        }
    }
    return NULL;
}
```

```
void Get_PN (char* PNstr)
{
        int i;
        char  PACKETreceive[SEND_PACKET_LEN];
        PACKET[0]=40;  //     PN code
        ret = hid_interrupt_write(hid, 0x01, PACKET, SEND_PACKET_LEN,1000);
    if (ret != HID_RET_SUCCESS) {
      fprintf(stderr, "hid_interrupt_write failed with return code %d\n", ret);
   }
        ret = hid_interrupt_read(hid, 0x01, PACKETreceive, SEND_PACKET_LEN,1000);
        if (ret == HID_RET_SUCCESS) {
              strncpy(PNstr,PACKETreceive,SEND_PACKET_LEN);
              for (i=0;PNstr[i+1]!='\0';i++) {
                       PNstr[i]=PNstr[i+1];
                                              }
              PNstr[i]='\0';
           }
          if (ret != HID_RET_SUCCESS) {
      fprintf(stderr, "hid_interrupt_read failed with return code %d\n", ret);   }

}
void Get_SN (char* SNstr)
{
       int i;
       char  PACKETreceive[SEND_PACKET_LEN];
       PACKET[0]=41;  //     SN Code
        ret = hid_interrupt_write(hid, 0x01, PACKET, SEND_PACKET_LEN,1000);
    if (ret != HID_RET_SUCCESS) {
      fprintf(stderr, "hid_interrupt_write failed with return code %d\n", ret);
   }
        ret = hid_interrupt_read(hid, 0x01, PACKETreceive, SEND_PACKET_LEN,1000);
        if (ret == HID_RET_SUCCESS) {
               strncpy(SNstr,PACKETreceive,SEND_PACKET_LEN);
             for (i=0;SNstr[i+1]!='\0';i++) {
                       SNstr[i]=SNstr[i+1];
                                              }
             SNstr[i]='\0';
           }
   if (ret != HID_RET_SUCCESS) {
      fprintf(stderr, "hid_interrupt_read failed with return code %d\n", ret);   }


}
void ReadFreq (char* FreqStr)
{
       int i=0;
       char  PACKETreceive[SEND_PACKET_LEN];
       PACKET[0]=2;  //     Read Freq code
        ret = hid_interrupt_write(hid, 0x01, PACKET, SEND_PACKET_LEN,1000);
    if (ret != HID_RET_SUCCESS) {
      fprintf(stderr, "hid_interrupt_write failed with return code %d\n", ret);
   }
        ret = hid_interrupt_read(hid, 0x01, PACKETreceive, SEND_PACKET_LEN,1000);
        if (ret == HID_RET_SUCCESS) {

             for (i=17;i<34;i++) {
                      FreqStr[i-17]=PACKETreceive[i];
                                              }
             FreqStr[i-17]='\0';
          }

   if (ret != HID_RET_SUCCESS) {
      fprintf(stderr, "hid_interrupt_read failed with return code %d\n", ret);   }


}
```

```
int main( int argc, unsigned char **argv)
{
 int ff;
 char AttValue[3];
 float LastAtt=0.0;

 usb_dev = device_init();
 if (usb_dev == NULL)
  {
      fprintf(stderr, "Device not found!\n");
      exit(-1);
  }
  if (usb_dev != NULL)
  {
      usb_handle = usb_open(usb_dev);
      int drstatus = usb_get_driver_np(usb_handle, 0, kdname, sizeof(kdname));
      if (kdname != NULL && strlen(kdname) > 0) {
     usb_detach_kernel_driver_np(usb_handle, 0);
      }
  }
  usb_reset(usb_handle);
  usb_close(usb_handle);
  HIDInterfaceMatcher matcher = { VENDOR_ID, PRODUCT_ID, NULL, NULL, 0 };
  ret = hid_init();
  if (ret != HID_RET_SUCCESS) {
    fprintf(stderr, "hid_init failed with return code %d\n", ret);
    return 1;
  }
  hid = hid_new_HIDInterface();
  if (hid == 0) {
    fprintf(stderr, "hid_new_HIDInterface() failed, out of memory?\n");
    return 1;
  }

  ret = hid_force_open(hid, 0, &matcher, 3);
  if (ret != HID_RET_SUCCESS) {
    fprintf(stderr, "hid_force_open failed with return code %d\n", ret);
    return 1;
  }

char  PNreceive[SEND_PACKET_LEN];
char  SNreceive[SEND_PACKET_LEN];
char Freq[SEND_PACKET_LEN];
int StrLen1,j;

 Get_PN(PNreceive);
 fprintf(stderr," PN=  %s .\n",PNreceive);

 Get_SN(SNreceive);
 fprintf(stderr," SN=  %s .\n",SNreceive);

 ff=open("FreqCounter.txt",O_WRONLY | O_CREAT,0644);
    if(ff==1){
        printf("Error - file not created.\n");
        return 0;
    }

for (j=1;j<=1000;++j)
{
 ReadFreq (Freq);
 fprintf(stderr," Freq=  %s \n",Freq);
 write(ff,Freq,15);
}
```

```
close(ff);
ret = hid_close(hid);
if (ret != HID_RET_SUCCESS) {
    fprintf(stderr, "hid_close failed with return code %d\n", ret);
    return 1;
  }

  hid_delete_HIDInterface(&hid);

  ret = hid_cleanup();
  if (ret != HID_RET_SUCCESS) {
    fprintf(stderr, "hid_cleanup failed with return code %d\n", ret);
    return 1;
  }

  return 0;
}
```

2.2.1 (f) - Input/Output (IO) Control Boxes

Finds a connected device, reads model name/serial number and sets the relay outputs.

```
/* ****************************************************************
This is an example code to communicate with USB Control Driver for RF switch.
The example use libusb and libhid libraries to connect to the USB ,
and are available to downlolad from the web (GNU GPL license ).
*****************************************************************/


#include <hid.h>
#include <stdio.h>
#include <string.h>
#include <usb.h>


#define VENDOR_ID  0x20ce   // MiniCircuits Vendor ID
#define PRODUCT_ID 0x0021   // MiniCircuits USB to I/O
#define PATHLEN  2
#define SEND_PACKET_LEN 64


 HIDInterface* hid;
 hid_return ret;
 struct usb_device *usb_dev;
 struct usb_dev_handle *usb_handle;
 char buffer[80], kdname[80];


const int PATH_IN[PATHLEN] = { 0x00010005, 0x00010033 };
char  PACKET[SEND_PACKET_LEN];


bool match_serial_number(struct usb_dev_handle* usbdev, void* custom, unsigned int len)
{
  bool ret;
  char* buffer = (char*)malloc(len);
  usb_get_string_simple(usbdev, usb_device(usbdev)->descriptor.iSerialNumber,
      buffer, len);
  ret = strncmp(buffer, (char*)custom, len) == 0;
  free(buffer);
  return ret;
}


static struct usb_device *device_init(void)
{
    struct usb_bus *usb_bus;
    struct usb_device *dev;
    usb_init();
    usb_find_busses();
    usb_find_devices();
    for (usb_bus = usb_busses; usb_bus; usb_bus = usb_bus->next)
    {
        for (dev = usb_bus->devices; dev; dev = dev->next)
        {
            if ((dev->descriptor.idVendor == VENDOR_ID) &&
                (dev->descriptor.idProduct == PRODUCT_ID)) {
      return dev;
       }
        }
    }
    return NULL;
}
```

```
void Get_PN (char* PNstr)
{
        int i;
        char  PACKETreceive[SEND_PACKET_LEN];
        PACKET[0]=40;  //     PN code
        ret = hid_interrupt_write(hid, 0x01, PACKET, SEND_PACKET_LEN,1000);
    if (ret != HID_RET_SUCCESS) {
      fprintf(stderr, "hid_interrupt_write failed with return code %d\n", ret);
   }
        ret = hid_interrupt_read(hid, 0x01, PACKETreceive, SEND_PACKET_LEN,1000);
        if (ret == HID_RET_SUCCESS) {
              strncpy(PNstr,PACKETreceive,SEND_PACKET_LEN);
              for (i=0;PNstr[i+1]!='\0';i++) {
                       PNstr[i]=PNstr[i+1];
                                              }
              PNstr[i]='\0';
           }
          if (ret != HID_RET_SUCCESS) {
      fprintf(stderr, "hid_interrupt_read failed with return code %d\n", ret);   }

}


void Get_SN (char* SNstr)
{
       int i;
       char  PACKETreceive[SEND_PACKET_LEN];
       PACKET[0]=41;  //     SN Code
        ret = hid_interrupt_write(hid, 0x01, PACKET, SEND_PACKET_LEN,1000);
    if (ret != HID_RET_SUCCESS) {
      fprintf(stderr, "hid_interrupt_write failed with return code %d\n", ret);
   }
        ret = hid_interrupt_read(hid, 0x01, PACKETreceive, SEND_PACKET_LEN,1000);
        if (ret == HID_RET_SUCCESS) {
               strncpy(SNstr,PACKETreceive,SEND_PACKET_LEN);
             for (i=0;SNstr[i+1]!='\0';i++) {
                       SNstr[i]=SNstr[i+1];
                                              }
             SNstr[i]='\0';
           }
   if (ret != HID_RET_SUCCESS) {
      fprintf(stderr, "hid_interrupt_read failed with return code %d\n", ret);   }


}


void Set_Relay (int RelayNo , int On_OFF )
//  Set a specific relay On or Off
{
        int i;
        char  PACKETreceive[SEND_PACKET_LEN];
        // Writing / Reading From USB
        PACKET[0]=34;          // 34 ' code for Set 1 Relay Bit
        PACKET[1]= RelayNo;         //
        PACKET[2]= On_OFF;         //
        ret = hid_interrupt_write(hid, 0x01, PACKET, SEND_PACKET_LEN,1000);
    if (ret != HID_RET_SUCCESS) {
      fprintf(stderr, "hid_interrupt_write failed with return code %d\n", ret);
   }
        ret = hid_interrupt_read(hid, 0x01, PACKETreceive, SEND_PACKET_LEN,1000);
        //  Read packet  Packetreceive[0]=1

       if (ret != HID_RET_SUCCESS) {
       fprintf(stderr, "hid_interrupt_read failed with return code %d\n", ret);   }

}
```

```
int main( int argc, unsigned char **argv)
{
  usb_dev = device_init();

  if (usb_dev == NULL)
  {
      fprintf(stderr, "Device not found!\n");
      exit(-1);
  }
  if (usb_dev != NULL)
  {
      usb_handle = usb_open(usb_dev);
      int drstatus = usb_get_driver_np(usb_handle, 0, kdname, sizeof(kdname));
      if (kdname != NULL && strlen(kdname) > 0) {
     usb_detach_kernel_driver_np(usb_handle, 0);
      }
  }
  usb_reset(usb_handle);
  usb_close(usb_handle);
  HIDInterfaceMatcher matcher = { VENDOR_ID, PRODUCT_ID, NULL, NULL, 0 };
  ret = hid_init();
  if (ret != HID_RET_SUCCESS) {
    fprintf(stderr, "hid_init failed with return code %d\n", ret);
    return 1;
  }
  hid = hid_new_HIDInterface();
  if (hid == 0) {
    fprintf(stderr, "hid_new_HIDInterface() failed, out of memory?\n");
    return 1;
  }

  ret = hid_force_open(hid, 0, &matcher, 3);
  if (ret != HID_RET_SUCCESS) {
    fprintf(stderr, "hid_force_open failed with return code %d\n", ret);
    return 1;
  }

//////////////   Switching   ////////////////////////////////////////////////////////

char  PNreceive[SEND_PACKET_LEN];
char  SNreceive[SEND_PACKET_LEN];

int StrLen1;

 Get_PN(PNreceive);
 fprintf(stderr," PN=  %s .\n",PNreceive);

 Get_SN(SNreceive);
 fprintf(stderr," SN=  %s .\n",SNreceive);

  Set_Relay(0,1); // turn on relay 0
 Set_Relay(5,1); // turn on relay 5
 Set_Relay(0,0); // turn off relay 0
 ////////////////////////////////////////////////////////////////////////////////////

  ret = hid_close(hid);
  if (ret != HID_RET_SUCCESS) {
    fprintf(stderr, "hid_close failed with return code %d\n", ret);
    return 1;
  }

  hid_delete_HIDInterface(&hid);

  ret = hid_cleanup();
  if (ret != HID_RET_SUCCESS) {
    fprintf(stderr, "hid_cleanup failed with return code %d\n", ret);
    return 1;
  }

  return 0;
}
```

2.2.1 (g) - Programmable Attenuator (Single Device)

RUDAT.c provides a simple console program to set the attenuation and read the attenuator model name and serial number.

The libusb and libhid libraries are required to enable the program to interface with the devices by USB (see USB Control in a Linux Environment).

To compile and run the program:

5. Open the terminal
6. Type “sudo su” in order to get root privilege (necessary for control over USB)
7. Type “gcc RUDAT.c -o RUDAT -lusb -lhid” to compile the code
8. Type “./RUDAT <attenuation>” in order to run the code (entering the required attenuation)

```
// Requires libusb and libhid libraries for USB control available under GNU GPL license

#include <usb.h>
#include <hid.h>
#include <stdio.h>
#include <string.h>

#define VENDOR_ID  0x20ce   // MiniCircuits Vendor ID
#define PRODUCT_ID 0x0023   // MiniCircuits HID USB RUDAT Product ID
#define PATHLEN  2
#define SEND_PACKET_LEN 64

 HIDInterface* hid;
 hid_return ret;
 struct usb_device *usb_dev;
 struct usb_dev_handle *usb_handle;
 char buffer[80], kdname[80];

const int PATH_IN[PATHLEN] = { 0x00010005, 0x00010033 };
char  PACKET[SEND_PACKET_LEN];

bool match_serial_number(struct usb_dev_handle* usbdev, void* custom, unsigned int len)
{
  bool ret;
  char* buffer = (char*)malloc(len);
  usb_get_string_simple(usbdev, usb_device(usbdev)->descriptor.iSerialNumber,
      buffer, len);
  ret = strncmp(buffer, (char*)custom, len) == 0;
  free(buffer);
  return ret;
}

static struct usb_device *device_init(void)
{
    struct usb_bus *usb_bus;
    struct usb_device *dev;
    usb_init();
    usb_find_busses();
    usb_find_devices();
    for (usb_bus = usb_busses; usb_bus; usb_bus = usb_bus->next)
    {
        for (dev = usb_bus->devices; dev; dev = dev->next)
        {
            if ((dev->descriptor.idVendor == VENDOR_ID) &&
                (dev->descriptor.idProduct == PRODUCT_ID)) {
      return dev;
       }
        }
    }
    return NULL;
}
```

```
void Get_PN (char* PNstr)
{
        int i;
        char  PACKETreceive[SEND_PACKET_LEN];
        PACKET[0]=40;  //     PN code
        ret = hid_interrupt_write(hid, 0x01, PACKET, SEND_PACKET_LEN,1000);
    if (ret != HID_RET_SUCCESS) {
      fprintf(stderr, "hid_interrupt_write failed with return code %d\n", ret);
   }
        ret = hid_interrupt_read(hid, 0x01, PACKETreceive, SEND_PACKET_LEN,1000);
        if (ret == HID_RET_SUCCESS) {
              strncpy(PNstr,PACKETreceive,SEND_PACKET_LEN);
              for (i=0;PNstr[i+1]!='\0';i++) {
                       PNstr[i]=PNstr[i+1];
                                              }
              PNstr[i]='\0';
           }
          if (ret != HID_RET_SUCCESS) {
      fprintf(stderr, "hid_interrupt_read failed with return code %d\n", ret);   }
}

void Get_SN (char* SNstr)
{
       int i;
       char  PACKETreceive[SEND_PACKET_LEN];
       PACKET[0]=41;  //     SN Code
        ret = hid_interrupt_write(hid, 0x01, PACKET, SEND_PACKET_LEN,1000);
    if (ret != HID_RET_SUCCESS) {
      fprintf(stderr, "hid_interrupt_write failed with return code %d\n", ret);
   }
        ret = hid_interrupt_read(hid, 0x01, PACKETreceive, SEND_PACKET_LEN,1000);
        if (ret == HID_RET_SUCCESS) {
               strncpy(SNstr,PACKETreceive,SEND_PACKET_LEN);
             for (i=0;SNstr[i+1]!='\0';i++) {
                       SNstr[i]=SNstr[i+1];
                                              }
             SNstr[i]='\0';
           }
   if (ret != HID_RET_SUCCESS) {
      fprintf(stderr, "hid_interrupt_read failed with return code %d\n", ret);   }
}

void ReadAtt (char* AttStr)
{
       int i;

       char  PACKETreceive[SEND_PACKET_LEN];
       PACKET[0]=18;  //     Ruturn attenuation  code
       ret = hid_interrupt_write(hid, 0x01, PACKET, SEND_PACKET_LEN,1000);
    if (ret != HID_RET_SUCCESS) {
      fprintf(stderr, "hid_interrupt_write failed with return code %d\n", ret);
   }
        ret = hid_interrupt_read(hid, 0x01, PACKETreceive, SEND_PACKET_LEN,1000);
        if (ret == HID_RET_SUCCESS) {
               strncpy(AttStr,PACKETreceive,SEND_PACKET_LEN);
             for (i=0;AttStr[i+1]!='\0';i++) {
                       AttStr[i]=AttStr[i+1];
                                              }
             AttStr[i]='\0';
           }

   if (ret != HID_RET_SUCCESS) {
      fprintf(stderr, "hid_interrupt_read failed with return code %d\n", ret);   }
}
```

```
void Set_Attenuation (unsigned char **AttValue)
{
        int i;
        char  PACKETreceive[SEND_PACKET_LEN];
        PACKET[0]=19;          // Set Attenuation code is 19.
        PACKET[1]= (int)atoi(AttValue[1]);
        float t1=(float)(atof(AttValue[1]));
        PACKET[2]=  (int) ((t1-PACKET[1])*4);
        ret = hid_interrupt_write(hid, 0x01, PACKET, SEND_PACKET_LEN,1000);
    if (ret != HID_RET_SUCCESS) {
      fprintf(stderr, "hid_interrupt_write failed with return code %d\n", ret);
   }
        ret = hid_interrupt_read(hid, 0x01, PACKETreceive, SEND_PACKET_LEN,1000);
        //  Read packet  Packetreceive[0]=1

       if (ret != HID_RET_SUCCESS) {
       fprintf(stderr, "hid_interrupt_read failed with return code %d\n", ret);   }

}

int main( int argc, unsigned char **argv)
{

  char AttValue[3];
  float LastAtt=0.0;
  usb_dev = device_init();

  if (usb_dev == NULL)
  {
      fprintf(stderr, "Device not found!\n");
      exit(-1);
  }

  if (usb_dev != NULL)
  {
      usb_handle = usb_open(usb_dev);
      int drstatus = usb_get_driver_np(usb_handle, 0, kdname, sizeof(kdname));
      if (kdname != NULL && strlen(kdname) > 0) {
     usb_detach_kernel_driver_np(usb_handle, 0);
      }
  }

  usb_reset(usb_handle);
  usb_close(usb_handle);
  HIDInterfaceMatcher matcher = { VENDOR_ID, PRODUCT_ID, NULL, NULL, 0 };
  ret = hid_init();

  if (ret != HID_RET_SUCCESS) {
    fprintf(stderr, "hid_init failed with return code %d\n", ret);
    return 1;
  }
  hid = hid_new_HIDInterface();
  if (hid == 0) {
    fprintf(stderr, "hid_new_HIDInterface() failed, out of memory?\n");
    return 1;
  }

  ret = hid_force_open(hid, 0, &matcher, 3);
  if (ret != HID_RET_SUCCESS) {
    fprintf(stderr, "hid_force_open failed with return code %d\n", ret);
    return 1;
  }
char  PNreceive[SEND_PACKET_LEN];
char  SNreceive[SEND_PACKET_LEN];

int StrLen1;
```

```
  Get_PN(PNreceive);
  fprintf(stderr," PN=  %s .\n",PNreceive);

  Get_SN(SNreceive);
  fprintf(stderr," SN=  %s .\n",SNreceive);

  Set_Attenuation(argv);  // set attenuation
  ReadAtt ( AttValue);
  LastAtt=(int)(AttValue[0])+(float)(AttValue[1])/4;
  fprintf(stderr," Att=  %f \n",LastAtt);



   ret = hid_close(hid);
   if (ret != HID_RET_SUCCESS) {
     fprintf(stderr, "hid_close failed with return code %d\n", ret);
     return 1;
   }


   hid_delete_HIDInterface(&hid);

   ret = hid_cleanup();
   if (ret != HID_RET_SUCCESS) {
     fprintf(stderr, "hid_cleanup failed with return code %d\n", ret);
     return 1;
   }

   return 0;
}
```

2.2.1 (h) - Programmable Attenuator (Single Device by Serial Number)

RUDAT_BySN2.c is a simple console program to set the attenuation of a specific programmable attenuator, specified by serial number.

The libusb and libhid libraries are required to enable the program to interface with the devices by USB (see USB Control in a Linux Environment).

To compile and run the program:

1. Open the terminal
2. Type “sudo su” in order to get root privilege (necessary for control over USB)
3. Type “gcc RUDAT_BySN2.c -o RUDAT_BySN -lusb -lhid” to compile the code
4. Type “./RUDAT_BySN [serial_number] [attenuation]” in order to run the code (entering the required serial number and attenuation)

```
#include <hid.h>
#include <stdio.h>
#include <string.h>
#include <usb.h>
#define VENDOR_ID  0x20ce   // MiniCircuits Vendor ID
#define PRODUCT_ID 0x0023   // MiniCircuits HID RUDAT Product ID
#define PATHLEN  2
#define SEND_PACKET_LEN 64

 HIDInterface* hid;
 hid_return ret;
 struct usb_device *usb_dev;
 struct usb_dev_handle *usb_handle;
 char buffer[80], kdname[80];

const int PATH_IN[PATHLEN] = { 0x00010005, 0x00010033 };
char  PACKET[SEND_PACKET_LEN];
char  PNreceive[SEND_PACKET_LEN];
char  SNreceive[SEND_PACKET_LEN];

bool match_serial_number(struct usb_dev_handle* usbdev, void* custom, unsigned int len)
{
  bool ret;
  char* buffer = (char*)malloc(len);
  usb_get_string_simple(usbdev, usb_device(usbdev)->descriptor.iSerialNumber,
      buffer, len);
  ret = strncmp(buffer, (char*)custom, len) == 0;
  free(buffer);
  return ret;
}

void Get_PN (char* PNstr)
{
        int i;
        char  PACKETreceive[SEND_PACKET_LEN];
        PACKET[0]=40;  //     PN code
        ret = hid_interrupt_write(hid, 0x01, PACKET, SEND_PACKET_LEN,1000);
       if (ret != HID_RET_SUCCESS) {
              fprintf(stderr, "hid_interrupt_write failed with return code %d\n", ret);
        }
        ret = hid_interrupt_read(hid, 0x01, PACKETreceive, SEND_PACKET_LEN,1000);
        if (ret == HID_RET_SUCCESS) {
             strncpy(PNstr,PACKETreceive,SEND_PACKET_LEN);
             for (i=0;PNstr[i+1]!='\0';i++) {
                      PNstr[i]=PNstr[i+1];
                                              }
             PNstr[i]='\0';
           }
       if (ret != HID_RET_SUCCESS) {
              fprintf(stderr, "hid_interrupt_read failed with return code %d\n", ret);   }
}
```

```
void Get_SN (char* SNstr)
{
       int i;
       char  PACKETreceive[SEND_PACKET_LEN];
       PACKET[0]=41;  //     SN Code
        ret = hid_interrupt_write(hid, 0x01, PACKET, SEND_PACKET_LEN,1000);
       if (ret != HID_RET_SUCCESS) {
              fprintf(stderr, "hid_interrupt_write failed with return code %d\n", ret);
       }
        ret = hid_interrupt_read(hid, 0x01, PACKETreceive, SEND_PACKET_LEN,1000);
        if (ret == HID_RET_SUCCESS) {
              strncpy(SNstr,PACKETreceive,SEND_PACKET_LEN);
            for (i=0;SNstr[i+1]!='\0';i++) {
                      SNstr[i]=SNstr[i+1];
                                              }
            SNstr[i]='\0';
          }
       if (ret != HID_RET_SUCCESS) {
              fprintf(stderr, "hid_interrupt_read failed with return code %d\n", ret);   }


}

void ReadAtt (char* AttStr)
{
       int i;

       char  PACKETreceive[SEND_PACKET_LEN];
       PACKET[0]=18;  //     Ruturn attenuation  code
       ret = hid_interrupt_write(hid, 0x01, PACKET, SEND_PACKET_LEN,1000);
    if (ret != HID_RET_SUCCESS) {
      fprintf(stderr, "hid_interrupt_write failed with return code %d\n", ret);
   }
        ret = hid_interrupt_read(hid, 0x01, PACKETreceive, SEND_PACKET_LEN,1000);
        if (ret == HID_RET_SUCCESS) {
              strncpy(AttStr,PACKETreceive,SEND_PACKET_LEN);
            for (i=0;AttStr[i+1]!='\0';i++) {
                      AttStr[i]=AttStr[i+1];
                                              }
            AttStr[i]='\0';
          }

   if (ret != HID_RET_SUCCESS) {
      fprintf(stderr, "hid_interrupt_read failed with return code %d\n", ret);   }


}

void Set_Attenuation (float AttValue)
{
        int i;
        char  PACKETreceive[SEND_PACKET_LEN];
        PACKET[0]=19;          // for Models: RUDAT-6000-90", RUDAT-6000-60, RUDAT-6000-30
RCDAT-6000-90", RCDAT-6000-60, RCDAT-6000-30  Set Attenuation code is 19.
        PACKET[1]= (int)(AttValue);
        PACKET[2]=  (int) ((AttValue-PACKET[1])*4);
        ret = hid_interrupt_write(hid, 0x01, PACKET, SEND_PACKET_LEN,1000);
    if (ret != HID_RET_SUCCESS) {
      fprintf(stderr, "hid_interrupt_write failed with return code %d\n", ret);
   }
        ret = hid_interrupt_read(hid, 0x01, PACKETreceive, SEND_PACKET_LEN,1000);
        //  Read packet  Packetreceive[0]=1

       if (ret != HID_RET_SUCCESS) {
       fprintf(stderr, "hid_interrupt_read failed with return code %d\n", ret);   }

}
```

```
int  device_init(char * SN1)
{
    struct usb_bus *usb_bus;
    struct usb_device *dev;
    int SNfound ;
    usb_init();

    int n=0;
    usb_find_busses();
    usb_find_devices();
    ret = hid_init();
    if (ret != HID_RET_SUCCESS)
    {
         fprintf(stderr, "hid_init failed with return code %d \n", ret);
         return 1;
    }
    for (usb_bus = usb_busses; usb_bus; usb_bus = usb_bus->next)
    {
        for (dev = usb_bus->devices; dev; dev = dev->next)
        {
            if ((dev->descriptor.idVendor == VENDOR_ID) &&
                (dev->descriptor.idProduct == PRODUCT_ID))
            {
        ////////////////////////////////////////////////////////////////////////
              n++;
              usb_handle = usb_open(dev);
              int drstatus = usb_get_driver_np(usb_handle, 0, kdname, sizeof(kdname));
              if (kdname != NULL && strlen(kdname) > 0)
                 usb_detach_kernel_driver_np(usb_handle, 0);
              usb_reset(usb_handle);
              usb_close(usb_handle);
              HIDInterfaceMatcher matcher = { VENDOR_ID, PRODUCT_ID, NULL, NULL, 0 };
              hid = hid_new_HIDInterface();
              if (hid != 0)
                {
                  ret = hid_force_open(hid, 0, &matcher, 3);
                  if (ret != HID_RET_SUCCESS)
                  {
                    fprintf(stderr, "hid_force_open failed with return code %d\n", ret);
                  }
                  else
                  {
                     Get_SN(SNreceive);
                     SNfound = strcmp (SNreceive,SN1);
                     if (SNfound!=0) hid=NULL; else return 0;
                  }
                }
        ////////////////////////////////////////////////////////////////////////
            }
        }
    }

    return 0;
}
```

```
int main( int argc, unsigned char **argv)
{
   int y=device_init(argv[1]);
   char AttValue1[3],AttValue2[3];
   float LastAtt=0.0;

        //////////////   Query devices
        ////////////////////////////////////////////////////////////////////////


char  RFpower[SEND_PACKET_LEN];
int StrLen1;
float Att1=0.0;

 Att1=(float)(atof(argv[2]));
 Set_Attenuation(Att1);  // set attenuation
 ReadAtt(AttValue1);
 LastAtt=(int)(AttValue1[0])+(float)(AttValue1[1])/4;
 fprintf(stderr," Attenuation=  %f \n",LastAtt);

        ////////////////////////////////////////////////////////////////////////

  ret = hid_close(hid);

  if (ret != HID_RET_SUCCESS) {
    fprintf(stderr, "hid_close failed with return code %d\n", ret);
    return 1;
  }

  hid_delete_HIDInterface(&hid);
  ret = hid_cleanup();
  if (ret != HID_RET_SUCCESS) {
    fprintf(stderr, "hid_cleanup failed with return code %d\n", ret);
    return 1;
  }

  return 0;
}
```

2.2.1 (i) - Programmable Attenuators (Multiple Devices)

RUDAT_2devices.c is a simple console program to set the attenuation of a pair of programmable attenuators. The code can be adapted to control more than 2 devices.

The libusb and libhid libraries are required to enable the program to interface with the devices by USB (see USB Control in a Linux Environment).

To compile and run the program:

1. Open the terminal
2. Type "sudo su" in order to get root privilege (necessary for control over USB)
3. Type "gcc RUDAT_2devices.c -o RUDAT_BySN -lusb -lhid" to compile the code
4. Type "./RUDAT_2devices [attenuation_1] [attenuation_2]" in order to run the code (entering the attenuation values to set for the 2 attenuators)

```
#include <hid.h>
#include <stdio.h>
#include <string.h>
#include <usb.h>

#define VENDOR_ID  0x20ce   // MiniCircuits Vendor ID
#define PRODUCT_ID 0x0023   // MiniCircuits HID RUDAT Product ID
#define PATHLEN  2
#define SEND_PACKET_LEN 64

 HIDInterface* hid1;
 HIDInterface* hid2;

 hid_return ret;
 struct usb_device *usb_dev;
 struct usb_dev_handle *usb_handle;
 char buffer[80], kdname[80];

const int PATH_IN[PATHLEN] = { 0x00010005, 0x00010033 };
char  PACKET[SEND_PACKET_LEN];

bool match_serial_number(struct usb_dev_handle* usbdev, void* custom, unsigned int len)
{
  bool ret;
  char* buffer = (char*)malloc(len);
  usb_get_string_simple(usbdev, usb_device(usbdev)->descriptor.iSerialNumber,
      buffer, len);
  ret = strncmp(buffer, (char*)custom, len) == 0;
  free(buffer);
  return ret;
}
```

```
int  device_init(void)
{
    struct usb_bus *usb_bus;
    struct usb_device *dev;
    usb_init();

    int n=0;
    usb_find_busses();
    usb_find_devices();
    ret = hid_init();
    if (ret != HID_RET_SUCCESS)
    {
         fprintf(stderr, "hid_init failed with return code %d \n", ret);
         return 1;
    }
    for (usb_bus = usb_busses; usb_bus; usb_bus = usb_bus->next)
    {
        for (dev = usb_bus->devices; dev; dev = dev->next)
        {
            if ((dev->descriptor.idVendor == VENDOR_ID) &&
                (dev->descriptor.idProduct == PRODUCT_ID))
            {
        ////////////////////////////////////////////////
              n++;
              usb_handle = usb_open(dev);
              int drstatus = usb_get_driver_np(usb_handle, 0, kdname, sizeof(kdname));
              if (kdname != NULL && strlen(kdname) > 0)
                 usb_detach_kernel_driver_np(usb_handle, 0);
              usb_reset(usb_handle);
              usb_close(usb_handle);
              HIDInterfaceMatcher matcher = { VENDOR_ID, PRODUCT_ID, NULL, NULL, 0 };

              if (n==1)
              {
                hid1 = hid_new_HIDInterface();
                if (hid1 != 0)
                {
                  ret = hid_force_open(hid1, 0, &matcher, 3);
                  if (ret != HID_RET_SUCCESS)
                  {
                    fprintf(stderr, "hid_force_open failed with return code %d\n", ret);
                  }

                }
        ////////////////////////////////////////////////
               }
               else // n=2
               {
                hid2 = hid_new_HIDInterface();
                if (hid2 != 0)
                {
                  ret = hid_force_open(hid2, 0, &matcher, 3);
                  if (ret != HID_RET_SUCCESS)
                  {
                    fprintf(stderr, "hid_force_open failed with return code %d\n", ret);
                  }
        ////////////////////////////////////////////////
                 }
              }
            }
        }
    }
    return 0;
}
```

```
void Get_PN (char* PNstr,HIDInterface* hid)
{
        int i;
        char  PACKETreceive[SEND_PACKET_LEN];
        PACKET[0]=40;  //     PN code
        ret = hid_interrupt_write(hid, 0x01, PACKET, SEND_PACKET_LEN,1000);
       if (ret != HID_RET_SUCCESS) {
              fprintf(stderr, "hid_interrupt_write failed with return code %d\n", ret);
       }
        ret = hid_interrupt_read(hid, 0x01, PACKETreceive, SEND_PACKET_LEN,1000);
        if (ret == HID_RET_SUCCESS) {
             strncpy(PNstr,PACKETreceive,SEND_PACKET_LEN);
             for (i=0;PNstr[i+1]!='\0';i++) {
                      PNstr[i]=PNstr[i+1];
                                             }
             PNstr[i]='\0';
          }
       if (ret != HID_RET_SUCCESS) {
              fprintf(stderr, "hid_interrupt_read failed with return code %d\n", ret);   }
}

void Get_SN (char* SNstr,HIDInterface* hid)
{
       int i;
       char  PACKETreceive[SEND_PACKET_LEN];
       PACKET[0]=41;  //     SN Code
        ret = hid_interrupt_write(hid, 0x01, PACKET, SEND_PACKET_LEN,1000);
       if (ret != HID_RET_SUCCESS) {
              fprintf(stderr, "hid_interrupt_write failed with return code %d\n", ret);
       }
        ret = hid_interrupt_read(hid, 0x01, PACKETreceive, SEND_PACKET_LEN,1000);
        if (ret == HID_RET_SUCCESS) {
              strncpy(SNstr,PACKETreceive,SEND_PACKET_LEN);
            for (i=0;SNstr[i+1]!='\0';i++) {
                      SNstr[i]=SNstr[i+1];
                                             }
            SNstr[i]='\0';
          }
       if (ret != HID_RET_SUCCESS) {
              fprintf(stderr, "hid_interrupt_read failed with return code %d\n", ret);   }
}

void ReadAtt (char* AttStr,HIDInterface* hid)
{
       int i;

       char  PACKETreceive[SEND_PACKET_LEN];
       PACKET[0]=18;  //     Ruturn attenuation  code
       ret = hid_interrupt_write(hid, 0x01, PACKET, SEND_PACKET_LEN,1000);
    if (ret != HID_RET_SUCCESS) {
      fprintf(stderr, "hid_interrupt_write failed with return code %d\n", ret);
   }
        ret = hid_interrupt_read(hid, 0x01, PACKETreceive, SEND_PACKET_LEN,1000);
        if (ret == HID_RET_SUCCESS) {
              strncpy(AttStr,PACKETreceive,SEND_PACKET_LEN);
            for (i=0;AttStr[i+1]!='\0';i++) {
                      AttStr[i]=AttStr[i+1];
                                             }
            AttStr[i]='\0';
          }

   if (ret != HID_RET_SUCCESS) {
      fprintf(stderr, "hid_interrupt_read failed with return code %d\n", ret);   }
}
```

```
void Set_Attenuation (float AttValue,HIDInterface* hid)
{
        int i;
        char  PACKETreceive[SEND_PACKET_LEN];
        PACKET[0]=19;          // Set Attenuation code is 19.
        PACKET[1]= (int)(AttValue);
        PACKET[2]=  (int) ((AttValue-PACKET[1])*4);
        ret = hid_interrupt_write(hid, 0x01, PACKET, SEND_PACKET_LEN,1000);
    if (ret != HID_RET_SUCCESS) {
      fprintf(stderr, "hid_interrupt_write failed with return code %d\n", ret);
   }
        ret = hid_interrupt_read(hid, 0x01, PACKETreceive, SEND_PACKET_LEN,1000);
        //  Read packet  Packetreceive[0]=1

       if (ret != HID_RET_SUCCESS) {
       fprintf(stderr, "hid_interrupt_read failed with return code %d\n", ret);   }
}

int main( int argc, unsigned char **argv)
{
   int y=device_init();
   char AttValue1[3],AttValue2[3];
   float LastAtt=0.0;

char  PNreceive[SEND_PACKET_LEN];
char  SNreceive[SEND_PACKET_LEN];
char  RFpower[SEND_PACKET_LEN];
int StrLen1;
float Att1=0.0;
float Att2=0.0;

 Get_PN(PNreceive,hid1);
 fprintf(stderr," PN1=  %s .\n",PNreceive);
 Get_PN(PNreceive,hid2);
 fprintf(stderr," PN2=  %s .\n",PNreceive);

 Get_SN(SNreceive,hid1);
 fprintf(stderr," SN1=  %s .\n",SNreceive);

 Get_SN(SNreceive,hid2);
 fprintf(stderr," SN2=  %s .\n",SNreceive);

 Att1=(float)(atof(argv[1]));
 Set_Attenuation(Att1,hid1);  // set attenuation
 ReadAtt(AttValue1,hid1);
 LastAtt=(int)(AttValue1[0])+(float)(AttValue1[1])/4;
 fprintf(stderr," Attenuation1=  %f \n",LastAtt);

 Att2=(float)(atof(argv[2]));
 Set_Attenuation(Att2,hid2);  // set attenuation
 ReadAtt(AttValue2,hid2);
 LastAtt=(int)(AttValue2[0])+(float)(AttValue2[1])/4;
 fprintf(stderr," Attenuation2=  %f \n",LastAtt);

  ret = hid_close(hid1);
  ret = hid_close(hid2);

  if (ret != HID_RET_SUCCESS) {
    fprintf(stderr, "hid_close failed with return code %d\n", ret);
    return 1;
  }

  hid_delete_HIDInterface(&hid1);
  hid_delete_HIDInterface(&hid2);
  ret = hid_cleanup();
  if (ret != HID_RET_SUCCESS) {
    fprintf(stderr, "hid_cleanup failed with return code %d\n", ret);
    return 1;
  }

  return 0;
}
```

2.2.2 - Ethernet Control in a Linux Environment

These examples demonstrate sending commands to Mini-Circuits' test equipment products over a TCP/IP network from an application running on a Linux operating system.

2.2.2 (a) - FCPM Integrated Frequency Counter & Power Meters

```
#include <iostream>
#include <ctype.h>
#include <cstring>
#include <stdlib.h>
#include <sys/types.h>
#include <sys/socket.h>
#include <netdb.h>
#include <netinet/in.h>
#include <unistd.h>
#include <sstream>
#include <fstream>
#include <string>

using namespace std;

int sock;
struct sockaddr_in client;
int PORT = 80;

int main(int argc, char const *argv[])
{
    struct hostent * host = gethostbyname("10.0.5.52");   // IP address of device

    if ( (host == NULL) || (host->h_addr == NULL) ) {
        cout << "Error retrieving DNS information." << endl;
        exit(1);
    }

    bzero(&client, sizeof(client));
    client.sin_family = AF_INET;
    client.sin_port = htons( PORT );
    memcpy(&client.sin_addr, host->h_addr, host->h_length);

    sock = socket(AF_INET, SOCK_STREAM, 0);

    if (sock < 0) {
        cout << "Error creating socket." << endl;
        exit(1);
    }

    if ( connect(sock, (struct sockaddr *)&client, sizeof(client)) < 0 ) {
        close(sock);
        cout << "Could not connect" << endl;
        exit(1);
    }
```

```
    stringstream FreqStr;
    // Reading Freq
    FreqStr << "GET /:FREQ?" << "\r\n"
       << "Host: 10.0.5.52\r\n"
       << "\r\n\r\n";
    string Frequest = FreqStr.str();

    if (send(sock, Frequest.c_str(), Frequest.length(), 0) != (int)Frequest.length()) {
        cout << "Error sending request." << endl;
        exit(1);
    }
// For Ubuntu : need to send twice , otherwise stuck
    if (send(sock, Frequest.c_str(), Frequest.length(), 0) != (int)Frequest.length()) {
        cout << "Error sending request." << endl;
        exit(1);
    }

    char Freq;
    int TTT=0;
    while ( read(sock, &Freq, 1) > 0  && TTT<100 ) {
        cout << Freq;++TTT;
    }
close(sock);


sock = socket(AF_INET, SOCK_STREAM, 0);
if ( connect(sock, (struct sockaddr *)&client, sizeof(client)) < 0 ) {
        close(sock);
        cout << "Could not connect" << endl;
        exit(1);
    }

    // Reading Power
       stringstream PwrStr;
    PwrStr << "GET /:POWER?" << "\r\n"
       << "Host: 10.0.5.52\r\n"
       << "\r\n\r\n";
     string Prequest = PwrStr.str();

    if (send(sock, Prequest.c_str(), Prequest.length(), 0) != (int)Prequest.length()) {
        cout << "Error sending request." << endl;
        exit(1);
    }
// For Ubuntu : need to send twice , otherwise stuck
     if (send(sock, Prequest.c_str(), Prequest.length(), 0) != (int)Prequest.length()) {
        cout << "Error sending request." << endl;
        exit(1);
    }

    TTT=0;
    char Pwr;

  while ( read(sock, &Pwr, 1) > 0  && TTT<100 ) {
        cout << Pwr;++TTT;
    }

close(sock);
    return 0;
}
```

2.3 - Visual Basic (VB) Programming

2.3.1 - USB Control Using the ActiveX DLL

These examples demonstrate control of Mini-Circuits' PTE products using Visual Basic in the following environment:

1. Host computer running a Windows operating system
2. PTE connected by the USB interface
3. Mini-Circuits ActiveX DLL installed and registered on the computer

2.3.1 (a) - Synthesized Signal Generator

Set the RF output of the generator.

```
' mcl gen.dll should be loaded as a reference file to the project

Dim MyGen As New MCL_Gen.USB_Gen

MyGen.Connect

x = MyGen.SetFreqAndPower(1000, -5, 0)
MyGen.SetPowerON

MyGen.Disconnect
```

2.3.1 (b) - Power Sensor

Set the calibration frequency of the power sensor and read the power.

```
' mcl pm.dll should be loaded as a reference file to the project

Dim pm1 As New mcl_pm.usb_pm, Status As Short

Dim SN As String = ""           ' Serial Number needed if more than 1 sensor connected
Dim ReadResult As Single

Status = pm1.Open_Sensor(SN)    ' Open connection
pm1.Freq = 3000                 ' Set the Frequency cal factor in MHz
ReadResult = pm1.ReadPower()    ' Read the power in dbm
pm1.Close_Sensor()              ' Close connection
```

2.3.1 (c) - Frequency Counter

Read the frequency measurement.

```
' mcl_freqcounter.dll should be loaded as a reference file to the project

Dim FCTR As New MCL_FreqCounter.USB_FreqCounter,Status as integer
dim Freq as double

Status=FCTR.Connect
Status = FCTR.ReadFreq(Freq)

FCTR.Disconnect
```

2.3.1 (d) - Input/Output (IO) Control Boxes

Set the I/O Control Box relay output.

```
' mcl usb to io.dll should be loaded as a reference file to the project

Dim IO1 As New mcl_USB_To_IO.USB_IO,Status as integer

Status=IO1.Connect
Status = IO1.Set_Relay(5,1) ' Set Relay5 ON

IO1.Disconnect
```

2.3.1 (e) - USB & RS232 to SPI Converters

Send SPI data from the USB port.

```
' mcl_usb_rs232_to_spi.dll should be loaded as a reference file to the project

Dim SPI1 As New MCL_RS232_USB_To_SPI.USB_To_SPI
Dim ReceivedData as double, DataToSend as double
Dim x as integer

x = SPI1.Connect                              ' Open the connection

' Send the value 56 in 8 bits and read 8 bits from SPI
DataToSend = 56
ReceivedData = SPI1.Send_Receive_SPI(8, DataToSend, 1, 0)

SPI1.Disconnect                               ' Close the connection
```

2.3.1 (f) - Programmable Attenuators

Set and read the attenuation level:

```
' mcl rudat.dll should be loaded as a reference file to the project

Dim att1 As New mcl_RUDAT.USB_DAT, Status As Short

Dim SN As String = ""                 ' Serial Number needed for multiple attenuators
Dim Attenuation As Single = 0

Status = att1.Connect(SN)             ' Open connection

att1.SetAttenuation(37)               ' Set attenuation
att1.Read_Att(Attenuation)            ' Read attenuation

att1.Disconnect()                     ' Close connection
```

Configure an attenuation sweep by sending commands individually to the attenuator:

```
Dim myRUDAT As New mcl_RUDAT.USB_DAT, Status As Short

'Create a loop to send each attenuation command to the attenuator one at a time
'Min dwell time limited by USB communication delays (typically ~1-10 ms each time)
'Timing for dwell time between each command needs to be handled by user program

myRUDAT.Connect        ' Connect to the attenuator (pass a serial number if you like)

Dim StartAttenuation As Integer= 0
Dim StopAttenuation As Integer= 90
Dim AttenuationStep As Single = 0.25
Dim DwellTime_ms As Integer = 100                          ' Dwell time in milliseconds

For Attenuation = StartAttenuation To StopAttenuation    ' Loop from start to stop

    Call myRUDAT.SetAttenuation(Attenuation)               ' Set the next attenuation

    'Wait for dwell time before moving on (timing handled the user's program)
    Call Delay_Loop(100)                                   ' Timing function

Next Attenuation                              ' Keep looping until stop attenuation

myRUDAT.Disconnect                                         ' Disconnect attenuator
```

Configure an attenuation sweep by programming the parameters into the attenuator's memory (allows faster sequences as the USB communication delay between steps is removed):

```
Dim myRUDAT As New mcl_RUDAT.USB_DAT, Status As Short

'Sends the parameters to the attenuator (start, stop, step attenuation and dwell time)
'Send the command to start the sweep
'All further actions and timing are managed internally by the attenuator itself
'Minimum dwell time in the order of us as USB delay removed between each command

myRUDAT.Connect        ' Connect to the attenuator (pass a serial number if you like)

Dim StartAttenuation As Integer= 0
Dim StopAttenuation As Integer= 90
Dim AttenuationStep As Single = 0.25
Dim DwellTime_us As Integer = 100                          ' Dwell time in microseconds

Call myRUDAT.Sweep_SetStartAtt(StartAttenuation)           ' Set start attenuation
Call myRUDAT.Sweep_SetStopAtt(StopAttenuation)             ' Set stop attenuation
Call myRUDAT.Sweep_SetStepSize(AttenuationStep)            ' Set attenuation step size
Call myRUDAT.Sweep_SetDwell(DwellTime_us, 117)             ' Set dwell time in microseconds

Call myRUDAT.Sweep_SetMode(1)                              ' Start the sweep

'Sweep will continue to run until interrupted
```

2.3.1 (g) - Switch Boxes

Identify connected switches, set and read switch states.

```
Public objSwitch1 As New MCL_RF_Switch_Controller.USB_RF_Switch
    'Instantiate new switch object, assign to variable objSwitch1


Private Sub ConnectSwitchBox()

'Look for any connected switch matrices and connects to the first one found
'Note: -Not strictly necessary here as Connect with no argument will achieve the same
'      -Demonstrates the concept if there is a need to identify a specific switch

    Dim st_SN_List As String
    Dim array_SN() As String
    Dim intStatus As Integer

    'Find any connected serial numbers
    If objSwitch1.Get_Available_SN_List(st_SN_List) > 0 Then
        'Get list of available SNs
        array_SN() = Split(st_SN_List, " ")
        'Split the list into an array of serial numbers
    End If

    intStatus = objSwitch1.Connect(array_SN(0))
        'Creates connection to the first switch matrix found above

End Sub


Private Sub DisconnectSwitch()

'Close the connection to the switch matrix
'This is recommended before terminating the programme

    Call objSwitch1.Disconnect

End Sub


Private Sub ReportSwitchCondition()

'Report the model name, serial number and current temperature

    Dim stModel As String
    Dim stSerial As String

    If objSwitch1.Read_ModelName(stModel) > 0 And objSwitch1.Read_SN(stSerial) > 0 Then
        MsgBox ("The connected switch is " & stModel & ", serial number " & stSerial & ".")
        'Display a message with the part number and serial number
    End If

    MsgBox ("Device temperature is " & objSwitch1.GetDeviceTemperature(1))
    'Display a message box with the device temperature

    If objSwitch1.GetHeatAlarm > 0 Then
        MsgBox ("Device temperature has exceeded specified limit")
        'Display a warning message
    End If

End Sub
```

```
Private Sub SetSwitchState(stSwitch as String, intState as Integer)

'The user specifies the switch, A to H (model dependent), and the state (0 or 1)

    Dim intStatus As Integer

    If Len(stSwitch) > 1 Or Asc(stSwitch) < 65 Or Asc (stSwitch) > 72 Then
        'Check specified switch is one character with ASCII value between 65 and 72 (A to H)
        MsgBox ("Invalid switch specified.")
        Exit Sub
    End If
    If intState > 1 Then
        'Check specified switch state is 0 or 1
        MsgBox ("Invalid switch state specified.")
        Exit Sub
    End If

    intStatus = objSwitch1.Set_Switch(stSwitch, intState)

    If intStatus = 0 Then
        MsgBox ("Unable to communicate with switch box.")
    Else
    If intStatus = 2 Then
        MsgBox ("Switching did not complete.  The 24V DC supply is disconnected.")
    Else
        'Switching completed successfully
    End If
    End If

End Sub


Private Sub GetSwitchState()

'Get the switch status and interpret the decimal value as a series of binary bits

    Dim intState As Integer
    Dim intSwitchState(8) As Integer
    Dim intBit As Integer

    intBit = 7      'Assume 8 switches (0 to 7)

    If objSwitch1.GetSwitchesStatus(intState) = 1 Then  'Communication successful

        'Loop bit by bit to calculate each switch state, starting at MSB
        Do Until intBit + 1 = 0

            If intState / (2 ^ (intBit)) >= 1 Then
                    'If >0 then the binary bit is 1 (the remainder is for LSBs)
                intSwitchState(intBit) = 1
                    'Store the switch state in the array of switch states
                intState = intState - (2 ^ (intBit))
                    'Remove this bit value from the equation for the next bit
            End If

            Select Case intSwitchState(intBit)
                    'Report the switch state in plain English
            Case 0
                MsgBox "Switch " & Chr(intBit + 65) & " is set Com to Port 1"
            Case 1
                MsgBox "Switch " & Chr(intBit + 65) & " is set Com to Port 2"
            End Select
            'The Chr function converts an ASCII code to the text character
            'The +65 offset brings 0 to 7 in line with the ASCII codes for A to H

            intBit = intBit - 1       'Decrement the bit number and keep looping
        Loop

    Else
        MsgBox ("Unable to communicate with switch box")
    End If

End Sub
```

2.3.2 - Ethernet Broadcast Using UDP

Mini-Circuits' PTE devices support UDP (Universal Datagram Protocol) for the purposes of device discovery (identifying any Mini-Circuits devices connected on the network) and disabling a pulsed output in the case of the signal generator.

2.3.2 (a) - Identifying Connected Devices on the Network

Each product family within Mini-Circuits' PTE range has an identification command that can be sent to the broadcast IP address using UDP on port 4950. The command is detailed in the respective programming manuals. Any relevant connected PTE devices will respond on port 4951.

The below example summarises the process of searching for any connected Mini-Circuits programmable attenuators on the network. The only details to change from one system to another are the IP address and subnet mask of the sending PC / server and the broadcast command for the particular PTE family to be searched.

```
Imports System.Net.Sockets
Imports System.Threading
Imports System.Net
Imports System.Text
Imports System.Text.RegularExpressions

Public Class Form1

    Private receivingClient As UdpClient ' Client for handling incoming data
    Private sendingClient As UdpClient   ' Client for sending data
    Private receivingThread As Thread    ' Create a separate thread to listen for incoming data
    Private Run_Receiver As Boolean = False ' Allows the receiver thread to be closed when required
    Private All_Responses As String = "" ' String to store the responses


    Private Sub UDP_Listener()
        On Error GoTo err_Receiver

        ' Listen for incoming data from any IP address on port 4951
        Dim endPoint As IPEndPoint = New IPEndPoint(IPAddress.Any, 4951)
        ' Loop long enough to receive all responses (Run_Receiver is set in Broadcast_UDP_Request)
        Do While (Run_Receiver = True)
            Dim data() As Byte = receivingClient.Receive(endPoint)      ' Receive incoming bytes
            ' Record the returns
            All_Responses = All_Responses & "/" & Encoding.ASCII.GetString(data)
        Loop

        receivingClient.Close()                                         ' Close the UDP client

exit_Receiver:
        receivingClient = Nothing
        receivingThread = Nothing
        Exit Sub

err_Receiver:
        MsgBox(Err.Description)
        Resume exit_Receiver
    End Sub


    Private Sub cmdAll_Click(sender As Object, e As EventArgs) Handles cmdAll.Click

        Call Broadcast_UDP_Request("MCLDAT?")

    End Sub
```

```
    Private Sub Broadcast_UDP_Request(toSend As String)
        On Error GoTo err_Broadcast_UDP_Request
        ' Create a UDP client to send the broadcast packet on port 4950
        ' Create a second UDP client to listen for responses on port 4951
        ' Requires: String to send (eg: "MCL_SSG?" to find signal generators)
        Dim LocalIPAddress As String = "192.168.9.53"       ' IP address of the local PC
        Dim LocalSubnetMask As String = "255.255.255.0"
        Dim IPByte() As String = Split(LocalIPAddress, ".")
        Dim SubnetByte() As String = Split(LocalSubnetMask, ".")
        Dim BroadcastIPByte(4) As Integer
        Dim x, y As Integer

        For i = 0 To 3 ' Get the broadcast IP (bitwise OR of IP and subnet mask's bit-complement )
            x = IPByte(i)
            y = 255 - SubnetByte(i)
            BroadcastIPByte(i) = x Or y
        Next
        Dim BroadcastIPAddress As String = BroadcastIPByte(0) & "." & BroadcastIPByte(1) & "." &
BroadcastIPByte(2) & "." & BroadcastIPByte(3)

        sendingClient = New UdpClient(BroadcastIPAddress, 4950) ' Set up the sending UDP client
        sendingClient.EnableBroadcast = True
        Dim data() As Byte = Encoding.ASCII.GetBytes(toSend)    'Convert string to bytes

        Run_Receiver = True ' Initialise the listening UDP client
        receivingClient = New UdpClient(4951)
        Dim start As ThreadStart = New ThreadStart(AddressOf UDP_Listener)
        receivingThread = New Thread(start)         'Start in new thread so it can run in parallel
        receivingThread.IsBackground = True
        receivingThread.Start()

        ' Send the data, then close the sending client
        sendingClient.Send(data, data.Length)
        sendingClient.Close()

        ' Allow 500ms to receive responses (the receiver is still running in the background)
        Threading.Thread.Sleep(500)
        Run_Receiver = False                ' Indicate that the receiver loop can close

        ' Use the returned information in All_Responses, eg: Use reg-ex to grab the key details
        If All_Responses.Length > 0 Then

            Dim Model_Array() As String = Split(All_Responses, "/") ' Create array element / device
            Dim Model_Details(Model_Array.Length - 1, 3) As String  ' Create array for the details

            For i = 0 To Model_Array.Length - 2
                ' Look for "Model Name:", space char, a group of letters/numbers/hyphens
                Model_Details(i, 0) = Regex.Match(Model_Array(i + 1), "Model Name:\s([A-Z0-
9\-]+)").Groups(1).Value
                ' Look for "Serial Number:", space char, a group of numbers
                Model_Details(i, 1) = Regex.Match(Model_Array(i + 1), "Serial
Number:\s(\d+)").Groups(1).Value
                ' Look for "IP Address=", a group of letters/numbers/decimal points
                Model_Details(i, 2) = Regex.Match(Model_Array(i + 1), "IP Address=([0-
9\.]+)").Groups(1).Value
                MsgBox("MN: " & Model_Details(i, 0) & " / SN: " & Model_Details(i, 1) & " / IP: " &
Model_Details(i, 2))
            Next

        Else
            MsgBox("No devices found on the network.")
        End If

exit_Broadcast_UDP_Request:
        sendingClient = Nothing
        Exit Sub
err_Broadcast_UDP_Request:
        MsgBox(Err.Description)
        Resume exit_Broadcast_UDP_Request
    End Sub

End Class
```

2.3.2 (b) - Cancelling Signal Generator Pulsed Output

When a pulsed output is configured on the signal generator with communication over Ethernet (HTTP/Telnet) there is no direct command to disable the output. Instead, UDP magic packet must be sent to the signal generator's IP address on port

The Magic Packet is made up of 6 bytes of decimal 255 (hex FF) followed by 16 repetitions of the signal generator's MAC address (1 byte per hex octet). The signal generator listens for UDP data on port 4950 and responds on port 4951.

An example of creating ans sending the magic packet is shown below.

```
Private Sub Send_Magic_Packet()
  On Error GoTo err_Send_Magic_Packet

  ' Send a UDP Magic Packet to turn off the generator when pulsed output enabled
  ' Note: the generator will not accept HTTP/Telnet commands in this mode

  ' The generator's MAC and IP addresses are required
  Dim GenIPAddress As String = "192.168.9.59"
  Dim GenMacAddress As String = "D0-73-7F-86-5C-2B"
  Dim MacByte() As String = Split(GenMacAddress, "-")
  Dim intCounter As Integer = 0
  Dim sendBytes(0 To 101) As Byte

  ' Create the first 6 bytes of the magic packet (all decimal 255/hex FF)
  For i = 1 To 6
    sendBytes(intCounter) = &HFF
    intCounter += 1
  Next

  ' Create rest of packet, 16 repetitions of the MAC address (byte per octet)
  For i = 1 To 16
    For J = 0 To 5
      sendBytes(intCounter) = Byte.Parse(MacByte(J), Globalization.NumberStyles.HexNumber)
      intCounter += 1
    Next
  Next

  Dim BCIP As System.Net.IPAddress
  Dim EP As System.Net.IPEndPoint
  Dim UDP As New System.Net.Sockets.UdpClient

  ' Send to the generator's IP address
  BCIP = System.Net.IPAddress.Parse(GenIPAddress)
  ' Create the IP end point (the generator listens on port 4950)
  EP = New System.Net.IPEndPoint(BCIP, 4950)
  ' Send the magic packet
  UDP.Send(sendBytes, sendBytes.Length, EP)
  UDP.Close()

  MsgBox("Generator output should be disabled." & vbCrLf & vbCrLf & _
              "Note: UDP does not offer guarantee of delivery.", , "Magic Packet Sent")

exit_Send_Magic_Packet:
  UDP = Nothing
  Exit Sub

err_Send_Magic_Packet:
  MsgBox(Err.Description)
  Resume exit Send Magic Packet
End Sub
```

2.3.3 - RS232 Control

These examples demonstrate control of Mini-Circuits' PTE products using Visual Basic in the following environment:

1. Host computer running a Windows operating system
2. PTE connected by the RS232 serial interface

2.3.3 (a) - Programmable Attenuators

Read model name and serial number.

```
Private Sub OpenRS232Port(PortNo As Integer)
On Error GoTo err1
'Set MSComm1 = CreateObject("MSCommLib.MsComm")
If MSComm1.PortOpen Then MSComm1.PortOpen = False
 MSComm1.CommPort = PortNo ' 1
    ' 9600 baud, N parity, 8 data, and 1 stop bit.
    MSComm1.Settings = "9600,N,8,1"
    MSComm1.InputLen = 1
    MSComm1.PortOpen = True
    Exit Sub
err1:
' MsgBox Error$, vbCritical
 Exit Sub
End Sub


Private Sub ReadModel_SN_RS232()
' Read Model Name and SN
On Error GoTo err1
 Dim Instring As String
 Dim str1$, model$, SN$
    str1$ = "M"
    MSComm1.Output = str1$ & Chr$(13)
    model$ = ""
    Instring = MSComm1.Input
    j = 0
    While Instring <> Chr$(13) And j < 10000
     If Len(Instring) > 0 Then If Asc(Instring) <> 10 Then model$ = model$ & Instring
    Instring = MSComm1.Input
    j = j + 1
    Wend

   While MSComm1.Input <> "": Wend  ' empty buffer

    str1$ = "S"
    MSComm1.Output = str1$ & Chr$(13)
    SN$ = ""
    Instring = MSComm1.Input
    j = 0
    While Instring <> Chr$(13) And j < 10000
    If Len(Instring) > 0 Then If Asc(Instring) <> 10 Then SN$ = SN$ & Instring
    Instring = MSComm1.Input
    j = j + 1
    Wend


   While MSComm1.Input <> "": Wend  ' empty buffer

 Exit Sub
err1:
 Exit Sub
End Sub
```

2.3.3 (b) - RS232 to SPI Converters

Read model name/serial number and send SPI data.

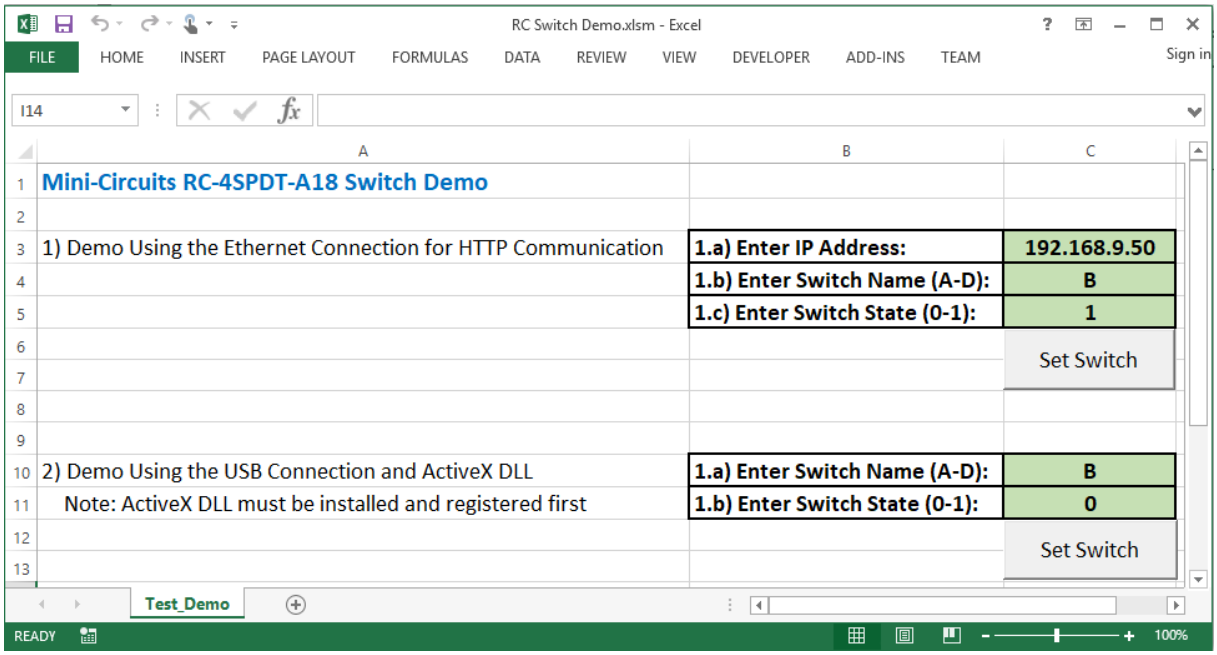
```
Private Sub OpenRS232Port(PortNo As Integer)
On Error GoTo err1
'Set MSComm1 = CreateObject("MSCommLib.MsComm")
If MSComm1.PortOpen Then MSComm1.PortOpen = False
 MSComm1.CommPort = PortNo ' 1
    ' 9600 baud, E parity, 8 data, and 1 stop bit.
    MSComm1.Settings = "9600,E,8,1"
    MSComm1.InputLen = 1
    MSComm1.PortOpen = True
    Exit Sub
err1:
' MsgBox Error$, vbCritical
 Exit Sub
End Sub


Private Sub ReadModel_SN_RS232()
' Read Model Name and SN
On Error GoTo err1
 Dim Instring As String
 Dim str1$, model$, SN$
    str1$ = "M"
    MSComm1.Output = str1$ & Chr$(13)
    model$ = ""
    Instring = MSComm1.Input
    j = 0
    While Instring <> Chr$(13) And j < 10000
     If Len(Instring) > 0 Then If Asc(Instring) <> 10 Then model$ = model$ & Instring
    Instring = MSComm1.Input
    j = j + 1
    Wend

   While MSComm1.Input <> "": Wend  ' empty buffer

    str1$ = "S"
    MSComm1.Output = str1$ & Chr$(13)
    SN$ = ""
    Instring = MSComm1.Input
    j = 0
    While Instring <> Chr$(13) And j < 10000
    If Len(Instring) > 0 Then If Asc(Instring) <> 10 Then SN$ = SN$ & Instring
    Instring = MSComm1.Input
    j = j + 1
    Wend


   While MSComm1.Input <> "": Wend  ' empty buffer

 Exit Sub
err1:
 Exit Sub
End Sub
```

```
Private Sub SendSPI_RS232()
On Error GoTo err1
   Dim Instring As String
    Dim SPI_STR as string
    SPI_STR="10110111"
    While MSComm1.Input <> "": Wend  ' clean buffer
    str1$ = "B" & SPI_STR & "E"
    MSComm1.Output = str1$ & Chr$(13)
   ' str11$ = MSComm1.Input
    Ret$ = ""
    Instring = MSComm1.Input
    j = 0
    While Instring <> Chr$(13) And j < 100000
   ' Ret$ = Ret$ & Instring
    If Len(Instring) > 0 Then If Asc(Instring) <> 10 Then Ret$ = Ret$ & Instring
    Instring = MSComm1.Input
    j = j + 1
    Wend
  ' If Ret$ = "ACK" Then OK else Fail

       Exit Sub
err1:
Shape1.BackColor = vbRed
       Exit Sub

End Sub
```

2.3.4 - Visual Basic for Applications (VBA) in Microsoft Excel

Microsoft Excel (in common with most of the Microsoft Office suite) includes the VBA (Visual Basic for Applications) programming environment. VBA supports HTTP and ActiveX so programs can be written within Microsoft Excel for control of Mini-Circuits' test equipment by USB or Ethernet, in conjunction with Excel's standard spreadsheet capabilities (so the program can read inputs from the spreadsheet and write data to it).

In the USB and Ethernet examples which follow, the code is attached to a worksheet within the Excel document which looks like this:



2.3.4 (a) - USB Control Using the ActiveX DLL

The following simple example shows how to communicate with Mini-Circuits' mechanical switch boxes using the USB connection, from within Excel / VBA. The same process can be applied to all other USB controlled test equipment from Mini-Circuits, by substituting the correct DLL and functions.

```
Option Explicit

Private Sub cmd_Start_USB_Click()
On Error GoTo err cmd Start USB Click

' Test USB communication using the ActiveX DLL
' Note: mcl_rf_switch_controller.dll (ActiveX DLL) must be placed in the \Windows\SysWOW64\
  folder and registered using regsvr32
' Note: It may be necessary to reset the reference to the DLL from this project when
  running on a different PC

    Dim sw As New MCL_RF_Switch_Controller.USB_RF_Switch
        ' Reference the switch DLL for USB control

    Dim sw name As String
    Dim sw state As String
    Dim int state As Integer
    Dim sw_serial_no As String
    Dim sw_model_name As String

    sw_name = Range("C10").Value        ' Get the switch name from the spreadsheet
    sw_state = Range("C11").Value       ' Get the switch state to set from the spreadsheet
    int_state = sw_state

    If sw.Connect = 1 Then              ' Connect returns 1 on succesful connection

        Call sw.Set_Switch(sw_name, int_state)      ' Set switch based on spreadsheet
        Call sw.Read_ModelName(sw_model_name)       ' Read model name
        Call sw.Read_SN(sw_serial_no)               ' Read serial number

        MsgBox "Switch " & sw_model_name & ", serial # " & sw_serial_no & " set."

        Call sw.Disconnect

    Else
        MsgBox "Could not connect to switch"
    End If

exit_cmd_Start_USB_Click:
    Set sw = Nothing
    Exit Sub

err_cmd_Start_USB_Click:
    MsgBox Err.Description
    Resume exit_cmd_Start_USB_Click
End Sub
```

2.3.4 (b) - Ethernet Control Using HTTP

The following simple example shows how to communicate with Mini-Circuits' mechanical switch boxes using the Ethernet connection, from within Excel / VBA. The same process can be applied to all other Ethernet controlled test equipment from Mini-Circuits, by substituting the correct DLL and functions.

```
Option Explicit

Public Function Get_HTTP_Response(PTE_IP_Address As String, Command_To_Send As String)
On Error GoTo err Get HTTP Response

    ' Create a function to send an HTTP Get request and return the response

    Dim HTTP_Server As New MSXML2.ServerXMLHTTP60

    HTTP_Server.Open "GET", "http://" & PTE_IP_Address & "/" & Command_To_Send, False
    HTTP_Server.SetRequestHeader "User-Agent", "Mozilla/4.0 (compatible; MSIE 6.0; Windows
NT 5.0)"
    HTTP_Server.Send ("")

    Get_HTTP_Response = Trim(HTTP_Server.ResponseText) & ""

exit_Get_HTTP_Response:
    Set HTTP_Server = Nothing
    Exit Function

err_Get_HTTP_Response:
    MsgBox Err.Number & Err.Description
    Resume exit Get HTTP Response
End Function

Private Sub cmd_Start_HTTP_Click()
On Error GoTo err cmd Start HTTP Click

' Test HTTP communication over the Ethernet connection

    Dim sw_IP_address As String
    Dim sw_name As String
    Dim sw state As String
    Dim sw serial no As String
    Dim sw_model_name As String

    sw_IP_address = Range("C3").Value    ' Get the IP address from the spreadsheet
    sw_name = Range("C4").Value          ' Get the switch name from the spreadsheet
    sw_state = Range("C5").Value         ' Get the switch state to set from the spreadsheet

    If Get_HTTP_Response(sw_IP_address, "SET" & sw_name & "=" & sw_state) = 1 Then
        ' Set switch based on parameters in the spreadsheet

        sw_serial_no = Replace(Get_HTTP_Response(sw_IP_address, "SN?"), "SN=", "")
               ' Get serial number
        sw_model_name = Replace(Get_HTTP_Response(sw_IP_address, "MN?"), "MN=", "")
               ' Get model name

        MsgBox "Switch " & sw_model_name & ", serial # " & sw_serial_no & " set."

    Else
        MsgBox "Could not set switch"
    End If

exit_cmd_Start_HTTP_Click:
    Exit Sub

err_cmd_Start_HTTP_Click:
    MsgBox Err.Description
    Resume exit_cmd_Start_HTTP_Click
End Sub
```

2.4 - C++ Programming

2.4.1 - USB Control Using the ActiveX DLL

These examples demonstrate control of Mini-Circuits' PTE products using C++ in the following environment:

1. Host computer running a Windows operating system
2. PTE connected by the USB interface
3. Mini-Circuits ActiveX DLL installed and registered on the computer

2.4.1 (a) - Power Sensors

Set calibration frequency and read power.

```
// mcl_pm.dll should be loaded as a reference file to the project

mcl_pm::USB_PM ^pm1 = gcnew mcl_pm::USB_PM();

short Status = 0;
System::String ^SN = "";        // Serial Number needed if more than 1 sensor connected
float ReadResult = 0;

Status = pm1->Open_Sensor(SN);  // Open a connection
pm1->Freq = 3000;               // Set the Frequency cal factor in MHz
ReadResult = pm1->ReadPower();  // Read the power in dbm
pm1->Close_Sensor();            // Close the connection
```

2.4.1 (b) - Synthesized Signal Generators

Set a pre-defined RF output.

```
// mcl gen.dll should be loaded as a reference file to the project

mcl_Gen::USB_Gen ^MyGen = gcnew mcl_Gen::USB_Gen();

short Status = 0;
System::String ^SN = "";

Status = Gen1->Connect(SN);

Gen1->SetFreqAndPower(1000,-5,0);

Gen1->Disconnect();
```

2.4.1 (c) - Frequency Counter

Read the frequency measurement.

```
// mcl_freqcounter.dll should be loaded as a reference file to the project

MCL_FreqCounter::USB_FreqCounter ^FCTR = gcnew MCL_FreqCounter::USB_FreqCounter();

short Status = 0;
double Freq;
System::String ^SN = "";

Status = FCTR->Connect(SN);
Status = FCTR->ReadFreq(Freq);

FCTR->Disconnect();
```

2.4.1 (d) - Input/Output (IO) Control Boxes

Set the relay output.

```
// mcl usb to io.dll should be loaded as a reference file to the project

mcl_USB_To_IO::USB_IO ^IO1 = gcnew mcl_USB_To_IO::USB_IO();

short Status = 0;
System::String ^SN = "";

Status = IO1->Connect(SN);
Status = IO1->Set_Relay(5,0); 'Set Relay5 OFF

IO1->Disconnect();
```

2.4.1 (e) - RS232 & USB to SPI Converters

Send SPI data from the USB port.

```
// mcl usb rs232 to spi.dll should be loaded as a reference file to the project

MCL_RS232_USB_To_SPI.USB_To_SPI SPI1 = new MCL_RS232_USB_To_SPI.USB_To_SPI();

double DataToSend = 0;
double ReceivedData = 0;

short x = 0;

SPI1->Connect;                              // Open connection

// Send the value 56 in 8 bits and read 8 bits from SPI
DataToSend = 56;
ReceivedData = SPI1->Send_Receive_SPI(8, DataToSend, 1, 0);

SPI1->Disconnect();                         // Close the connection
```

2.4.1 (f) - Solid-State Switches (C++ MFC)

This example demonstrated the technique for control in Visual Studio 6 (MFC),

```
HRESULT hresult;
CLSID clsid;

CoInitialize(NULL);      //initialize COM library
hresult=CLSIDFromProgID(OLESTR("MCL_SolidStateSwitch.USB_Control"), &clsid);    //retrieve CLSID of
component

_USB_Control *SW1;
hresult=CoCreateInstance(clsid,NULL,CLSCTX_INPROC_SERVER,__uuidof(_USB_Control),(LPVOID *) &SW1);
if(FAILED(hresult))
{
        AfxMessageBox("Creation Failed");
        return;
}
CString P1,VAL1;
BSTR USBlist = ::SysAllocString(L"SolidState");
SW1->Get_Available_SN_List (&USBlist);
_bstr_t SN1 =USBlist;
// if more then 1 power  meter then this string include all available S/N , separated  by space
SW1->Connect (SN1);  //call method

GetDlgItemText(IDC_EDIT1,P1);


short swp= atoi(P1);

SW1->Set_SP4T_COM_To(swp);
SW1->Disconnect ();  // close sensor
CoUninitialize();  //Unintialize the COM library
```

2.4.1 (g) - Custom ZT Switch Assemblies

The below example is a simple console application using the ActiveX DLL to send SCPI commands to the test system. It requires the ActiveX DLL to be installed inserted in the Windows system folder and registered using regsvr32.

```
#include "stdafx.h"
#include <stdio.h>
#include <tchar.h>
#include <Windows.h>

#import "c:\windows\SysWOW64\MCL_ZTxxx.dll"      // Import relevant DLL for the ZT model
using namespace MCL_ZTxxx;                       // Use the relevant namespace (usually model name)

int _tmain(int argc, _TCHAR* argv[])
{
	HRESULT hresult;
	CLSID clsid;
	int status;
	BSTR response, command;

	CoInitialize(NULL);                          // Initialize COM library
	// Retrieve CLSID (note: correct model name must be used for the DLL)
	hresult = CLSIDFromProgID(OLESTR("MCL_ZTxxx.USB_Control"), &clsid);
	if (FAILED(hresult))
	{
		printf("failed1: x%08x\n", hresult);
		goto done;
	}
	_USB_Control *dev;                           // Instance of DLL's USB control class
	hresult=CoCreateInstance(clsid,NULL,CLSCTX_INPROC_SERVER,__uuidof(_USB_Control),(LPVOID *)&dev);
	if (FAILED(hresult))
	{
		printf("failed2: x%08x\n", hresult);
		goto done;
	}

	command = SysAllocString(L"");               // Pass serial number or leave blank for any box
	status = dev->Connect(command);              // Connect to the device
	if (status == 0) {
		printf("Cannot Connect: x%08x\n", st);
		goto done;
	} else {                                     // Send any commands / queries as required…

		command = SysAllocString(L":MN?");       // Pass any SCPI command (:MN? for model name)
		status = dev->Send_SCPI(&command, &response);
		if (status > 0) {
			printf(response);
		}

		dev->Disconnect();                       // Disconnect at end of routine

	}

done:
	CoUninitialize();
	while (1);                                   // Keep the command prompt open
}
```

2.4.2 - USB Control Using the .NET DLL

These examples demonstrate control of Mini-Circuits' PTE products using C++ in the following environment:

1. Host computer running a Windows operating system
2. PTE connected by the USB interface
3. Mini-Circuits' .NET DLL saved on the computer

2.4.2 (a) - Programmable Attenuators

Console application to set and read the attenuation.

```
// To Do: Add reference to the DLL file

#include "stdafx.h"

using namespace System;

int main(array<System::String ^> ^args)
{
        mcl_RUDAT64::USB_RUDAT ^my_test1 = gcnew mcl_RUDAT64::USB_RUDAT();

        short Status = 0;
        System::String ^SN = "";        // Serial number needed if multiple devices connected
        System::String ^SCPI_Return = "";

        Status = my_test1->Connect(SN);                 // Open a connection

        my_test1->Send_SCPI(":MN?", SCPI_Return);       // Read model name
        Console::WriteLine(SCPI_Return);

        my_test1->Send_SCPI(":SN?", SCPI_Return);       // Read serial number
        Console::WriteLine(SCPI_Return);

        my_test1->Send_SCPI(":SETATT:25.75", SCPI_Return); // Set attenuation
        Console::WriteLine(SCPI_Return);

        my_test1->Send_SCPI(":ATT?", SCPI_Return);      // Read attenuation
        Console::WriteLine(SCPI_Return);

        my_test1->Disconnect();                         // Close the connection

    return 0;
}
```

2.4.2 (b) - Custom Switch Racks (ZT Series)

Console application to set and read the switches.

```
// To Do: Add reference to the DLL file

#include "stdafx.h"

using namespace System;

int main(array<System::String ^> ^args)
{
	// To Do: Update reference below ("ZT-xxx") to refer to correct DLL and class name
	mcl_ZTxxx_64::USB_ZTxxx ^my_test1 = gcnew mcl_ZTxxx_64::USB_ZTxxx();

	short Status = 0;
	System::String ^SN = "";          // Serial number needed if multiple devices connected
	System::String ^SCPI_Return = "";

	Status = my_test1->Connect(SN);                    // Open a connection

	my_test1->Send_Command(":MN?", SCPI_Return);       // Read model name
	Console::WriteLine(SCPI_Return);

	my_test1->Send_Command(":SN?", SCPI_Return);       // Read serial number
	Console::WriteLine(SCPI_Return);

	my_test1->Send_Command(":C1=3;:C5=2;:C11=6", SCPI_Return); // Set switches SW1, SW5 & SW11
	Console::WriteLine(SCPI_Return);          // Response should be “1” for success

	my_test1->Send_Command(":GETSSW1", SCPI_Return);   // Read state of switch SW1
	Console::WriteLine(SCPI_Return);

	my_test1->Disconnect();                            // Close the connection

    return 0;
}
```

2.4.3 - USB Control for Linux

USB control in a Linux environment makes use of USB interrupt codes. The examples below for specific models / model families can be adapted to any other of Mini-Circuits USB controlled test devices, by adjusting the interrupt codes used according to the relevant program manual for your device.

2.4.3 (a) - Programmable Attenuators

Please refer to https://github.com/WebbyMD1/rudatctrl for a method to work with Mini-Circuits' RUDAT / RCDAT series programmable attenuators, kindly provided by Richard Webb of MD1 Technology, Cheltenham, UK. The same process can be applied to other Mini-Circuits product families by adapting the functions / interrupt codes used, per the respective programming manuals.

2.4.4 - Ethernet Control Using HTTP

2.4.4 (a) - Signal Generators

This example demonstrates how to send HTTP Get commands in order to control the signal generator over an Ethernet connection and read the response.

```
#include "stdafx.h"
#include <iostream>

using namespace System;
using namespace System;
using namespace System::Net;
using namespace System::IO;
using namespace System::Text;
using namespace System::Web;

public ref class HttpPostRequest
{
public:
  static String^ HttpMethodPost(String^ postUrl)
  {
    // A function to send an HTTP command and read the response as an array of chars
    HttpWebRequest^ httpRequest = nullptr;
    HttpWebResponse^ httpResponse = nullptr;
    Stream^ httpPostStream = nullptr;
    BinaryReader^ httpResponseStream = nullptr;
    StringBuilder^ encodedPostData;
    array<Byte>^ postBytes = nullptr;
    String^ SSG_Return;
    try
    {
      httpRequest = (HttpWebRequest^)WebRequest::Create(postUrl);
      httpRequest->Method = "POST";
      httpPostStream = httpRequest->GetRequestStream();
      httpPostStream->Close();
      httpPostStream = nullptr;
      httpResponse = (HttpWebResponse^)httpRequest->GetResponse();
      httpResponseStream = gcnew BinaryReader(httpResponse->GetResponseStream(), Encoding::UTF8);
      array<Char>^ readSCPIChars;
      while (true)
      {
        readSCPIChars = httpResponseStream->ReadChars(64);       // Read the response
        if (readSCPIChars->Length == 0)
          break;
        for( int a = 0; a < readSCPIChars->Length; a = a + 1 )
        {
          SSG_Return += readSCPIChars->GetValue(a);      // Create a string for the response
        }
      }
    }
    catch (WebException^ wex)
    {
      Console::WriteLine("HttpMethodPost() - Exception occurred: {0}", wex->Message);
      httpResponse = (HttpWebResponse^)wex->Response;
    }
    finally
    {
      // Close any remaining resources
      if (httpResponse != nullptr)
      {
        httpResponse->Close();
      }
    }
    return SSG_Return;
    }
};
```

```
int main()
{
  //  SCPI command to send to SSG eg: IP 192.168.9.78; protocol HTTP; command to get serial number
  String^ urlToPost = "http://192.168.9.78/:SN?";
  Console::WriteLine("Sending: " + urlToPost);
  try
  {
    String^ SSG_Response = HttpPostRequest::HttpMethodPost(urlToPost);
    Console::WriteLine(SSG_Response);
  }
  catch (Exception^ ex)
  {
    Console::WriteLine("Main() - Exception occurred: {0}", ex->Message);
  }
  Console::WriteLine("Complete.  Hit enter to finish.");
  std::cin.ignore();            // Keep the console screen open until the user hits enter
  return 0;
}
```

2.5 - C# Programming

2.5.1 - USB Control Using the ActiveX DLL

These examples demonstrate control of Mini-Circuits' PTE products using C# in the following environment:

1. Host computer running a Windows operating system
2. PTE connected by the USB interface
3. Mini-Circuits ActiveX DLL installed and registered on the computer

2.5.1 (a) - Power Sensor

Set the calibration frequency and read the power.

```
// mcl pm.dll should be loaded as a reference file to the project

mcl_pm.usb_pm pm1 = new mcl_pm.usb_pm();

double ReadResult;
short Status = 0;
string pm_SN = "";                  // Serial Number needed if more than 1 sensor connected

Status = pm1.Open_Sensor(pm_SN);    // Open connection
pm1.Freq = 3000;                    // Set the Frequency cal factor in MHz
ReadResult = pm1.ReadPower() ;       // Read the power in dbm
pm1.Close_Sensor();                 // Close the connection
```

2.5.1 (b) - RS232 & USB to SPI Converter

Send SPI data from the USB port.

```
// mcl usb rs232 to spi.dll should be loaded as a reference file to the project

MCL_RS232_USB_To_SPI.USB_To_SPI SPI1 = new MCL_RS232_USB_To_SPI.USB_To_SPI();

double DataToSend = 0;
double ReceivedData = 0;

short x = 0;

SPI1.Connect;                                   // Open connection

// Send the value 56 in 8 bits and read 8 bits from SPI
DataToSend = 56;
ReceivedData = SPI1.Send_Receive_SPI(8, DataToSend, 1, 0);

SPI1.Disconnect();                              // Close the connection
```

2.5.1 (c) - Programmable Attenuator

Set and read the attenuation.

```
// mcl_rudat.dll should be loaded as a reference file to the project

mcl_RUDAT.USB_DAT att1 = new mcl_RUDAT.USB_DAT();

double Attenuation = 0;
short Status = 0;
string SN = "";                         // Serial Number needed for multiple attenuators

Status = att1.Connect(SN);              // Open connection

att1.SetAttenuation(37);                // Set attenuation
att1.Read_Att(Attenuation);             // Read attenuation

att1.Disconnect();                      // Close the connection
```

2.5.1 (d) - Programmable Attenuator (2 Devices)

Demonstration of how to control a pair of programmable attenuators, refered to by serial number.

```
string sn1 = "11310090001";
string sn2 = "11406170049";
int status1 = 0, status2 = 0;

// Declare 2 instances of the switch class and assign them to 2 objects

mcl_RUDAT.USB_DAT Att1;
mcl_RUDAT.USB_DAT Att2;

Att1 = new mcl_RUDAT.USB_DAT();
Att2 = new mcl_RUDAT.USB_DAT();

// Connect the 2 attenuators by serial number (check return code, if 0 do not continue)

status1 = Att1.Connect(sn1);    // status1 = 1 if connection was successful
status2 = Att2.Connect(sn2);    // status2 = 1 if connection was successful

// Carry out the rest of the program as required

float fAttenuation1 = 15.75F;    // Need the F suffix to initialize as a float
float fAttenuation2 = 0.25F;

status1 = Att1.SetAttenuation(ref fAttenuation1);   // Set attenuation
fAttenuation1 = -1;
status1 = Att1.Read_Att(ref fAttenuation1);         // Read attenuation
MessageBox.Show("Attenuator 1 set to " + fAttenuation1);

status2 = Att2.SetAttenuation(ref fAttenuation2);   // Set attenuation
fAttenuation2 = -1;
status2 = Att2.Read_Att(ref fAttenuation2);         // Read attenuation
MessageBox.Show("Attenuator 2 set to " + fAttenuation2);

// Disconnect the attenuators on completion

Att1.Disconnect();
Att2.Disconnect();
```

2.5.2 - USB Control Using the .Net DLL

These examples demonstrate control of Mini-Circuits' PTE products using C# in the following environment:

1. Host computer running a Windows operating system
2. PTE connected by the USB interface
3. Mini-Circuits .Net DLL installed

2.5.2 (a) - ZTM Series Modular Test Systems

The below example is a simple executable program that connects to the DLL, sends a user specified SCPI command to the ZTM Series test system, returns the response, then disconnects from the DLL and terminates.

```
namespace ZTM
{
    class Program
    {
        static int Main(string[] args)
        {
            int x = 0;
            string SN = null;
            string SCPI = null;
            string RESULT = null;
            int Add = 0;
            ModularZT64.USB_ZT ZT;           // Reference the DLL
            if (args.Length == 0) return 0;
            ZT = new ModularZT64.USB_ZT ();  // Declare a class (defined in the DLL)
            SCPI = args[2];
            if (args[0].ToString().Contains("-help"))  // Print a help file
            {
                Console.WriteLine("Help ZTM.exe");
                Console.WriteLine("-----------------------------------------");
                Console.WriteLine("ZTM.exe -s SN command :Send SCPI command to S/N");
                Console.WriteLine("ZTM.exe -a add SCPI :Send SCPI command to Address");
                Console.WriteLine("-----------------------------------------");
            }
            if (args[0].ToString().Contains("-s"))   // User want to connect by S/N
            {
                SN = args[1];
                x = ZT.Connect(ref SN);                    // Call DLL connect function
                x = ZT.Send_SCPI(ref SCPI, ref RESULT);    // Send SCPI command
                Console.WriteLine(RESULT);                 // Return the result
            }
            if (args[0].ToString().Contains("-a"))   // User wants to connect by address
            {
                Add = Int16.Parse(args[1]);
                x = ZT.ConnectByAddress(ref Add);
                x = ZT.Send_SCPI(ref SCPI, ref RESULT);
                Console.WriteLine(RESULT);
            }
            ZT.Disconnect();                // Call DLL disconnect function to finish
            return x;
        }
    }
}
```

This executable can be called from a command line prompt or within a script. The following command line calls demonstrate use of the executable (compiled as ZTM.exe), connecting by serial number or address, to set and read attenuation:

- `ZTM.exe -s 11401250027 :RUDAT:1A:ATT:35.75` (serial number 11401250027)
- `ZTM.exe -a 255 :RUDAT:1A:ATT?` (USB address 255)

2.5.2 (b) - Programmable Attenuator (2 Devices)

Demonstration of how to control a pair of programmable attenuators, refered to by serial number.

```
string sn1 = "11310090001";
string sn2 = "11406170049";
int status1 = 0, status2 = 0;

// Declare 2 instances of the switch class and assign them to 2 objects

mcl_RUDAT64.USB_RUDAT Att1;
mcl_RUDAT64.USB_RUDAT Att2;

Att1 = new mcl_RUDAT64.USB_RUDAT();
Att2 = new mcl_RUDAT64.USB_RUDAT();

// Connect the 2 attenuators by serial number (check return code, if 0 do not continue)

status1 = Att1.Connect(ref sn1);    // status1 = 1 if connection was successful
status2 = Att2.Connect(ref sn2);    // status2 = 1 if connection was successful

// Carry out the rest of the program as required

float fAttenuation1 = 15.75F;    // Need the F suffix to initialize as a float
float fAttenuation2 = 0.25F;

status1 = Att1.SetAttenuation(fAttenuation1);   // Set attenuation
fAttenuation1 = -1;
status1 = Att1.Read_Att(ref fAttenuation1);         // Read attenuation
MessageBox.Show("Attenuator 1 set to " + fAttenuation1);

status2 = Att2.SetAttenuation(fAttenuation2);   // Set attenuation
fAttenuation2 = -1;
status2 = Att2.Read_Att(ref fAttenuation2);         // Read attenuation
MessageBox.Show("Attenuator 2 set to " + fAttenuation2);

// Disconnect the attenuators on completion

Att1.Disconnect();
Att2.Disconnect();
```

2.5.2 (c) - Power Sensor

This example is a simple executable program that connects to the DLL, uses a pre-defined DLL function to communicate with the power sensor, returns the response from the sensor, then disconnects from the DLL and terminates.

The purpose of the executable is to enclose the .NET DLL interaction and functionality within a simple console application that can be called from elsewhere. This allows the executable to act as a middle layer between a programming environment which does not provide .NET support (typical Python 64-bit distributions for example) and one that does (Visual C#) so that the power sensor's functionality can be used in the former without directly accessing the DLL.

To run the application, the command line takes the below form (assuming the executable is compiled as pwr_cs.exe and the power sensor has serial number 1150825015):

- `pwr_cs.exe -ls` List all serial numbers for connected sensors
- `pwr_cs.exe -sn 11508250015 -m` Return the model name
- `pwr_cs.exe -sn 11508250015 -t` Return the temperature
- `pwr_cs.exe -sn 11508250015 -p 1500` Read power at 1500 MHz

```
using System;
using System.Collections.Generic;
using System.Linq;
using System.Text;
using System.Threading.Tasks;

namespace PWR_CS
{
    class Program
    {
        static int Main(string[] args)
        {
            int x = 0;
            string Serial_Number = null;
            string Temp_Str = "";
            float Temp_Flt = 0;
            double Temp_Dbl = 0;
            if (args.Length == 0) return 0;
            mcl_pm64.usb_pm pwr_sen;            // Reference the DLL
            pwr_sen = new mcl_pm64.usb_pm();

            // Look for the command line arguments and generate the appropriate response
            if (args[0].ToString().Contains("-ls"))     // List available sensors by serial number
            {
                x = pwr_sen.Get_Available_SN_List(ref(Serial_Number));
                Console.WriteLine(Serial_Number);
            }
            if (args[0].ToString().Contains("-sn"))                 // Connect to a sensor
            {
                Serial_Number = args[1];                            // Get the serial number

                // Each needed DLL function must be added below

                x = pwr_sen.Open_Sensor(ref Serial_Number);         // Connect by serial number
                if (args[2].ToString().Contains("-m"))              // Return model name
                {
                    Console.WriteLine(pwr_sen.GetSensorModelName());
                }
                else if (args[2].ToString().Contains("-t"))         // Return temperature
                {
                    Temp_Str = "C";
                    Temp_Flt = pwr_sen.GetDeviceTemperature(ref Temp_Str);
                    Console.WriteLine(Temp_Flt);
                }
                else if (args[2].ToString().Contains("-p"))         // Read power
                {
                    // Format: -sn xxxxxxxxxx -p freq

                    Temp_Dbl = Convert.ToDouble(args[3]);           // Get the frequency
                    pwr_sen.Freq = Temp_Dbl;                        // Set the frequency
                    Console.WriteLine(pwr_sen.ReadPower());         // Read the power
                }

                pwr_sen.Close_Sensor();

            }

            return x;
        }

    }
}
```

2.5.2 (d) - Programmable Attenuator

This example is a simple executable program that connects to the DLL, uses the "Send_SCPI" function to send a command / query to the attenuator, return the response from the sensor, then disconnect from the DLL and terminate.

The purpose of the executable is to enclose the .NET DLL interaction and functionality within a simple console application that can be called from elsewhere. This allows the executable to act as a middle layer between a programming environment which does not provide .NET support (typical Python 64-bit distributions for example) and one that does (Visual C#) so that the attenuator's functionality can be used in the former without directly accessing the DLL.

To run the application, the command line takes the below form (assuming the executable is compiled as RUDAT.exe and the attenuator has serial number 11406170049):

- `RUDAT.exe -sn 11406170049 :MN?` Return the model name
- `RUDAT.exe -sn 11406170049 :SN?` Return the serial number
- `RUDAT.exe -sn 11406170049 :SETATT=12.75` Set attenuation to 12.75 dB

```
using System;
using System.Collections.Generic;
using System.Linq;
using System.Text;
using System.Threading.Tasks;

namespace RUDAT_CS_EXE
{
    class Program
    {
        static int Main(string[] args)
        {

            int x = 0;
            string SN = null;
            string SCPI = null;
            string RESULT = null;
            int Add = 0;

            mcl_RUDAT64.USB_RUDAT RUDAT;                // Reference the .NET DLL

            if (args.Length == 0) return 0;

            RUDAT = new mcl_RUDAT64.USB_RUDAT();        // Declare the attenuator class
            SCPI = args[2];

            if (args[0].ToString().Contains("-help"))   // Print a help file
            {
                Console.WriteLine("Help RUDAT.exe");
                Console.WriteLine("-----------------------------------------");
                Console.WriteLine("RUDAT.exe -s SN command / Send SCPI command to serial number");
                Console.WriteLine("RUDAT.exe -a add SCPI / Send SCPI command to address");
                Console.WriteLine("-----------------------------------------");
            }

            if (args[0].ToString().Contains("-s"))      // User wants to connect by S/N
            {
                SN = args[1];
                x = RUDAT.Connect(ref SN);                  // Call DLL connect function
                x = RUDAT.Send_SCPI(SCPI, ref RESULT);      // Send the command, get the response
                Console.WriteLine(RESULT);                  // Return the result
            }

            if (args[0].ToString().Contains("-a"))      // User wants to connect by address
            {
                Add = Int16.Parse(args[1]);
                x = RUDAT.ConnectByAddress(Add);
                x = RUDAT.Send_SCPI(SCPI, ref RESULT);
                Console.WriteLine(RESULT);
            }

            RUDAT.Disconnect();                         // Call DLL disconnect function to finish
            return x;

        }
    }
}
```

2.5.2 (e) - ZT-166 Switch Rack

Connect to a ZT-166 switch rack using the .NET DLL and send a few typical commands / queries.

```
// Send some typical commands / queries using the .NET DLL

// Add a reference to the DLL mcl_ZT166_64.dll to the project
mcl_ZT166_64.USB_ZT166 mySW = new mcl_ZT166_64.USB_ZT166(); // Declare the ZT-166 class

string sw_serial = "";
// Enter a serial number or leave blank to connect to any ZT-166
mySW.Connect(ref(sw_serial));

string sw_command = ":MN?";
string sw_model = "";
mySW.Send_Command(ref(sw_command), ref(sw_model));      // Read model name

sw_command = ":SN?";
mySW.Send_Command(ref(sw_command), ref(sw_serial));     // Read serial number

MessageBox.Show(sw_model + " / " + sw_serial);

sw_command = ":C1=2";
string sw_set = "";
mySW.Send_Command(ref(sw_command), ref(sw_set));        // Set switch 1 to state COM<>2 (returns 1
on success)

sw_command = ":GETSSW1?";
string sw_get = "";
mySW.Send_Command(ref(sw_command), ref(sw_get));        // Get switch 1 state

mySW.Disconnect();
```

2.5.2 (f) - USB IO Control Box (USB-I/O-16D8R)

Console application to connect to USB-I/O-16D8R, read model name / serial number, set the TTL output and read the TTL input.

```
using System;

namespace MCL_IO_CS
{
    class Program
    {
        static void Main(string[] args)
        {

            // mcl_USB_To_IO_64.dll must be added as a reference to this project
            // Create a new object from the DLL, call it MyIO
            mcl_USB_To_IO_64.USB_IO MyIo = new mcl_USB_To_IO_64.USB_IO();

            int status = 0;
            // Pass a serial number to connect to a specific IO box, or leave blank
            string sn = "", mn = "";
            byte byte_input = 0, byte_output = 0;

            status = MyIo.Connect(ref(sn));    // Connect the IO box (returns 1 on success)

            if (status == 1)                    // IO box connected successfully
            {
                MyIo.Read_ModelName(ref(mn));   // Read model name
                MyIo.Read_SN(ref (sn));         // Read serial number

                // Output the model name / serial number
                Console.WriteLine("Model Name: " + mn + " / Serial Number: " + sn);

                // Set output on byte A
                MyIo.Set_ByteA_As_Output();

                // Set the output byte from 0 (output byte = 00000000) to 255 (output byte = 11111111)
                byte_output = 255;
                MyIo.Set_ByteA(ref(byte_output));   // Set the output

                // Read input from byte A
                MyIo.Set_ByteA_As_Input();
                MyIo.ReadByteA(ref(byte_input));    // Read the TTL inputs as a byte

                Console.WriteLine("Value read from byte A: " + byte_input);

                MyIo.Disconnect();                // Disconnect the hardware when done

            } else
            {
                Console.WriteLine("Could not connect");
            }

            Console.ReadKey(true);  // Keep the console open until any key is pressed

        }
    }
}
```

2.5.3 - Ethernet Control Using HTTP

This example demonstrates how to send HTTP Get commands / queries for contorl of any Mini-Circuits Ethernet connected test devices.

The System, System.Net and System.IO namespaces need to be used:

```
using System;
using System.Net;
using System.IO;
```

The below function takes the device's IP address and the control command as arguments, creates the URL and uses the WebRequest class to call the URL and return the result as a string:

```
public string Send_HTTP_Get(string sw_command)
{

    // Define a function to send an HTTP get command to the device
    // Returns the device's response as a string

    string sw_ip_address = "192.168.9.70";      // IP address of the Mini-Circuits device
    string command_url = "http://" + sw_ip_address + "/" + sw_command;

    WebRequest wrGETURL;
    wrGETURL = WebRequest.Create(command_url);

    Stream objStream;
    objStream = wrGETURL.GetResponse().GetResponseStream();

    StreamReader objReader = new StreamReader(objStream);

    string sw_response = objReader.ReadLine();
    return sw_response;

}
```

Usage of the function is as below:

```
string sw_model = Send_HTTP_Get(":MN?");        // Read model name
string sw_serial = Send_HTTP_Get(":SN?");       // Read serial number

MessageBox.Show(sw_model + " / " + sw_serial);
```

2.6 - Perl Programming

2.6.1 - USB Control with 32-Bit Perl

These examples demonstrate control of Mini-Circuits' PTE products using Perl in the following environment:

1. Host computer running a Windows operating system
2. PTE connected by the USB interface
3. Mini-Circuits ActiveX DLL installed and registered on the computer

2.6.1 (a) - Programmable Attenuator

Set the attenuation to a specific value.

```
use feature ':5.10';

say "Programmable Attenuator Set to 12.75 dB";

use Win32::OLE;
use Win32::OLE::Const 'Microsoft ActiveX Data Objects';

my $Att = Win32::OLE->new( 'mcl_RUDAT.USB_DAT' );

$Att->Connect();
$Att->SetAttenuation (12.75);
$Att->Disconnect;
```

2.6.2 - USB Control with 64-Bit Perl

Some typical 64-bit versions of Perl do not include support for .Net components, this prevents Mini-Circuits' .Net DLLs being called directly from Perl script on these systems. 32-bit Perl distributions typically support ActiveX and therefore Mini-Circuit's ActiveX DLLs can be used (see USB Control with 32-Bit Perl).

The work around when using a 64-bit Perl distribution is to create a separate executable program whose only function is to reference the .Net DLL, connect to the device, send a single user specified command, return the response to the user, and disconnect from the DLL. This executable can then be easily called from Perl script to send as many commands as needed to the PTE device.

2.6.2 (a) - ZTM Series Modular Test Systems

Mini-Circuits can supply on request an executable to interface with the DLL. For ZTM Series test systems, and all customer specific designs based on the same controller, the example source code for such an executable (C#) is shown at ZTM Series Control Using .Net.

The below script demonstrates use of the executable in Perl script to send a SCPI command to a ZTM Series test system (specified by serial number or address) and read the response.

```
#!/usr/bin/perl
use strict;
use warnings;

my $serial_number = 11404280010;      # The ZTM Series serial number
my $att_list = "1A,2A,3A,4A";         # The list of attenuator locations in the ZTM
my @att_location = split /,/, $att_list;
my $value = 40;

my $exe = "ZTM.exe";    # The .exe providing an interface to the ZTM DLL
my @cmd;

foreach my $att_location (@att_location) {

    # Loop for each attenuator location

    # Set attenuator in this location
    @cmd = ($exe, "-s $serial_number :RUDAT:$att_location:ATT:$value");
    my $return_value = qx{@cmd};
    print "ZTM Series response: $return_value\n";

    # Confirm attenuation setting for this attenuator
    @cmd = ($exe, "-s $serial_number :RUDAT:$att_location:ATT?");
    $return_value = qx{@cmd};
    print "Attenuator $att_location set to $return_value\n";

}
```

2.6.3 - Ethernet Control Using HTTP

These examples demonstrate control of Mini-Circuits' PTE products over a TCP/IP network by making use of Perl's *LWP Simple* interface.

2.6.3 (a) - ZTM Series Modular Test Systems

Send HTTP commands to set and read attenuators within the ZTM Series test system.

```
#!/usr/bin/perl
use strict;
use warnings;
use LWP::Simple;                        # Use the LWP::Simple interface for HTTP

my $value = 40;
my $ip_address = "192.168.9.74";        # The ZTM Series serial number

my $att_list = "1A,2A,3A,4A";           # The list of attenuator locations in the ZTM
my @att_location = split /,/, $att_list;

foreach my $att_location (@att_location) {

        # Loop for each attenuator location

        # Set attenuator in this location
        my $return_value = get("http://$ip_address/:RUDAT:$att_location:ATT:$value");
        print "ZTM Series response: $return_value\n";

        # Confirm attenuation setting for this attenuator
        $return_value = get("http://$ip_address/:RUDAT:$att_location:ATT?");
        print "Attenuator $att_location set to $return_value\n";

}
```

2.7 - Delphi Examples

2.7.1 - USB Control Using the ActiveX DLL

Mini-Circuits provides a series of Delphi examples using the ActiveX DLL for most software controlled test products, these can be found on our website at:
https://www.minicircuits.com/softwaredownload/software_download.html

To work with these examples in the Delphi environment it is first necessary to install and register the relevant ActiveX DLL, then follow the below instructions:

- Open Delphi
- Select Menu -> Project -> Import Type Library
- Look for the Mini-Circuits DLL in the list and click on it
- Click on install and follow the instructions
- At the end of the install process look in the pallete under ActiveX
- Select the icon with the USB class name for the Mini_Circuits product (eg: USB_RF_Switch for the mechanical switch series)
- Drag it to the form and use it as an ActiveX control to create a new program, or run the example downloaded from the Mini-Circuits website

2.8 - LabVIEW Worked Examples

2.8.1 - USB Control Using the ActiveX DLL

2.8.1 (a) - Power Sensors

These instructions demonstrate control of Mini-Circuits power sensors in LabVIEW using Mini-Circuits' supplied ActiveX DLL file. The same methodology applies to the full range of Mini-Circuits' PTE (Portable Test Equipment); substituting the relevant DLL file and functions into the instructions below.

1. Install and Register the DLL

Install the supplied DLL file (mcl_pm.dll) to the relevant Windows system folder and register using the Windows regsvr32 program (see the product Programming Manual for full details).

2. Create a New VI (Virtual Instrument) and Reference the DLL

a. Open LabVIEW with a new, blank VI.
b. In the Block Diagram window (accessible by pressing Ctrl+E), select Functions Palette from the "View" menu at the top of the screen.
c. Click through the Connectivity palette to the ActiveX sub-palette. Select the **Automation Open** function and place it on the block diagram.

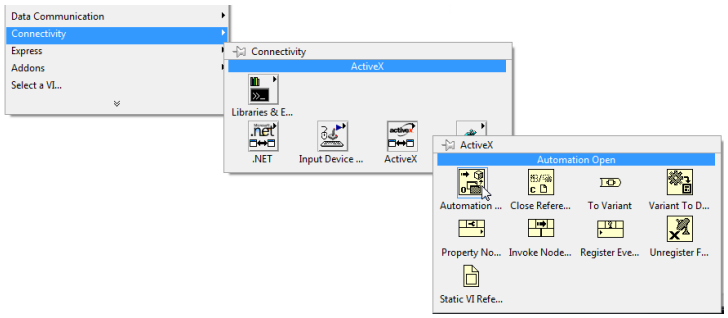


Fig 2.8-i - Place an ActiveX Automation Open function

d. Right click on the *Automation Refnum* terminal on the left of the **Automation Open** function and create a control.
e. Right-click on the new control, choose "Select ActiveX Class" to the object selection window.

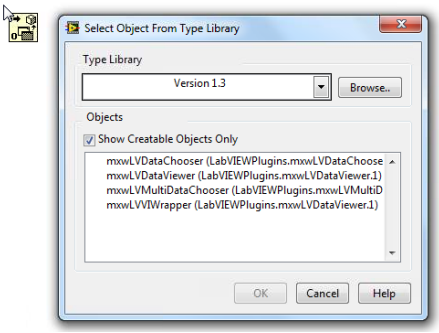


Fig 2.8-ii - LabVIEW object selection window

f. Click "Browse…" and select the mcl_pm.dll file from the compluter's system folder.
g. The object selection window will show all of the available classes contained in the DLL; highlighting the "Show Creatable Objects Only" option should limit the list to the correct class, shown as "USB_PM (mcl_pm.USB_PM)". Select this and cick OK.

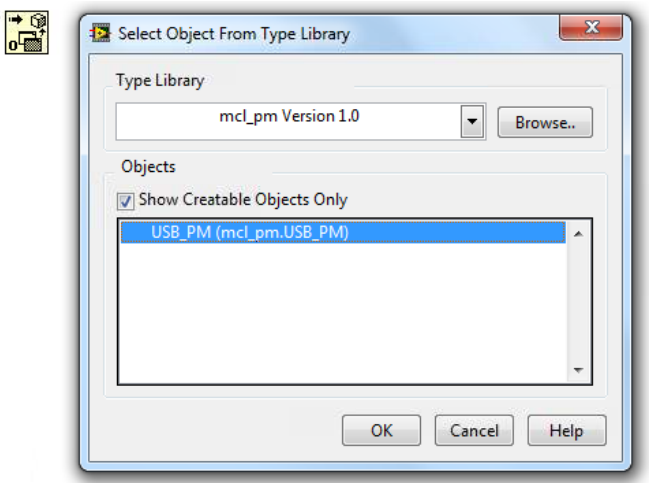


Fig 2.8-iii - Select the USB_PM class

h. Right click on the *Error In* terminal of the **Automation Open** function and create a new control, **Error In**.

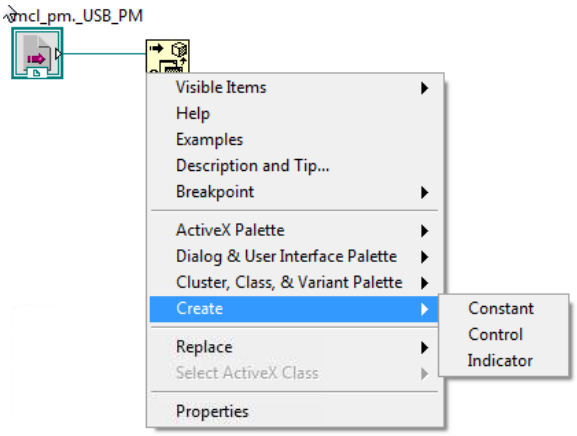


Fig 2.8-iv - Create Error In control

3. Connecting to the Power Sensor

a. From the ActiveX sub-palette, choose **Invoke Node** and place the node on the block diagram.

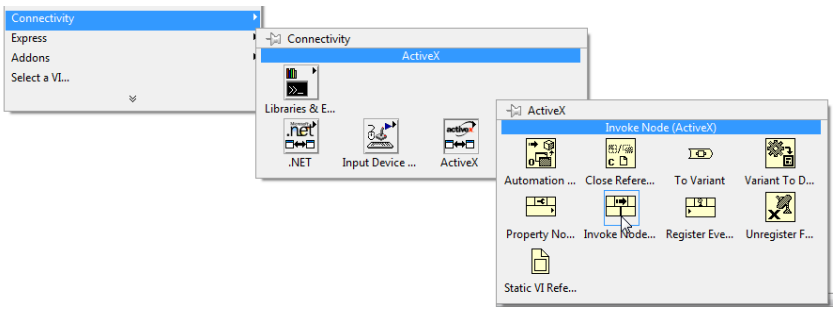


Fig 2.8-v - Create the first Invoke Node

b. Connect the right *Automation Refnum* terminal of the **Automation Open** function to the *Reference* terminal on the **Invoke Node**.
c. Connect the *Error Out* terminal of the **Automation Open** function to the *Error In* terminal of the **Invoke Node**.
d. Click on the Method of the **Invoke Node** to display a list of all available functions and select "Open_Sensor".

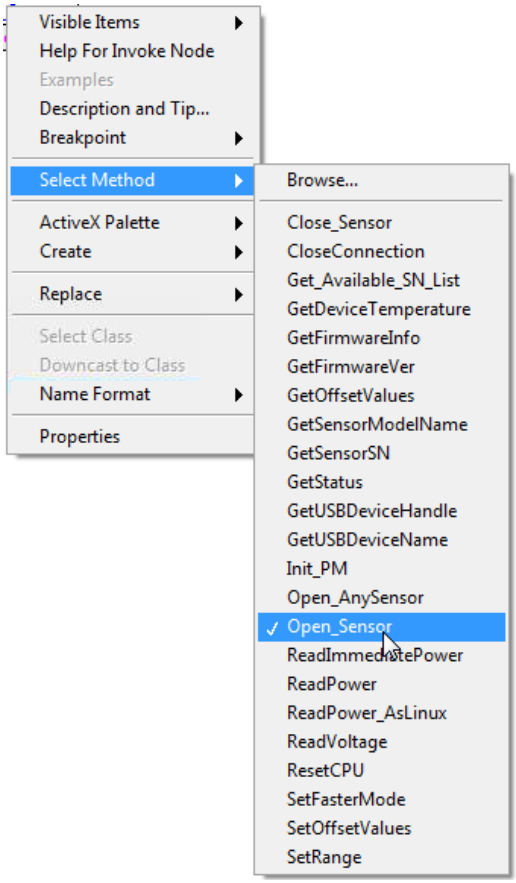


Fig 2.8-vi - The available power sensor functions, defined in the DLL

e. Right-click the *Input* terminal of the SN_Request parameter and create a numeric control.

f. An indicator can be added to the **Open_Sensor Node** to confirm whether the operation was successful; click through the Programming palette to the Comparison sub-paletter and select the "Not Equal to 0?" operation. Place this on the block diagram and connect to the *Output* terminal of the **Open_Sensor Node**.

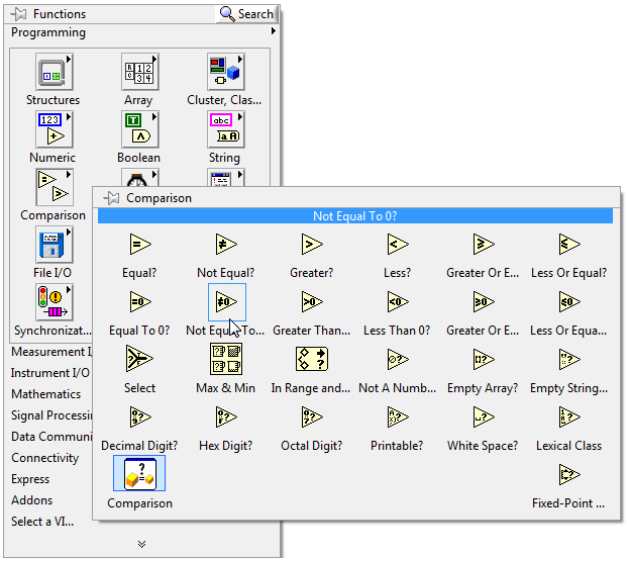


Fig 2.8-vii - Place the "Not Equal to 0?" comparison operator

g. Right click on the output of the "Not Equal to 0?" comparison operation and create an indicator.

h. If multiple power sensors are to be connected then a serial number should be entered in the numeric control, otherwise it can be left blank.

i. Following the **Open_Sensor Node**, the user can place any number of additional nodes in sequence to perform all operations required of the power sensor. The *Reference In* and *Error In* terminals of each new node should be connected to the *Reference Out* and *Error Out* terminals of the previous nodes.

4. Setting the Calibration Frequency

a. Select **Invoke Property** from the Connectivity palette, ActiveX sub-palette and place it on the block diagram.

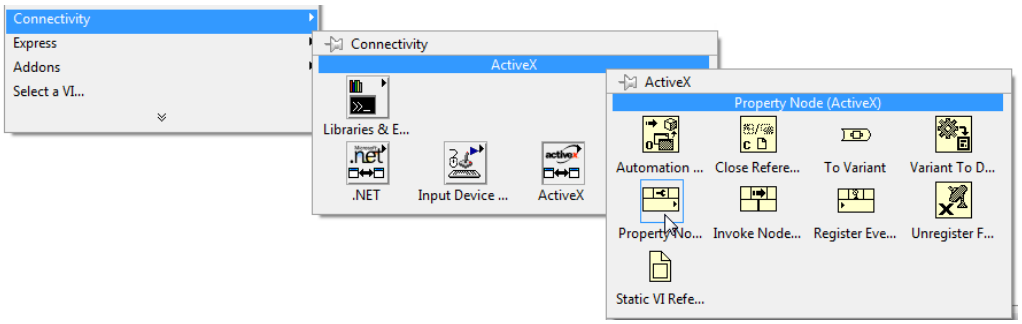


Fig 2.8-viii - Creating an ActiveX Property Node

b. Right-click on the new property node and select "Freq" from the "Select Property" menu option.

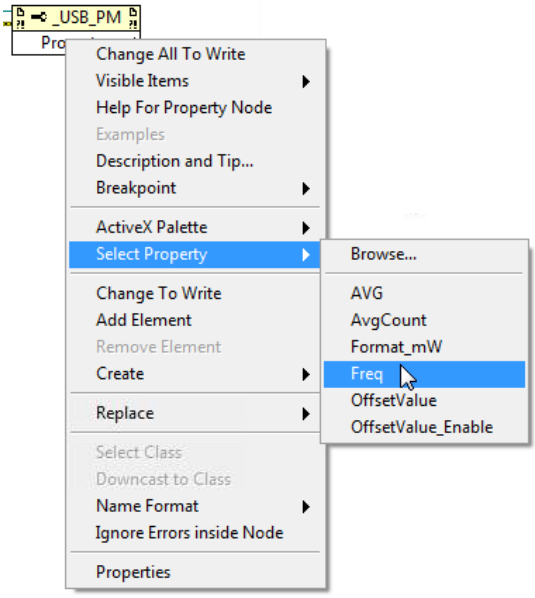


Fig 2.8-ix - The available power sensor properties, defined in the DLL

c. The LabVIEW default for the property is to read so right-click on it and select "Change To Write".

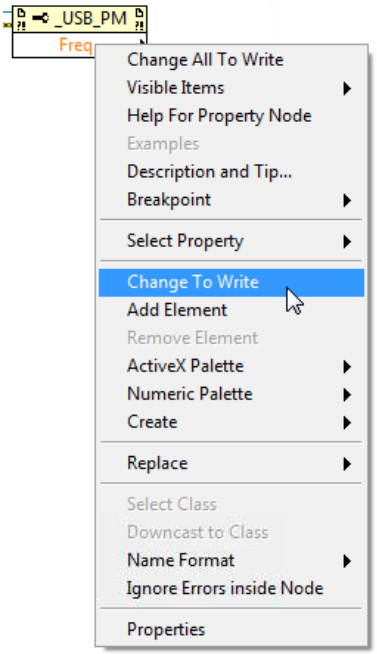


Fig 2.8-x - Set the property to "write" rather than "read"

d. Right-click on the *Input* terminal of the **Set Frequency Property** and create a constant so that the user can specify the frequency.
e. Connect the *Reference In* and *Error In* terminals of the property to the *Reference Out* and *Error Out* terminals of the **Open_Sensor Node**.

5. Reading the Power Sensor

a. Create a new Invoke Node and set the method to "ReadPower".
b. Create a numeric control on the *Output* terminal of the Read Power Node to display the power.
c. Create a further Invoke Node and set the method to "GetDeviceTemperature".
d. Create a numeric control on the *Output* terminal of the GetDeviceTemperature Node to display the temperature.
e. Connect the *Reference* and *Error* terminals in sequence.

6. Disconnecting

a. The final Invoke Node in the program should be set with the “Close_Sensor” function in order to properly close the USB connection to the power sensor.
b. The final step in the LabVIEW sequence is to create a Close Reference function from the Connectivity palette to terminate the reference to the DLL file. The *Reference In* and *Error In* terminals of the Close Reference function should be connected to the respective terminals of the Close_Sensor Node.

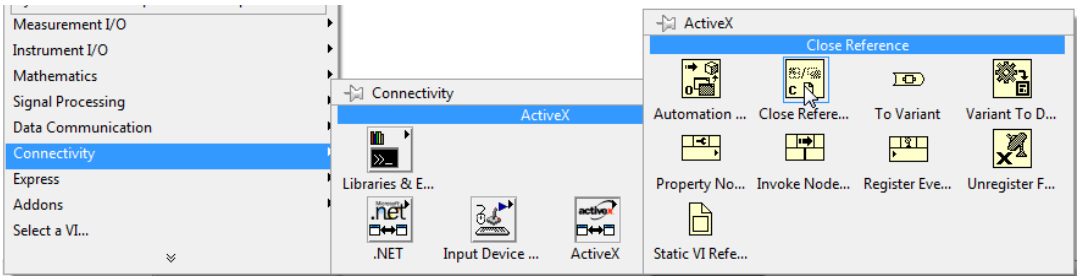


Fig 2.8-xi - Creating the Close Reference function from the ActiveX sub-palette

7. Continuous Readings

a. The read power and temperature sequence can be configured to run continuously until stopped by the user. To do this, select "While Loop" from the Programming palette, Structures sub-palette.

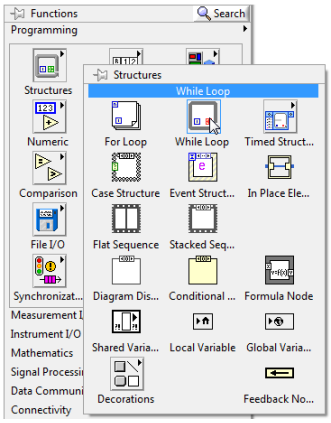


Fig 2.8-xii - LabVIEW's programming structures

b. Drag the while loop so that it encompasses the **Set Frequency Property**, the **ReadPower Node** and the **GetDeviceTemperature Node** but not the open/close nodes.

c. If a **Stop Button** was not created automatically then right-click on the loop condition and select “Create Control” to place the button in the loop.

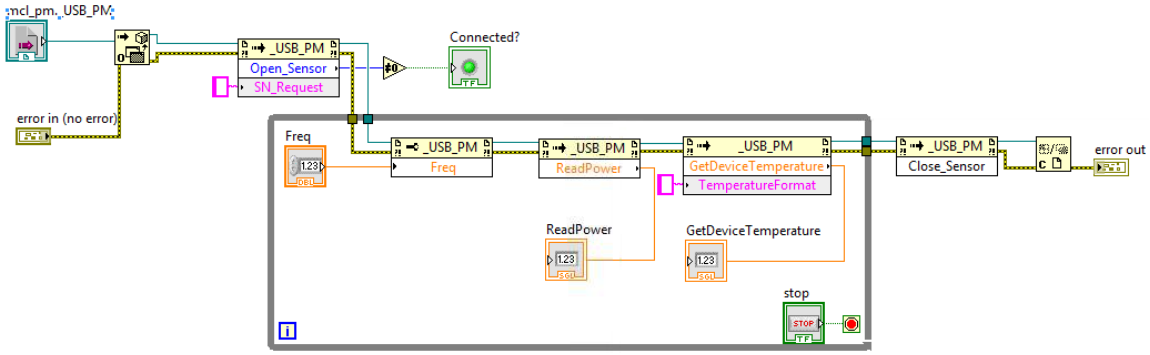


Fig 2.8-xiii - Complete VI including the While loop for continuous reading

2.8.1 (b) - Programmable Attenuators

These instructions demonstrate control of Mini-Circuits programmable attenuators in LabVIEW using Mini-Circuits' supplied ActiveX DLL file. The same methodology applies to the full range of Mini-Circuits' PTE (Portable Test Equipment); substituting the relevant DLL file and functions into the instructions below.

These instructions were prepared using LabVIEW 8.5 to demonstrate compatibility with older versions of the environment.

1. Install and Register the DLL

Install the supplied DLL file (mcl_rudat.dll) to the relevant Windows system folder and register using the Windows regsvr32 program (see the product Programming Manual for full details).

2. Create a New VI (Virtual Instrument) and Reference the DLL

a. Open LabVIEW with a new, blank VI.
b. In the Block Diagram window (accessible by pressing Ctrl+E), select Functions Palette from the "View" menu at the top of the screen.
c. Click through the Connectivity palette to the ActiveX sub-palette. Select the **Automation Open** function and place it on the block diagram.
d. Right click on the *Automation Refnum* terminal on the left of the **Automation Open** function and create a control.
e. Right-click on the new control, choose "Select ActiveX Class" and click "Browse…"

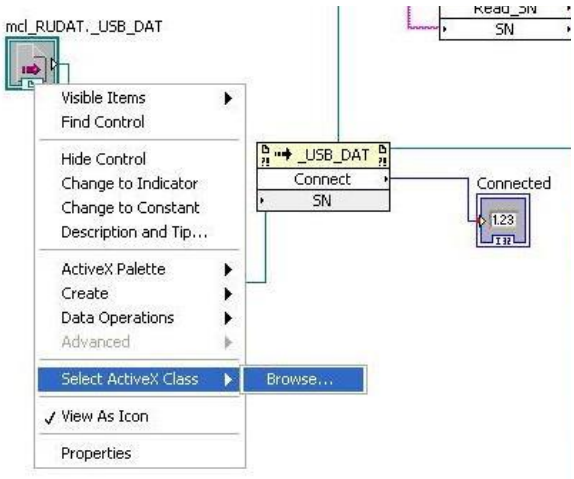


Fig 2.8-xiv - Place an Automation Open function and select the ActiveX class

f. Browse to the computers system folder and select the mcl_rudat.dll file.

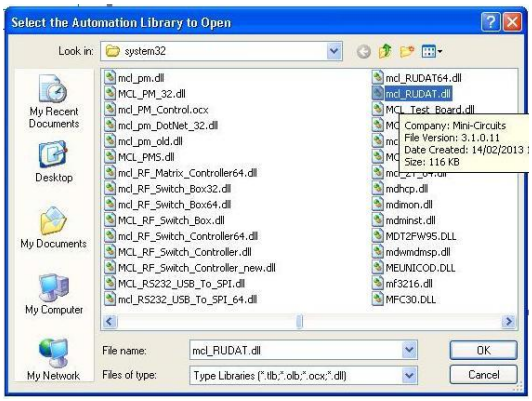


Fig 2.8-xv - Select the mcl_rudat.dll file

g. Select the “USB_DAT (MCL_RUDAT.USB_DAT)” class when prompted.

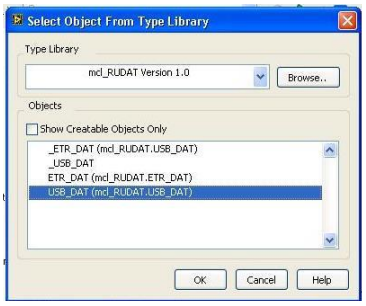


Fig 2.8-xvi - Select the USB_DAT class

h. Right click on the *Error In* terminal of the **Automation Open** function and create a new control.

i. To save space on the block diagram, right-click the **Error In** icon and uncheck the “View As Icon” option.

3. Connecting to the Attenuator

a. From the ActiveX sub-palette, choose **Invoke Node** and place the node on the block diagram.
b. Connect the right *Automation Refnum* terminal of the **Automation Open** function to the *Reference* terminal on the **Invoke Node**.
c. Connect the *Error Out* terminal of the **Automation Open** function to the *Error In* terminal of the **Invoke Node**.
d. Click on the Method of the **Invoke Node** to display a list of all available functions (defined in the mcl_rudat.dll file), select “Connect”.

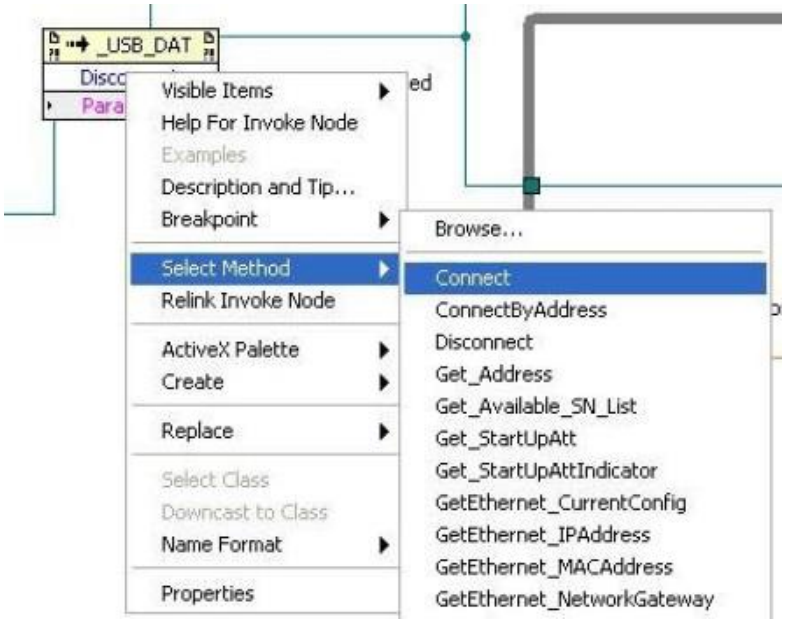


Fig 2.8-xvii - Select the Connect method for the Invoke Node

e. Right-click the *Input* terminal of the SN parameter and create a numeric control.
f. If multiple attenuators are to be connected then a serial number should be entered in the numeric control, otherwise it can be left blank.
g. Following the **Connect Node**, the user can place any number of additional nodes in sequence to perform all operations required of the attenuator. The *Reference In* and *Error In* terminals of each new node should be connected to the *Reference Out* and *Error Out* terminals of the previous nodes.

4. Setting Attenuation

a. Create a new **Invoke Node** and set the method to "SetAttenuation".
b. Connect the Input terminal of the Set Attenuation **Invoke Node** to the Connect **Invoke Node**.
c. Create a numeric control to allow the attenuation to be adjusted and connect this to the "TotalAtt" input terminal of the Set Attenuation node.

5. Reading Attenuation

a. Create a new **Invoke Node** and set the method to "Read_Att".
b. Connect the Input terminal of the Read Attenuation **Invoke Node** to the Connect **Invoke Node**.
c. Select method Read_att.
d. Create a numeric control to display the attenuation and connect it the "CAtt1" Output terminal of the Read Attenuation node.

6. Disconnecting

a. The final **Invoke Node** in the program should be set with the “Disconnect” function in order to properly close the connection to the attenuator.
b. The final step in the LabVIEW sequence is to create a **Close Reference** function from the Connectivity palette to terminate the reference to the DLL file. The *Reference In* and *Error In* terminals of the **Close Reference** function should be connected to the respective terminals of the **Disconnect** function.

2.8.1 (c) - ZTM Series Modular Test Systems

These instructions demonstrate control of Mini-Circuits ZTM-X modular test systems in LabVIEW using Mini-Circuits' supplied ActiveX DLL file. The same methodology applies to the full range of Mini-Circuits' PTE (Portable Test Equipment); substituting the relevant DLL file and functions into the instructions below.

1. Install and Register the DLL

Install the supplied DLL file (ModularZT.dll) to the relevant Windows system folder and register using the Windows regsvr32 program (see the product Programming Manual for full details).

2. Create a New VI (Virtual Instrument) and Reference the DLL

a. Open LabVIEW with a new, blank VI.
b. In the Block Diagram window (accessible by pressing Ctrl+E), select Functions Palette from the "View" menu at the top of the screen.
c. Click through the Connectivity palette to the ActiveX sub-palette. Select the **Automation Open** function and place it on the block diagram.

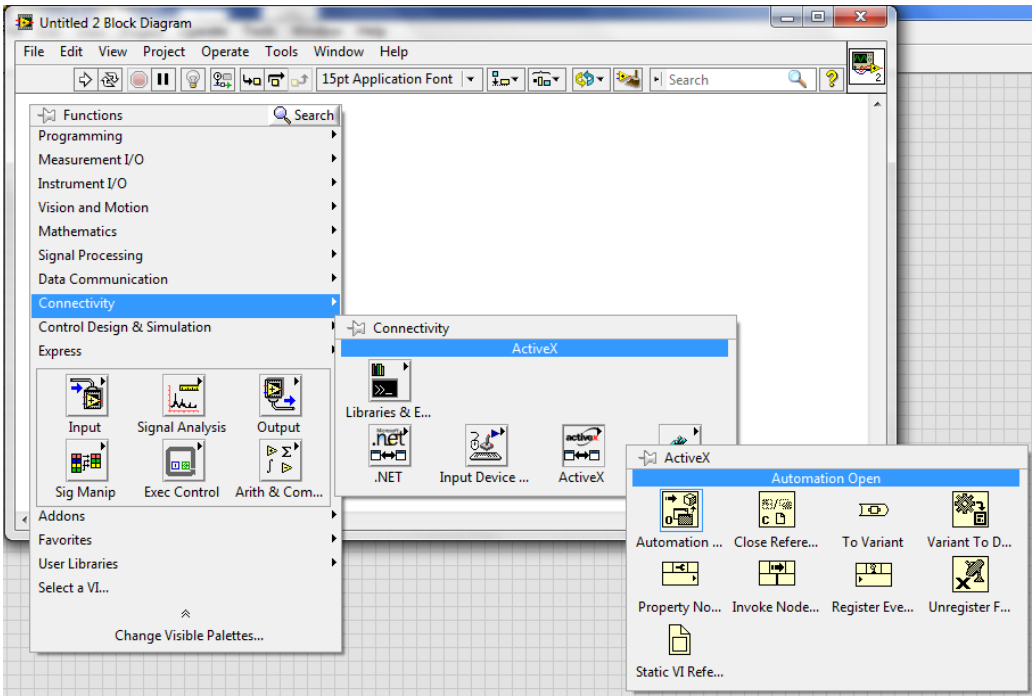


Fig 2.8-xviii: Path to Automation Open in the ActiveX sub-palette, with Automation Refnum highlighted

d. Right click on the *Automation Refnum* terminal on the left of the **Automation Open** function and create a control.

e. Right click on the new control, choose the 'Select ActiveX Class' option and browse to the location of the ModularZT.dll file.

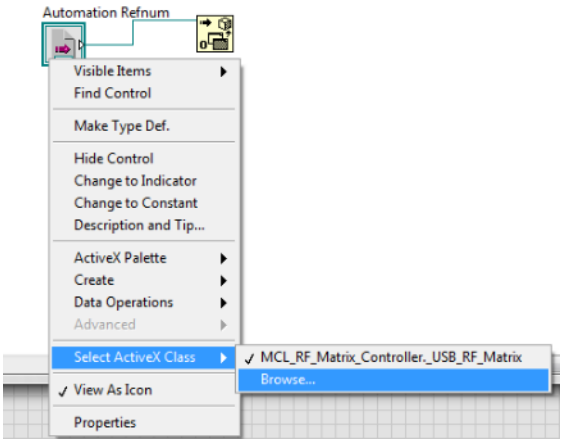


Fig 2.8-xix: Menu options for the Automation Refnum terminal

f. After selecting the DLL file, choose "USB_Control" from the list of objects presented.
g. Right click on the *Error In* terminal of the **Automation Open** function and create a new control.
h. To save space on the block diagram, right-click the **Error In** icon and uncheck the "View As Icon" option.

3. Identifying the Serial Numbers of all Connected ZTM-X Systems

This section makes use of the Get_Available_SN_List DLL function to provide a drop-down list of all connected serial numbers, allowing the user to choose which system to connect. If the serial numbers are already known or only a single system is connected then this process can be omitted.

a. From the ActiveX sub-palette, choose **Invoke Node** and place the node on the block diagram.
b. Connect the right *Automation Refnum* terminal of the **Automation Open** function to the *Reference* terminal on the **Invoke Node**.
c. Connect the *Error Out* terminal of the **Automation Open** function to the *Error In* terminal of the **Invoke Node**.
d. Click on the Method of the **Invoke Node** to display a list of all available functions (defined in the ModularZT.dll file), select "Get_Available_SN_List".
e. Right-click the *Input* terminal of the SN_List parameter and create a blank constant. The constant will provide the SN_List parameter to the Get_Available_SN_List function.

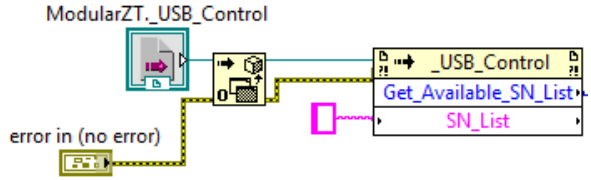


Fig 2.8-xx: Block diagram including Automation Refnum and Invoke Node controls

f. From the Programming palette, go to the Comparison sub-palette. Select the **Not Equal To 0** function and place it on the block diagram.

g. Connect the *Get_Available_SN_List* terminal of the **Invoke Node** to the input of the **Not Equal To 0** function.
h. Create an **Indicator** at the *Output* terminal of the **Not Equal To 0** function. The output of the Get_Available_SN_List function will be 0 (failure to connect) or 1 (successfully connected) so the indicator should light up when the retrieval of the serial numbers is successful.
i. Right-click on the **Indicator** and rename to "Get SN List Success?".

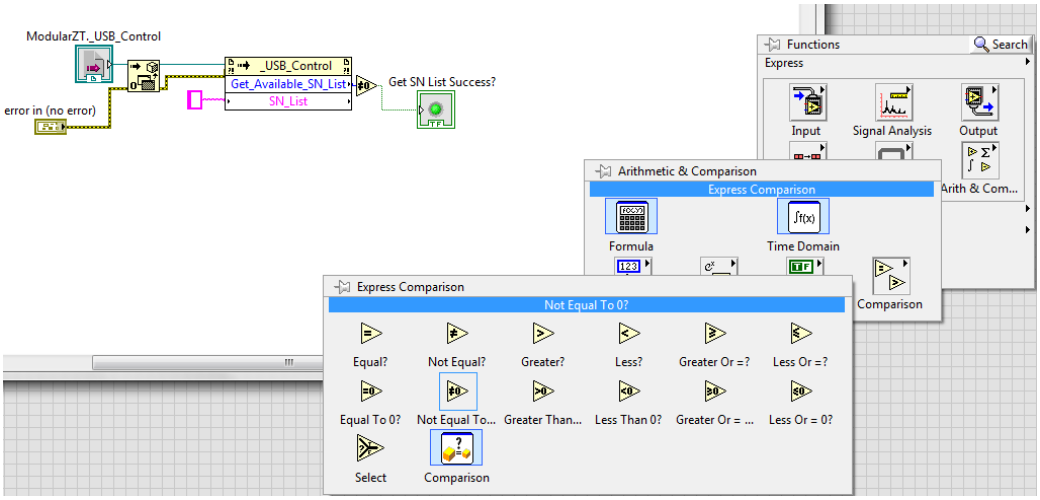


Fig 2.8-xxi: Adding the Not Equal To 0 function and "Get SN List Success?" indicator

j. Place a **While Loop** (found in the Programming palette, Structures sub-palette) on the block diagram, external to the previous objects.
k. Delete the stop button if it was included automatically but not the loop condition (the red dot).
l. Place a **Match Pattern** function (found in the Programming palette, String sub-palette) inside the **While Loop**.
m. Connect the output of the "SN_List" parameter (from the Get_Available_SN_List node) to the *String* input terminal of the **Match Pattern** function.
n. Create another empty string constant outside the **While Loop**, connected to the *Regular Expression* terminal of the **Match Pattern** function. This is because each SN that the Node outputs will be separated by a blank space.
o. Connect the *Before Substring* terminal of the **Match Pattern** function to the right-hand edge of the **While Loop**.
p. Right-click on the **Loop Tunnel** between the "SN_List" parameter and the *String* input terminal of the **Match Pattern**, select 'Replace with Shift Register'. The mouse cursor will automatically change to signify the other end of the **Shift Register**, click on the **Loop Tunnel** at the right-hand edge of the **While Loop** to place it.

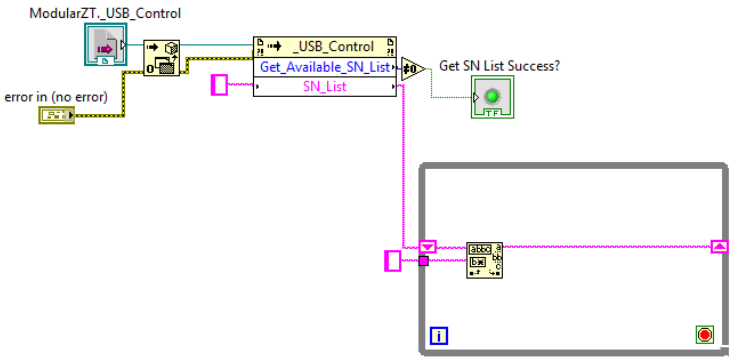


Fig 2.8-xxii: Block diagram with While Loop and Shift Register

q. Place a **Trim Whitespace.vi** from the String sub-palette inside the **While Loop**.
r. Connect the *After Substring* terminal of the **Match Pattern** function to the input of the **VI**.
s. Place a **Build Array** function (found in the Programming palette, Array sub-palette) in the **While Loop** and expand it to have two inputs by dragging the bottom edge down
t. An empty **String Array** constant is needed for the **Build** Array function. Select **Array** constant from the Array sub-palette and place it outside the **While Loop**.
u. Place another **String** constant on the block diagram and drag it into the **Array** constant box to create the empty **String Array**.
v. Connect the **String Array** constant to the first *Input* terminal of the **Build Array** function.
w. Connect the *Trimmed String* terminal of the **Trim Whitespace** VI to the second terminal of the **Build Array** function.
x. Connect the output of the **Build Array** function to the edge of the **While Loop** and create another **Shift Register**, with the other end at the empty **String Array Loop Tunnel**.
y. Place a **String Length** function (from the String sub-palette) inside the **While Loop**.
z. Connect the *Input* terminal of the function to the *After Substring* terminal of the **Match Pattern** function. This will form a junction since the *After* Substring terminal is also connected to the **Trim Whitespace** VI.
aa. Connect the *Length* output terminal of the **String** Length function to the input of a new **Equal to 0** function (found in the Comparison sub-palette).
bb. Connect the output of the **Equal to 0** function to the loop condition. If the output of the **String Length** function is 0 it will indicate that there are no more serial numbers and the **Equal to 0** operator will cause the loop to stop.

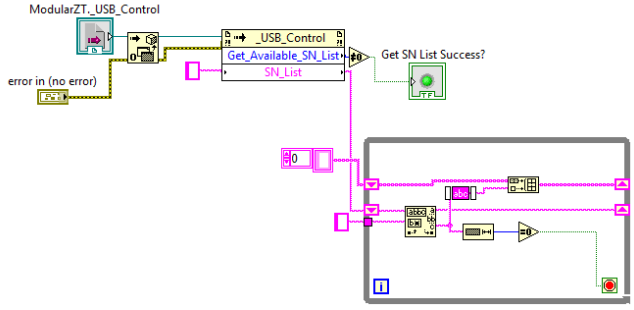


Fig 2.8-xxiii: While loop with exit check

cc. On the Front Panel of this VI, create a drop-down menu by placing a **System Combo Box** function (found in the Systems palette, String & Path sub-palette).
dd. On the Block Diagram, right click the corresponding **System Combo Box** function, create a **Strings[] Property Node** by selection “Create”, “Property Node”, then “Strings[]”. Place the **Strings[] Property Node** outside the **While Loop**.

ee. Right click the **Strings[] Property Node** and select “Change to Write”.
ff. Rename the **System Combo Box** function to “SN_List”. Right-click and un-tick “View As Icon” to save space on the block diagram.
gg. Connect the output from the **Shift Register** that follows the **Build Array** function to the input of the **Strings[] Property Node**.
hh. Connect the *Error Out* terminal of the **_USB_Control Node** to the *Error In* terminal of the **Strings[] Node**.
ii. Create another **While Loop** and arrange it so that it encompasses everything from the **Automation Open** function onwards.
jj. If a **Stop Button** was not created automatically then right-click on the loop condition and select “Create Control” to place the button in the loop.

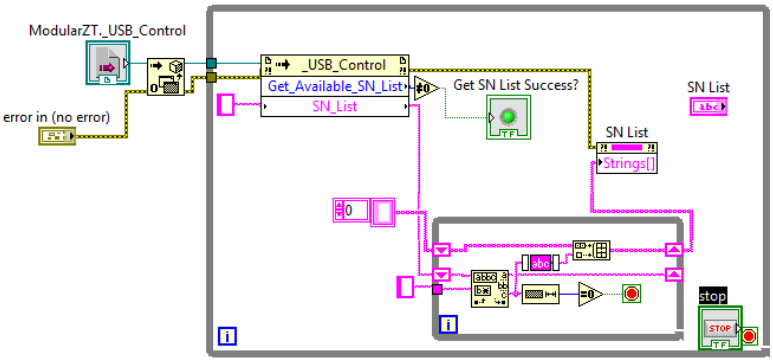


Fig 2.8-xxiv: While Loop encompassing the steps to get the serial number list

kk. On the Front Panel, change the **Stop Button** text from “Stop” to “Connect”.

4. Connecting to a ZTM-X Test System

a. Create a new **Invoke Node** outside the **While Loop**.
b. Connect the *Reference Out* terminal of the **Get_Available_SN_List Node** to the *Reference* terminal of the new **Invoke Node**.
c. Select “Connect” as the method for the new node.
d. Connect the *Error Out* terminal of the **Strings[]** node to the *Error In* terminal of the **Connect** node.
e. Connect the output terminal of the SN_List combo box to the *SN* input terminal of the **Connect Node**.
f. During execution, the program will not get to this stage until the **While Loop** has exited, the result being that the program will populate the drop-down box with all serial numbers and wait for a user input. The program will continue when the user selects the desired serial number and clicks the **Connect** button. If the process of identifying serial numbers is not required (see step 3 above) then the “Connect” function can be used in place of the “Get_Available_SN_List” function and everything that followed.
g. Following the **Connect Node**, the user can place any number of additional nodes in sequence to perform all operations required of the ZTM-X system. The *Reference In* and *Error In* terminals of each new node should be connected to the *Reference Out* and *Error Out* terminals of the previous nodes.
h. The final **Invoke Node** in the program should be set with the “Disconnect” function in order to properly close the connection to the ZTM-X system.
i. The final step in the LabVIEW sequence is to create a **Close Reference** function from the Connectivity palette to terminate the reference to the DLL file. The *Reference In* and *Error In* terminals of the **Close Reference** function should be connected to the respective terminals of the **Disconnect** function.

j. An **Error Out** indicator should be added by right clicking on the *Error Out* terminal of the **Close Reference** function and creating an indicator to show the result.

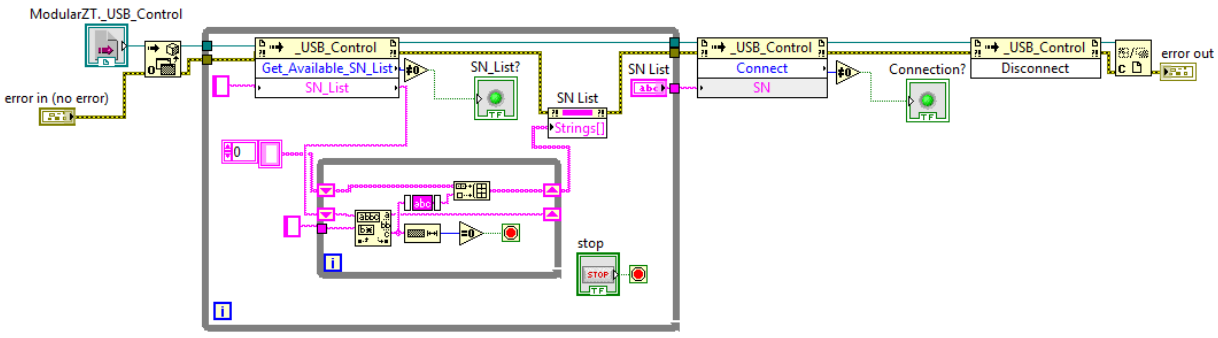


Fig 2.8-xxv: Final program (additional functions to be placed after "Connect")

2.8.2 - USB Control Using the .Net DLL

2.8.2 (a) - Programmable Attenuators

These instructions demonstrate control of Mini-Circuits programmable attenuators in LabVIEW using Mini-Circuits' supplied .Net DLL file. The same methodology applies to the full range of Mini-Circuits' PTE (Portable Test Equipment); substituting the relevant DLL file and functions into the instructions below.

1. Install the DLL

Install the supplied DLL file (mcl_rudat64.dll) to the relevant Windows system folder (see the product Programming Manual for full details). Since this is a .Net DLL rather than ActiveX, it should not be registered.

2. Create a New VI (Virtual Instrument) and Reference the DLL

a. Open LabVIEW with a new, blank VI.
b. In the Block Diagram window (accessible by pressing Ctrl+E), select Functions Palette from the "View" menu at the top of the screen.
c. Click through the Connectivity palette to the .Net palette. Select the **Constructor Node** and place it on the block diagram.

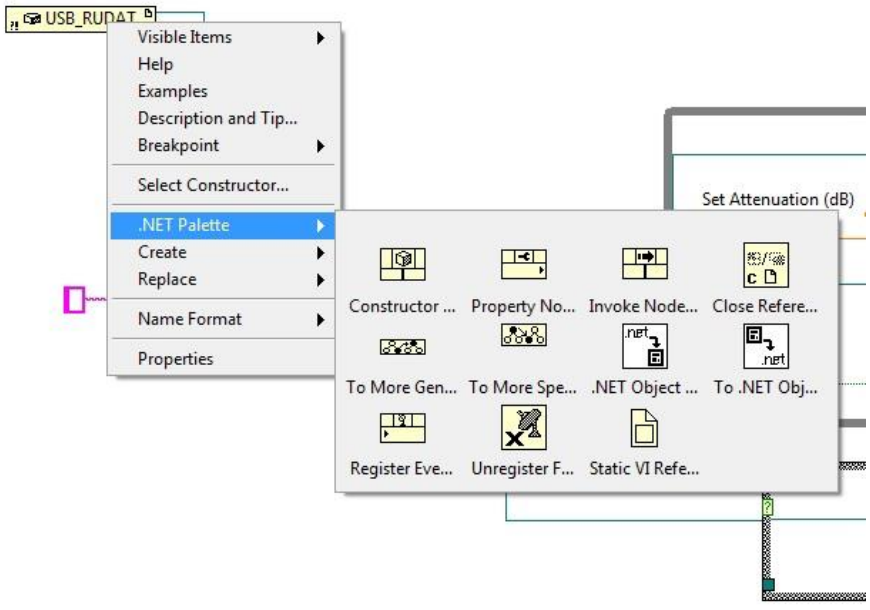


Fig 2.8-xxvi - Path to the Constructor Node in the .Net palette

d. Right-click on the new control, choose the "Select Constructor" option and browse to the location of MCL_rudat64.dll file.

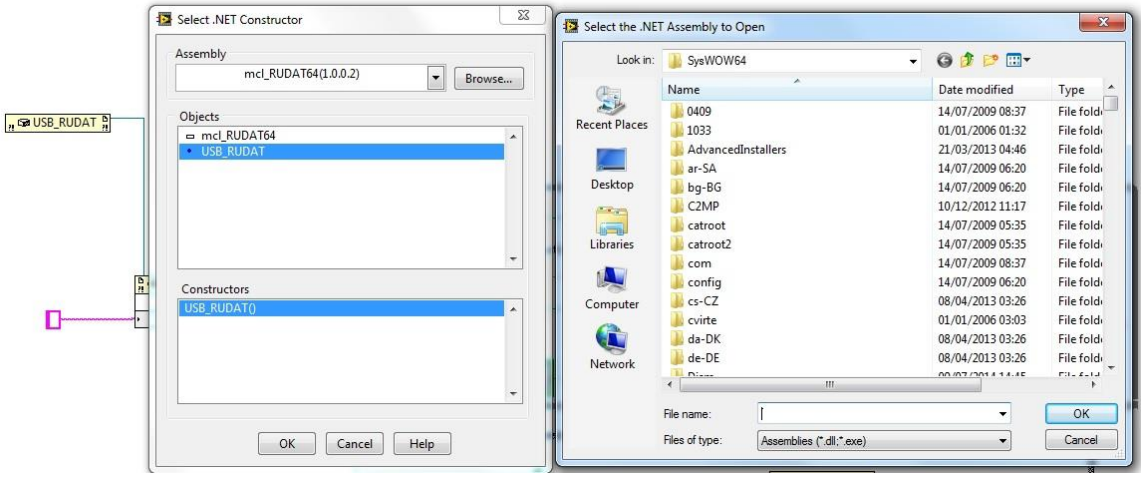


Fig 2.8-xxvii - Selecting the mcl_rudat64.dll .Net assembly

e. After selecting the DLL file, choose “USB_RUDAT” from the list of objects presented.
f. Right-click on the *Error In* terminal of the **Constructor Node** and create a new control.
g. Choose **Invoke Node** from the .Net Palette.
h. Connect the **Constructor Node** to the **Invoke Node** control.

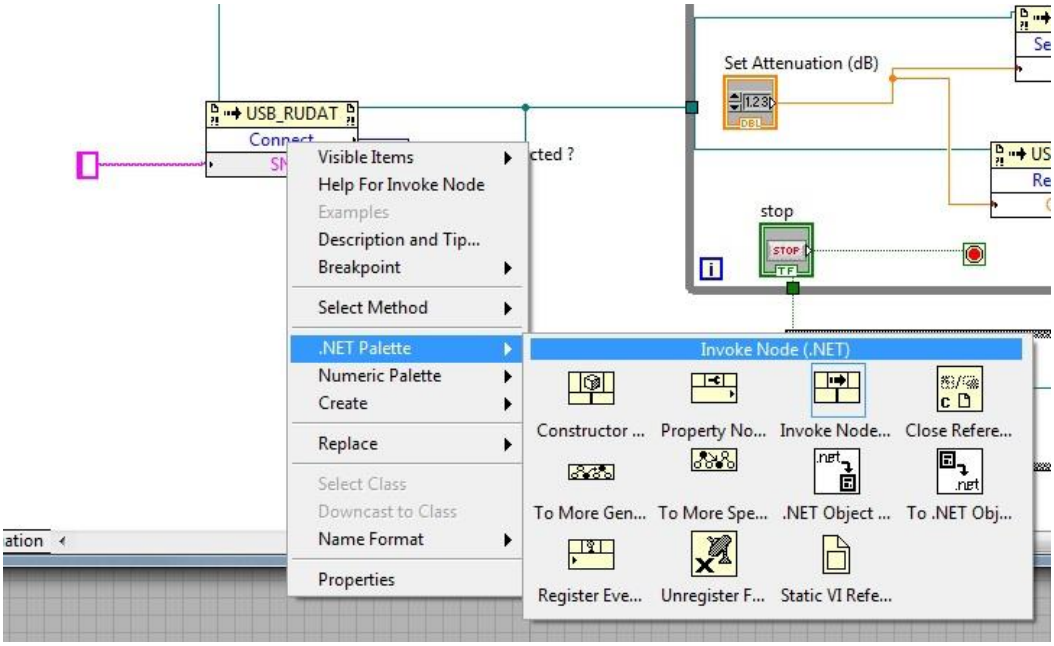


Fig 2.8-xxviii - Placing an Invoke Node

i. Right-click on the Invoke Node and choose the "Select Method" option to view all functions defined in the mcl_rudat64.dll DLL.
j. Select the "Connect" function.

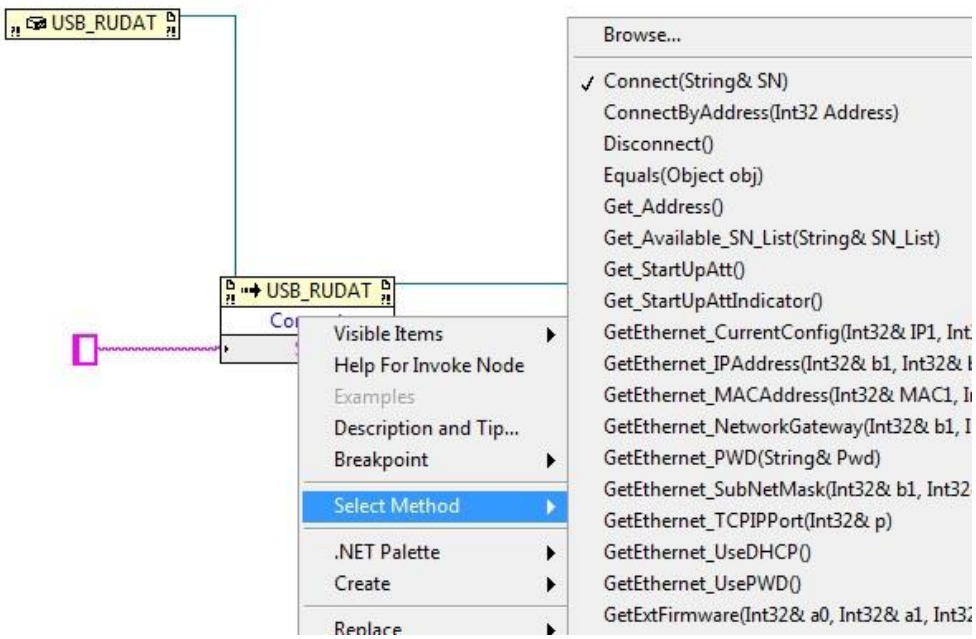


Fig 2.8-xxix - Select the attenuator's Connect function

k. If more than one attenuator will be physically connected then the Connect function requires the serial number of the relevant attenuator to be supplied. Create a numeric control to store the serial number and connect it to the input terminal of the "SN" parameter. This control can be left blank if only one attenuator is connected.

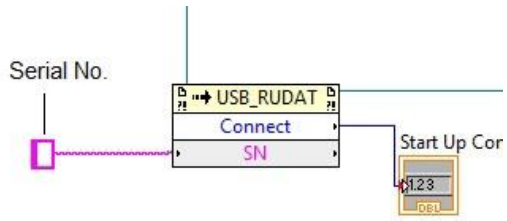


Fig 2.8-xxx - Create a numeric control for the attenuator's serial number

3. Setting Attenuation

a. Create a new **Invoke Node** and set the method to "SetAttenuation".
b. Connect the Input terminal of the Set Attenuation **Invoke Node** to the Connect **Invoke Node**.
c. Create a numeric control to allow the attenuation to be adjusted and connect this to the "TotalAtt" input terminal of the Set Attenuation node.

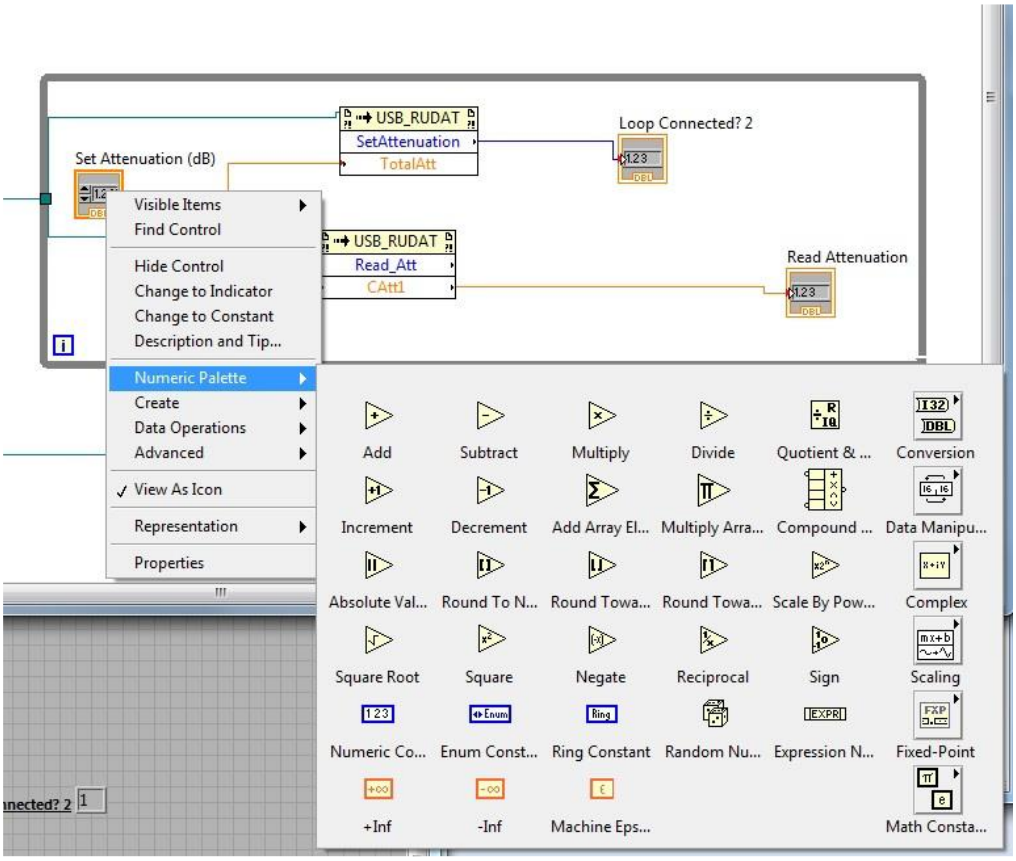


Fig 2.8-xxxi - Placing the "SetAttenuation" node and numeric control to set attenuation

4. Read Attenuation

a. Create a new **Invoke Node** and set the method to "Read_Att".
b. Connect the Input terminal of the Read Attenuation **Invoke Node** to the Connect **Invoke Node**.
c. Select method Read_att.
d. Create a numeric control to display the attenuation and connect it the "CAtt1" Output terminal of the Read Attenuation node.

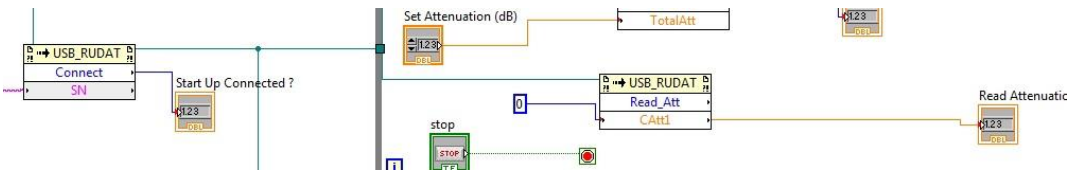


Fig 2.8-xxxii - The Read Attenuation Invoke Node with the numeric control to display the value

2.8.3 - Ethernet Control Using HTTP

2.8.3 (a) - Switch Boxes

These instructions demonstrate control of Mini-Circuits switch boxes in LabVIEW using HTTP communication over an Ethernet network. The same methodology applies to the full range of Mini-Circuits' PTE (Portable Test Equipment), by sending the HTTP commands detailed in the respective programming manuals.

The Mini-Circuits DLL file is not required for HTTP communication since LabVIEW provides an HTTP GET function in the standard package.

1. Create a New VI (Virtual Instrument)

a. Open LabVIEW with a new, blank VI.
b. In the Block Diagram window (accessible by pressing Ctrl+E), select Functions Palette from the "View" menu at the top of the screen.

2. Create a new HTTP GET function

a. In the Functions menu, click through *Data Communications*, to the *HTTP Client* sub-pallette and place an **HTTP Get** function on the block diagram.

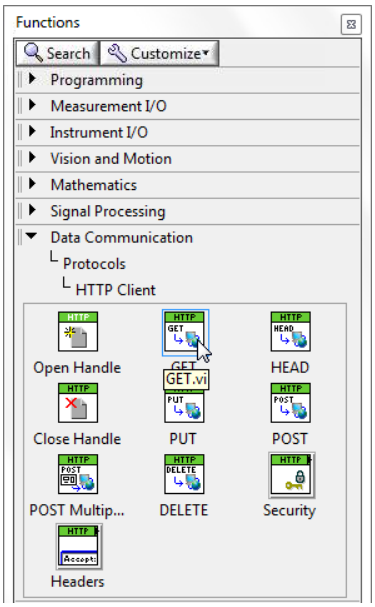


Fig 2.8-xxxiii - Finding the HTTP Get function block

b. Right-click on the *URL* input terminal of the **HTTP Get** function and select *Create* > *Constant*

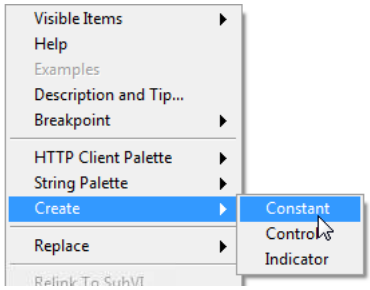


Fig 2.8-xxxiv - Create the string input constant to store the command

c. Place the string constant on the block diagram and enter the HTTP command to send (omitting the "HTTP://"); for example "192.168.9.67/:MN?" to read the model name of a switch with IP address 192.168.9.67.

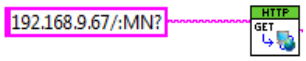


Fig 2.8-xxxv - The HTTP command to read model name

d. Right-click on the *Body* output terminal of the **HTTP Get** function and select *Create* > *Indicator* to store the return value of the HTTP command

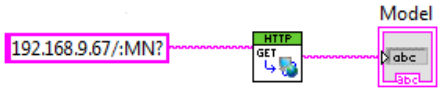


Fig 2.8-xxxvi - HTTP Get function with output indicator

3. Add additional HTTP Get commands

a. Step 2 above can be repeated to add as many HTTP Get functions as needed
b. HTTP Get can also be used to set the switch by sending the relevant command in the string constant, for example "192.168.9.67/:SETA=1" to set switch A to state 1; the return value in that case would be 0 or 1 to indicate whether the command was successful

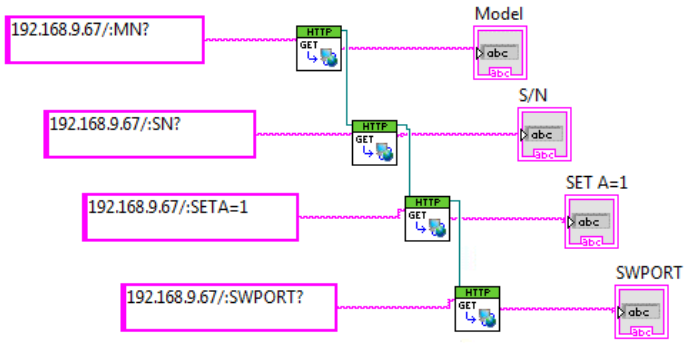


Fig 2.8-xxxvii - HTTP commands to read model name/serial number, set switch state and confirm result

2.9 - MATLAB Worked Examples

2.9.1 - USB Control Using the ActiveX DLL

2.9.1 (a) - Switch Boxes

Overview

These instructions demonstrate how to control any Mini-Circuits USB switch box in MatLab using the ActiveX DLL. The same methodology applies for the full Mini-Circuits range of PTE (Portable Test Equipment); substituting the relevant DLL file and functions into the instructions below.

1. Install and Register the DLL

Install the switch box's DLL file (mcl_rf_switch_controller.dll) to the relevant Windows system folder and register using the Windows regsvr32 program (see the product Programming Manual for full details).

2. Declare the DLL Class

Use the `actxserver` function in Matlab to declare the DLL class and assign it to an object that will represent the switch. The object can be given any name (eg: "sw1") as long as it complies with the naming rules in MatLab.

This process can be repeated in order to control multiple switch boxes simultaneously with MatLab.

For example, to control two switch boxes that are to be referred to as "sw1" and "sw2", the following 2 commands would be needed:

```
>>     sw1 = actxserver('MCL_RF_Switch_Controller.USB_RF_Switch')
>>     sw2 = actxserver('MCL_RF_Switch_Controller.USB_RF_Switch')
```

The program should respond with:

```
sw1 = COM.MCL__RF__Switch__Controller_USB__RF__Switch
sw2 = COM.MCL__RF__Switch__Controller_USB__RF__Switch
```

3. Connect the Switch Boxes by Serial Number

The physical switch hardware must now be assigned to the software switch objects just created (sw1 and sw2). Use the "`Connect`" function (defined in the switch DLL) with the hardware serial numbers. In this example, the 2 switch boxes have serial numbers 11308230011 and 11308230015. MatLab will respond with "`ans = 1`" on success.

```
>>     sw1.Connect('11308230011')
ans = 1
>>     sw2.Connect('11308230015')
ans = 1
```

4. Send Commands

The 2 switch boxes are now configured for use and can be commanded as required. Use the "sw1" or "sw2" name before each command sent in order to address the correct hardware.

A full explanation of the available commands is included in the switch chapter of the Programming Manual at http://www.minicircuits.com/softwaredownload/Prog_Manual-2-Switch.pdf but some brief examples are below:

1) Set sw1 to state 4 and sw2 to state 0:

```
>>      sw1.Set_SwitchesPort(char(4))
ans = 1
>>      sw2.Set_SwitchesPort(char(0))
ans = 1
```

2) Confirm switch states (first define 2 variables "Status" and "SwState" which can accept the return values of the DLL function):

```
>>      [Status,SwState]=sw1.GetSwitchesStatus(SwState)
ans = 1
>>      SwState
ans = 4
>>      [Status,SwState]=sw21.GetSwitchesStatus(SwState)
ans = 1
>>      SwState
ans = 0
```

5. Disconnect the Switch Boxes

The switch boxes should be disconnected on completion of the switching routine using the "Disconnect" function in the DLL:

```
>>      sw1.Disconnect
>>      sw2.Disconnect
```

6. Display all Commands

If required, MatLab can print the full list of available commands to the console using the "invoke" command:

```
>>      sw1.Invoke
GetConnectionStatus = Variant GetConnectionStatus(handle)
GetDeviceTemperature = [single, int16] GetDeviceTemperature(handle, int16)
Get_Available_SN_List = [int16, string] Get_Available_SN_List(handle, string)
Get_Available_Address_List = [int16, string] Get_Available_Address_List(handle, string)
…
…
```

7. Summary

The above sections have been summarized as a complete series of commands below:

```
>>      sw1 = actxserver('MCL_RF_Switch_Controller.USB_RF_Switch')
sw1 = COM.MCL__RF__Switch__Controller_USB__RF__Switch

>>      sw2 = actxserver('MCL_RF_Switch_Controller.USB_RF_Switch')
sw2 = COM.MCL__RF__Switch__Controller_USB__RF__Switch

>>      sw1.Connect('11308230011')
ans = 1

>>      sw2.Connect('11308230015')
ans = 1

>>      sw1.Set_SwitchesPort(char(4))
ans = 1

>>      sw2.Set_SwitchesPort(char(0))
ans = 1

>>      [Status,SwState]=sw1.GetSwitchesStatus(SwState)
ans = 1

>>      SwState
ans = 4

>>      [Status,SwState]=sw21.GetSwitchesStatus(SwState)
ans = 1

>>      SwState
ans = 0

>>      sw1.Disconnect

>>      sw2.Disconnect
```

2.9.2 - USB Control Using the .Net DLL

2.9.2 (a) - Switch Boxes

Overview

These instructions demonstrate how to control any Mini-Circuits USB switch box in MatLab using the .Net DLL. The same methodology applies for the full Mini-Circuits range of PTE (Portable Test Equipment); substituting the relevant DLL file and functions into the instructions below.

1. Install the DLL

Install the switch's DLL file (mcl_rf_switch_controller64.dll) to the relevant Windows system folder (usually \sysWOW64\); there is no need to register .Net DLLs.

2. Provide the Location of the DLL File to MatLab

Use the `NET.addAssembly` function in Matlab to provide a handle to the DLL (so that MatLab can locate it). The handle can be given any name that complies with MatLab's naming rules (eg: "MCL_SW"). This step only needs to be taken once, even if multiple switches are to be commanded simultaneously.

```
>>
MCL_SW=NET.addAssembly('C:\Windows\SysWOW64\mcl_RF_Switch_Controller6
4.dll')
```

MatLab will acknowledge the command with some generic information about .Net assemblies.

3. Reference the .NET assembly

Declare an object that will represent the switch and then assign it to the USB_RF_SwitchBox class defined in the DLL. This process can be repeated in order to control multiple switch boxes simultaneously with MatLab. For example, to control two switch boxes that are to be referred to as "sw1" and "sw2", the following 2 commands would be needed:

```
>> sw1 = mcl_RF_Switch_Controller64.USB_RF_SwitchBox
>> sw2 = mcl_RF_Switch_Controller64.USB_RF_SwitchBox
```

4. Connect the Switch Boxes by Serial Number

The physical switch box hardware must now be assigned to the software objects just created (sw1 and sw2). Use the "`Connect`" function (defined in the DLL) with the hardware serial numbers. In this example, the 2 switch boxes have serial numbers 11504210025 and 11504210026. MatLab will respond with "`ans = 1`" on success.

```
>>    sw1.Connect('11504210025')
ans = 1
>>    sw2.Connect('11504210026')
ans = 1
```

5. Send Commands

The 2 switch boxes are now configured for use and can be commanded as required. Use the "sw1" or "sw2" name before each command sent in order to address the correct hardware.

A full explanation of the available commands is included in the relevant chapter of the Programming Manual at http://www.minicircuits.com/softwaredownload/Prog_Manual-2-Switch.pdf but some brief examples are below:

1) Assume switch box 1 and 2 are both model RC-2SP6T-A18 (dual switch boxes):

```
>>    sw1.Set_2SP6T_COM_To(3, 0)
ans = 1
>>    sw2.Set_2SP6T_COM_To(6, 6)
ans = 1
```

The above commands set the following switch states:

- Switch box 1
  - Switch A = state 3 (Com port connected to port 3)
  - Switch B = state 0 (all ports disconnected)
- Switch box 2
  - Switch A = state 6 (Com port connected to port 6)
  - Switch B = state 6 (Com port connected to port 6)

2) Confirm the above switch states were set using the below commands:

```
>>    sw1.Get_2SP6T_State('A')
ans = 3
>>    sw1.Get_2SP6T_State('B')
ans = 0
>>    sw2.Get_2SP6T_State('A')
ans = 6
>>    sw2.Get_2SP6T_State('B')
ans = 6
```

6. Disconnect the Switch Boxes

The switch boxes should be disconnected on completion of the switching routine using the "Disconnect" function in the DLL:

```
>>    sw1.Disconnect
>>    sw2.Disconnect
```

7. Summary

The above sections have been summarized as a complete series of commands below:

```
>>      MCL_SW=NET.addAssembly('C:\Windows\SysWOW64\mcl_rf_switch_controller64.dll')

>>      sw1 = mcl_rf_switch_controller64.USB_RF_SwitchBox
sw1 =
        mcl_RF_Switch_Controller64.USB_RF_SwitchBox handle with no properties.
        Package: mcl_RF_Switch_Controller64

        Methods, Events, Superclasses

>>      sw2 = mcl_rf_switch_controller64.USB_RF_SwitchBox
sw2 =
        mcl_RF_Switch_Controller64.USB_RF_SwitchBox handle with no properties.
        Package: mcl_RF_Switch_Controller64

        Methods, Events, Superclasses

>>      sw1.Connect('11504210025')
ans = 1
>>      sw2.Connect('11504210026')
ans = 1

>>      sw1.Set_2SP6T_COM_To(3, 0)
ans = 1

>>      sw2.Set_2SP6T_COM_To(6, 6)
ans = 1

>>      sw1.Get_2SP6T_State('A')
ans = 3

>>      sw1.Get_2SP6T_State('B')
ans = 0

>>      sw2.Get_2SP6T_State('A')
ans = 6

>>      sw2.Get_2SP6T_State('B')
ans = 6

>>      sw1.Disconnect

>>      sw2.Disconnect
```

2.9.2 (b) - IO Control Boxes

Overview

These instructions demonstrate how to control any Mini-Circuits USB Input/Output Control box in MatLab using the .Net DLL. The same methodology applies for the full Mini-Circuits range of PTE (Portable Test Equipment); substituting the relevant DLL file and functions into the instructions below.

1. Install the DLL

Install the control box's DLL file (MCL_USB_To_IO_64.dll) to the relevant Windows system folder (usually \sysWOW64\); there is no need to register .Net DLLs.

2. Provide the Location of the DLL File to MatLab

Use the `NET.addAssembly` function in Matlab to provide a handle to the DLL (so that MatLab can locate it). The handle can be given any name that complies with MatLab's naming rules (eg: "USB_IO"). This step only needs to be taken once, even if multiple control boxes are to be commanded simultaneously.

```
>> USB_IO=NET.addAssembly('C:\Windows\SysWOW64\mcl_USB_To_IO_64.dll')
```

MatLab will acknowledge the command with some generic information about .Net assemblies.

3. Reference the .NET assembly

Declare an object that will represent the control box and then assign it to the USB_IO class defined in the DLL. This process can be repeated in order to control multiple control boxes simultaneously with MatLab. For example, to control two input/output control boxes that are to be referred to as "io1" and "io2", the following 2 commands would be needed:

```
>> io1 = mcl_USB_To_IO_64.USB_IO
>> io2 = mcl_USB_To_IO_64.USB_IO
```

4. Connect the Control Boxes by Serial Number

The physical control box hardware must now be assigned to the software objects just created (io1 and io2). Use the "`Connect`" function (defined in the DLL) with the hardware serial numbers. In this example, the 2 control boxes have serial numbers 11308230011 and 11308230015. MatLab will respond with "`ans = 1`" on success.

```
>>    io1.Connect('11308230011')
ans = 1
>>    io2.Connect('11308230015')
ans = 1
```

5. Send Commands

The 2 control boxes are now configured for use and can be commanded as required. Use the "io1" or "io2" name before each command sent in order to address the correct hardware.

A full explanation of the available commands is included in the relevant chapter of the Programming Manual at www.minicircuits.com/softwaredownload/Prog_Manual-7-IO_Control.pdf but some brief examples are below:

1) Set the "byte A" output of io1 to state 52 and io2 to 48:

```
>>    io1.Set_ByteA(52)
ans = 1
>>    io2.Set_ByteA(48)
ans = 1
```

2) Confirm the output states (first define 2 variables, arbitrarily called "Status" and "ioValue", which can accept the return values of the DLL function):

```
>>    [Status,ioValue]=io1.ReadByteA(ioValue)
ans = 1
>>    ioValue
ans = 52
>>    [Status,ioValue]=io2.ReadByteA(ioValue)
ans = 1
>>    ioValue
ans = 48
```

6. Disconnect the Control Boxes

The control boxes should be disconnected on completion of the routine using the "Disconnect" function in the DLL:

```
>>    io1.Disconnect
>>    io2.Disconnect
```

7. Summary

The above sections have been summarized as a complete series of commands below:

```
>>      USB_IO=NET.addAssembly('C:\Windows\SysWOW64\mcl_USB_To_IO_64.dll')

>>      io1 = mcl_USB_To_IO_64.USB_IO
io1 =
        mcl_USB_To_IO64.USB_IO handle with no properties
        Package: mcl_USB_To_IO_64

        Methods, Events, Superclasses

>>      io2 = mcl_USB_To_IO_64.USB_IO
io1 =
        mcl_USB_To_IO64.USB_IO handle with no properties
        Package: mcl_USB_To_IO_64

        Methods, Events, Superclasses

>>      io1.Connect('11308230011')
ans = 1

>>      io2.Connect('11308230015')
ans = 1

>>      io1.Set_ByteA(52)
ans = 1

>>      io2.Set_ByteA(48)
ans = 1

>>      [Status,ioValue]=io1.ReadByteA(ioValue)
ans = 1

>>      ioValue
ans = 52

>>      [Status,ioValue]=io2.ReadByteA(ioValue)
ans = 1

>>      ioValue
ans = 48

>>      io1.Disconnect

>>      io2.Disconnect
```

2.9.2 (d) - Daisy-Chained Solid-State Switches

Example for control of multiple Mini-Circuit's Z-Series solid-state switches. The switches can be connected in a daisy-chain configuration via their serial control interfaces, with control for the full chain through the USB connection of the Master switch module.

Note: The example uses the Send_SCPI function from the Mini-Circuits DLL. This function is defined with 2 arguments passed by reference but since this concept does not fit exactly when implemented in MatLab, the results can be obtained by interpreting the function's return value as a tuple of all parameters, as shown below.

```
% Reference the DLL
MCL_SW =
NET.addAssembly('c:\Windows\SysWOW64\mcl_MasterSlaveSwitch_64.dll');
sw = mcl_MasterSlaveSwitch_64.USB_Control;

% Connect to the master switch module
status = sw.Connect();

% Check how many switch modules are connected in the daisy-chain
[status, command, sw_count] = sw.Send_SCPI(":NumberOfSlaves?", "");

% Check model name / serial number of the connected switch modules
[status, command, model_name] = sw.Send_SCPI(":00:MN?", "");
[status, command, serial_no] = sw.Send_SCPI(":00:SN?", "");

[status, command, model_name] = sw.Send_SCPI(":01:MN?", "");
[status, command, serial_no] = sw.Send_SCPI(":01:SN?", "");

% Set switch state
status = sw.Send_SCPI(":02:SP16T:STATE:16", "");

% Get switch state
[status, command, sw_state] = sw.Send_SCPI(":02:SP16T:STATE?", "");

sw.Disconnect();
```

2.9.2 (e) - ZTVX 2 by n Switch Matrices

This brief example demonstrates how to send SCPI commands to the ZTVX Series 2 by n switch matrices to control the system. The full range of SCPI commands is covered in the ZTVX programming manual.

```
% Reference the path / filename of the DLL below
ZTVX_USB = NET.addAssembly('C:\Windows\SysWOW64\MCL_ZTVX_64.dll')
MyPTE1 = MCL_ZTVX_64.USB_Control

MyPTE1.Connect()     % Connect to the switch matrix
                     % (pass serial number as a string if more than 1 connected)

% Use Send_SCPI for most switch matrix control requirements:
%  [status, return_string] = MyPTE1.Send_SCPI(command_string, return_string)
%  Parameters:
%    command_string = The command / query to send to the switch matrix
%                     (see section 2 of the programming manual)
%    return_string = variable to contain the response from the matrix
%    (not strictly needed for MatLab, empty string constant should also work)
%  Return values:
%    status = 0 (fail) or 1 (success)
%    return_string = the response from the switch matrix

% General queries:
[status, serial_no] = MyPTE1.Send_SCPI(":SN?", serial_no)       % Get serial no
[status, model_name] = MyPTE1.Send_SCPI(":MN?", model_name)     % Get model name

% Set switch paths (switch_success will be 0 or 1 to indicate success)
[status, switch_success] = MyPTE1.Send_SCPI(":PATH:A1:N7", switch_success)
      % Connect port A1 to port N7
[status, switch_success] = MyPTE1.Send_SCPI(":PATH:A2:N5", switch_success)
      % Connect port A2 to port N5

% Get the output ports to which input ports A1 and A2 are connected
% A1_connection and A2_connection should be N7 and N5 respectively in this example
[status, A1_connection] = MyPTE1.Send_SCPI(":PATH:A1?, A1_connection)
[status, A2_connection] = MyPTE1.Send_SCPI(":PATH:A2?", A2_connection)

MyPTE1.Disconnect          % Disconnect at the end of the program
```

2.9.3 - Ethernet Control Using HTTP

Mini-Circuits' software controlled test devices with an Ethernet connection support HTTP communication so MatLab's urlread() function can be used for control. The urlread function takes a URL as an argument and returns the response from the device as a string. The URL argument is formed using the device's IP address and the command / query to send.

2.9.3 (a) - Switch Boxes

```
str = urlread('http://192.100.100.1/:MN?')
% Read model name (str should be MN=…)

str = urlread('http://192.100.100.1/:SN?')
% Read serial number (str should be SN=…)

str = urlread('http://192.100.100.1/:SP4TA:STATE:3')
% Set SP4T to state 3 (str should be 1 to indicate success)

str = urlread('http://192.100.100.1/:SP4TA:STATE?')
% Get state of SP4T (str should be 3 to indicate Com to port 3)
```

2.9.3 (b) - Programmable Attenuators

```
str = urlread('http://192.100.100.1/:MN?')
% Read model name (str should be MN=…)

str = urlread('http://192.100.100.1/:SN?')
% Read serial number (str should be SN=…)

str = urlread('http://192.100.100.1/:SETATT:12.25')
% Set attenuation to 12.25 dB (str should be 1 to indicate success)

str = urlread('http://192.100.100.1/:ATT?')
% Get attenuation value
```

2.9.3 (c) - Signal Generator (SSG-15G-RC)

This example demonstrates how to configure a dynamic pulse sequence with the SGM-15G-RC signal generator from MatLab.

```
url='http:%10.0.6.48/:DFS:NoOfPulses:3' ;   % define 3 pulses
str = urlread(url);
%  Disable continuous mode in order to set a specific number or repetitions
url='http:%10.0.6.48/:DFS:Cont:0' ;
str = urlread(url);
url='http:%10.0.6.48/:DFS:NoOfCycles:100' ;  %  Set 100 cycles
str = urlread(url);

% define the 3 pulses
% PULSE #0
url='http:%10.0.6.48/:DFS:Pulse_IDX:0' ;  %  set pulse index to 0
str = urlread(url);
url='http:%10.0.6.48/:DFS:RF:FREQ:1000 ' ;  %  set RF freq to 1000 MHz
str = urlread(url);
url='http:%10.0.6.48/:DFS:RF:Power:5 ' ;  %  set RF Power to +5 dBm
str = urlread(url);
url='http:%10.0.6.48/:DFS:PulseWidth:1 ' ;  %  set pulse width to 1 us
str = urlread(url);
url='http:%10.0.6.48/:DFS:Interval:100 ' ;  %  set interval to 100 us
str = urlread(url);

%  PULSE #1
url='http:%10.0.6.48/:DFS:Pulse_IDX:1' ;  %  set pulse index to 1str =
urlread(url);
url='http:%10.0.6.48/:DFS:RF:FREQ:1100 ' ;  %  set RF freq to 1100 MHz
str = urlread(url);
url='http:%10.0.6.48/:DFS:RF:Power:5 ' ;  %  set RF Power to +5 dBm
str = urlread(url);
url='http:%10.0.6.48/:DFS:PulseWidth:2 ' ;  %  set pulse width to 2 us
str = urlread(url);
url='http:%10.0.6.48/:DFS:Interval:150 ' ;  %  set interval to 150 us
str = urlread(url);

% PULSE #2
url='http:%10.0.6.48/:DFS:Pulse_IDX:2' ;  %  set pulse index to 2
str = urlread(url);
url='http:%10.0.6.48/:DFS:RF:FREQ:1200 ' ;  %  set RF freq to 1200 MHz
str = urlread(url);
url='http:%10.0.6.48/:DFS:RF:Power:5 ' ;  %  set RF Power to +5 dBm
str = urlread(url);
url='http:%10.0.6.48/:DFS:PulseWidth:3 ' ;  %  set pulse width to 3 us
str = urlread(url);
url='http:%10.0.6.48/:DFS:Interval:200 ' ;  %  set interval to 200 us
str = urlread(url);

DFS:MODE:ON     % Enable the pulsed output
```

2.10 - Keysight VEE Worked Examples

2.10.1 - USB Control Using the ActiveX DLL

2.10.1 (a) - Switch Boxes

Overview

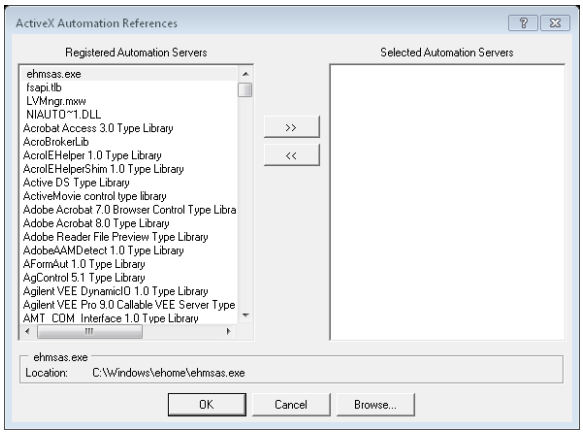
These instructions demonstrate how to control any Mini-Circuits USB switch box in Keysight VEE using the ActiveX DLL. The same methodology applies for the full Mini-Circuits range of PTE (Portable Test Equipment); substituting the relevant DLL file and functions into the instructions below.

1. Install the DLL

Install the DLL file (mcl_rf_switch_controller.dll) to the relevant Windows system folder and register using the Windows regsvr32 program (see the product Programming Manual for full details).

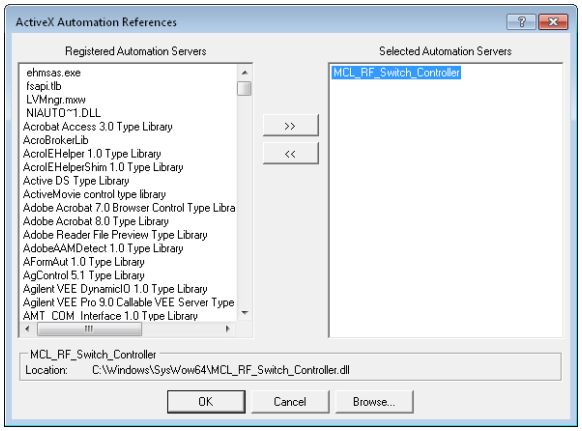
2. Create the Switch Object in Agilent VEE

a. Open the Agilent VEE program as an administrator (right-click the icon on the Windows Start Menu and select “Run as administrator”)
b. Select Device >> ActiveX Automation References from the VEE main menu:



c. Click Browse, navigate to the DLL (MCL_RF_Switch_Controller.dll) and click Open

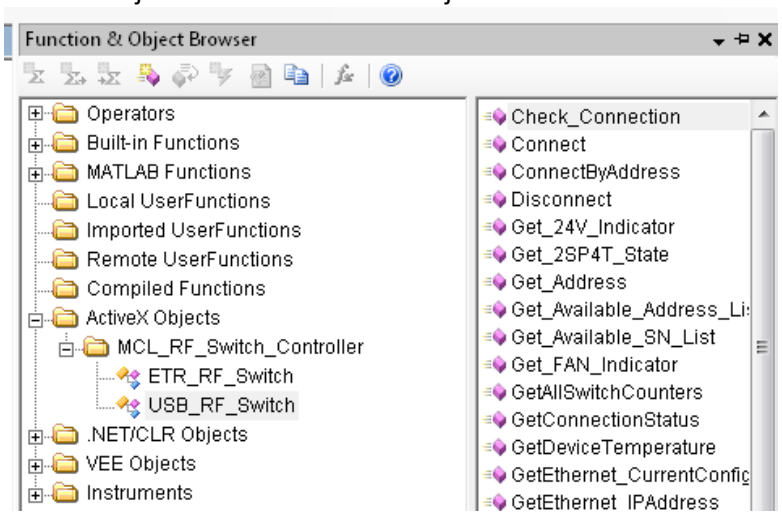
d. MCL_RF_Switch_Controller should appear in the list of Select Automation Servers, click OK:



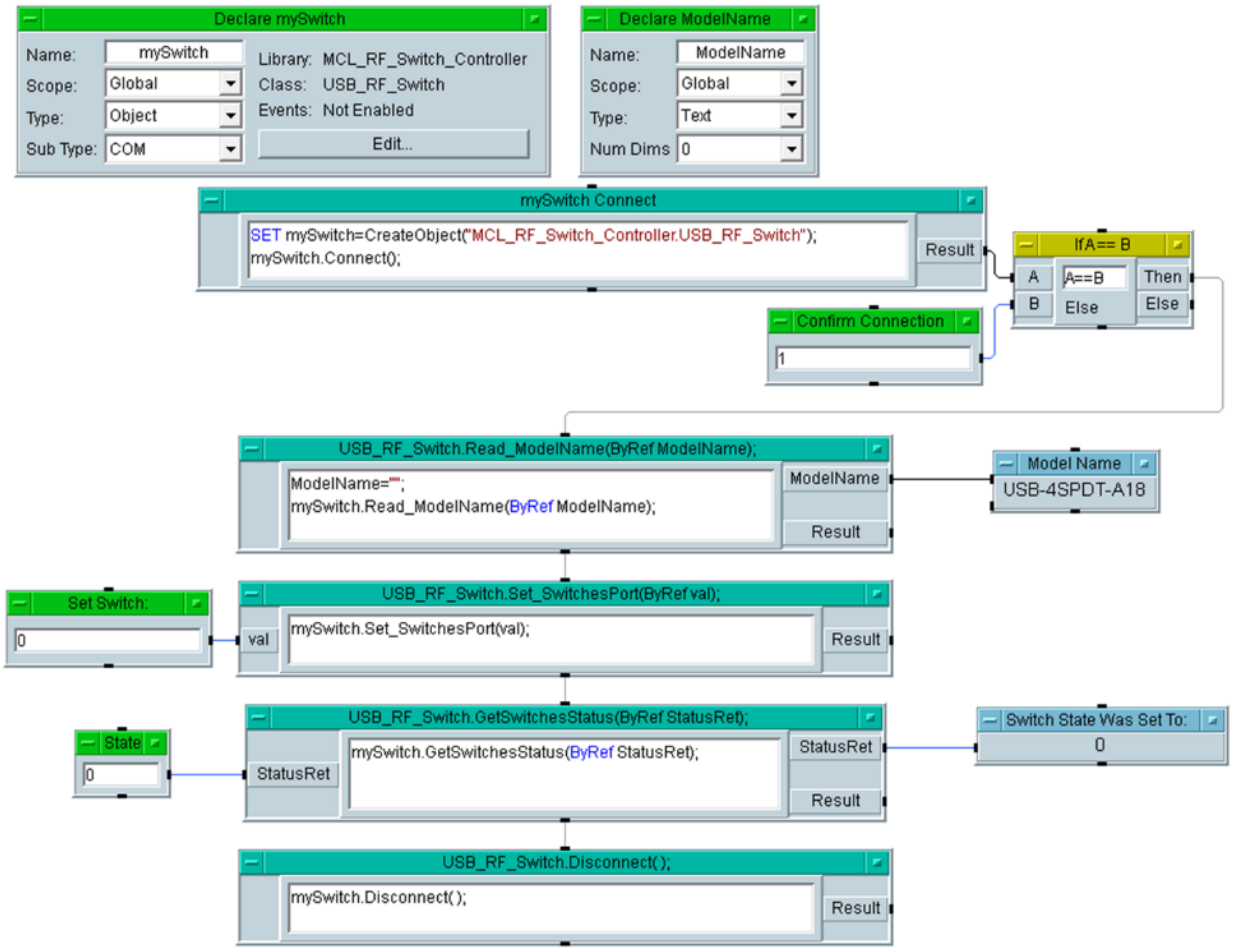
e. Click OK when the switch DLL appears in the Selected Automation Servers column

3. Create the Program

Agilent VEE can now access the switch DLL and will display all the switch functions under ActiveX Objects in the Function & Object Browser:



The functions can be arranged in the VEE workspace as required to create the switching routine. A simple example is shown below:



The program takes the following steps:

a. Declare global variables:
    a. mySwitch – the switch object, linked to the ActiveX COM object
    b. ModelName – a variable to store the switches model name
b. Use the CreateObject function to declare the switch software object, then use Connect to connect the hardware
c. Check that the return value from Connect is 1 before continuing
d. Check and output the model name of the switch
e. Set the switch state using a numeric value entered by the user in SetSwitch
f. Confirm the switch state and output it to the screen
g. Disconnect the switch

2.10.2 - USB Control Using the .Net DLL

2.10.2 (a) - Switch Boxes

Overview

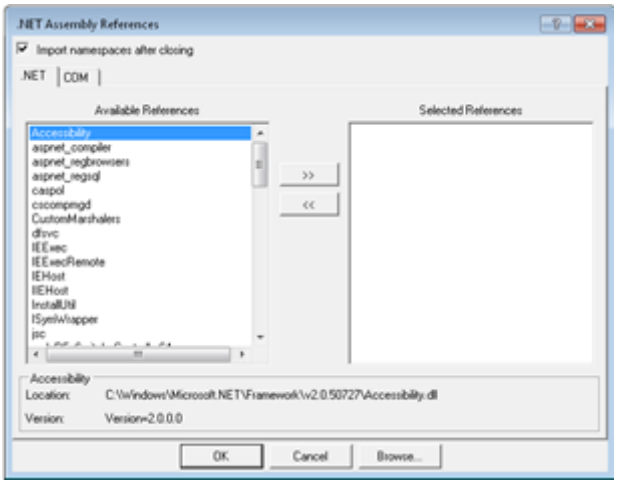
These instructions demonstrate how to control any Mini-Circuits USB switch box in Keysight VEE using the .Net DLL. The same methodology applies for the full Mini-Circuits range of PTE (Portable Test Equipment); substituting the relevant DLL file and functions into the instructions below.

1. Install the DLL

Install the DLL file (MCL_RF_Switch_Controller64.dll) to the relevant Windows system folder (usually \sysWOW64\); there is no need to register .Net DLLs.

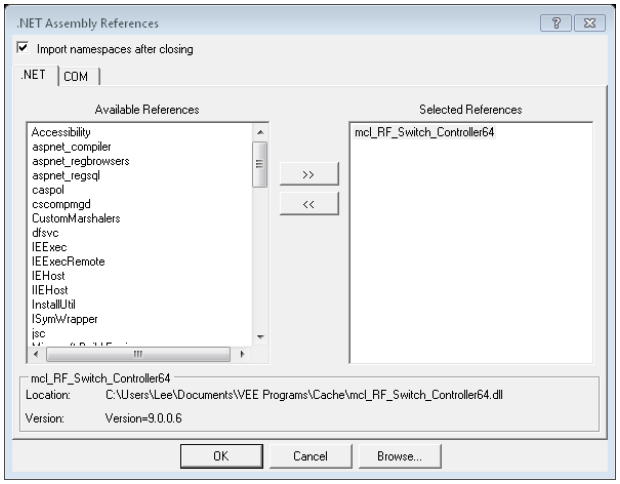
2. Create the Switch Object in Agilent VEE

a. Open Agilent VEE and select Device >> .NET Assembly References from the main menu:

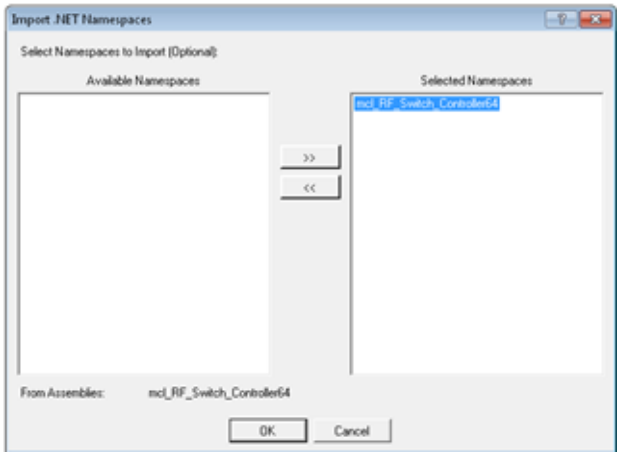


b. Click Browse, navigate to the DLL (MCL_RF_Switch_Controller64.dll) and click Open

c. MCL_RF_Switch_Controller64 should appear in the list of Selected References, click OK:

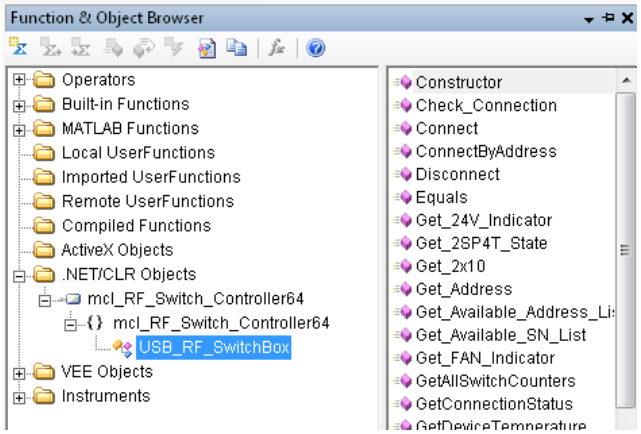


d. mcl_RF_Switch_controller64 should appear in the list of Available Namespaces; double-click on it to move it to Selected Namespaces and then click OK:

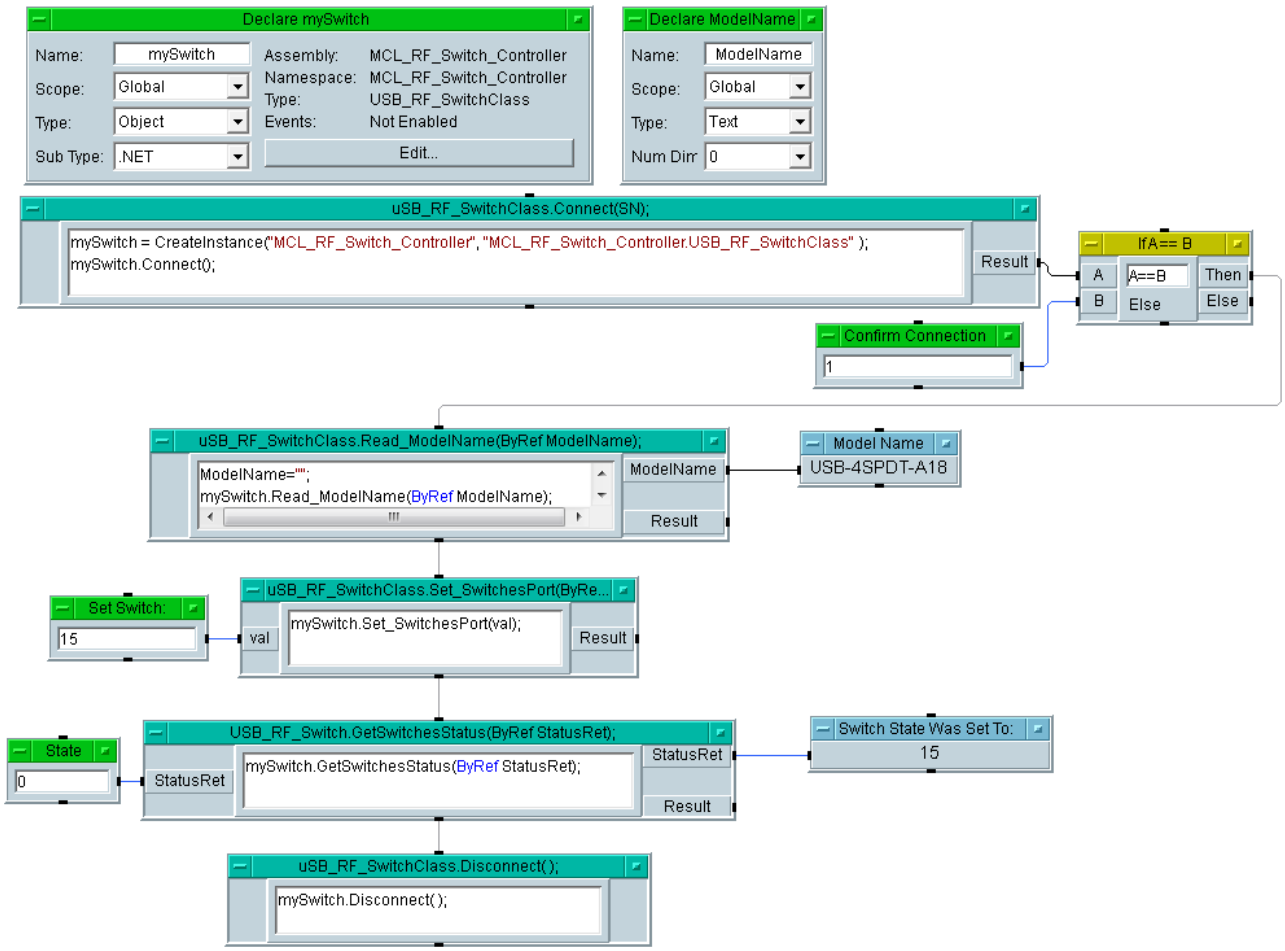


3. Create the Program

Agilent VEE can now access the switch DLL and will display all the switch functions under .NET/CLR Objects in the Function & Object Browser:



The functions can be arranged in the VEE workspace as required to create the switching routine. A simple example is shown below.



The program takes the following steps:

h. Declare global variables:
   a. mySwitch – the switch object, linked to the .NET object
   b. ModelName – a variable to store the switches model name
i. Use the CreateInstance function to declare an instance of the switch software object, then use Connect to connect the hardware
j. Check that the return value from Connect is 1 before continuing
k. Check and output the model name of the switch
l. Set the switch state using a numeric value entered by the user in SetSwitch
m. Confirm the switch state and output it to the screen
n. Disconnect the switch

3 - Troubleshooting

3.1 - Working with the DLL Files

3.1.1 - File Placement

32-bit Operating Systems

The default DLL file location is the System32 sub-folder of the Windows root directory, usually:
`C:\Windows\System32\`

- ActiveX DLL files must be placed in this directory
- .NET DLL files can generally be placed in any directory as long as the correct reference is set within the programming environment. However, if there is an issue with using the DLL then we would recommend placing it in the default directory as the first step in troubleshooting.

64-bit Operating Systems

The default DLL file location is the SysWoW64 sub-folder of the Windows root directory, usually:
`C:\Windows\SysWOW64\`

- ActiveX DLL files must be placed in this directory
- .NET DLL files can generally be placed in any directory as long as the correct reference is set within the programming environment. However, if there is an issue with using the DLL then we would recommend placing it in the default directory as the first step in troubleshooting.

3.1.2 - Windows File Blocking

Windows will occasionally block system files downloaded from the Internet when it is not sure of the source. In this state the DLL file can be placed in the relevant directory but it will not be useable from the programming environment. To review and unblock a DLL, right-click on the file in Windows Explorer and select Properties:

Fig 3.1-i - Windows file properties dialog for a blocked DLL (see Security comment at the bottom)

A Security comment will appear at the bottom of the dialog if the file is blocked, advising "This file came from another computer and might be blocked to help protect this computer." Click the Unblock button to enable the DLL.

3.1.3 - File Registration

The .NET DLL does not need to be registered in the operating system; an error will be returned if this is attempted.

The ActiveX DLL must be registered in the operating system using the Windows regsvr32.exe program. This can be done using the Windows command prompt in elevated mode (right-click on the icon and select "run as administrator").

Fig 3.1-ii - Opening the Command Prompt in WIndows XP (left-click on Command Prompt)

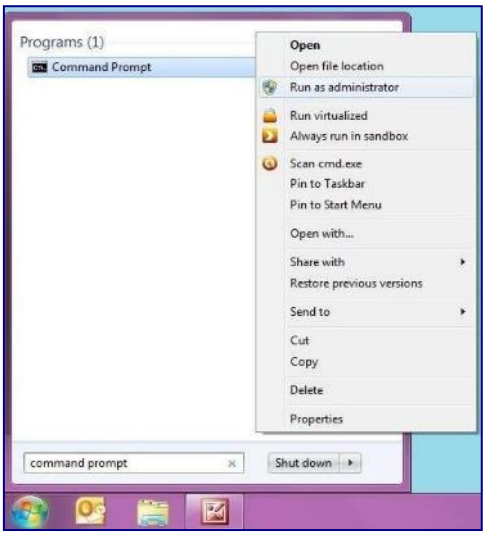


Fig 3.1-iii - Opening the Command Prompt in Windows 7 (right-click and select "Run as administrator")

Fig 3.1-iv - Opening the Command Prompt in Windows 8 (right-click and select "Run as administrator")

32-bit Operating Systems

The command to enter into the command prompt is as below (where "dll_filename.dll" is replaced with the dll to register, eg: "mcl_pm.dll"):

- Type `regsvr32 dll_filename.dll`

64-bit Operating Systems

64-bit Windows operating systems have 2 versions of the regsvr32.exe program and 2 default directories for DLL files (the System32 and SysWOW64 folders) so it is important to be explicit with the pathnames to ensure the correct program and DLL are found.

1. Type `cd \windows\syswow64` to move from the current directory to the SysWOW64 directory
2. Type `regsvr32 dll_filename.dll` to register the DLL (where "dll_filename.dll" is replaced with the dll to register, eg: "mcl_pm.dll")

3.1.3 (a) - Successful Registration

When a DLL file is successfully registered using the instructions above, the below message (or similar) will be displayed:

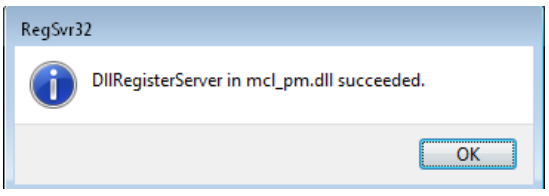


Fig 3.1-v - Successful registration message

3.1.3 (b) - Common Registration Error Messages

Some commonly encountered error messages when attempting to register DLL files are summarised below.

DLLRegisterServer Was Not Found

The below error indicates that the regsvr32 program found the DLL but could not locate the necessary section in order to register it. This is commonly encountered for Mini-Circuits' DLL files when attempting to register a .NET DLL.

Solution: Mini-Circuits' .NET DLLs should not be registered so you can ignore this error and start using the DLL without doing anything further.

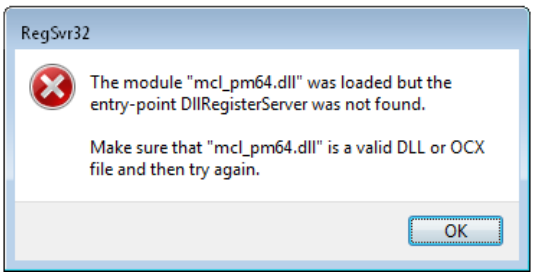


Fig 3.1-vi - "DLLRegisterServer was not found" Error

DLLRegisterServer Failed

The below error indicates that the regsvr32 program found the DLL and attempted to register it but was unable to do so. The most common occurrence of this error when attempting to register Mini-Circuits' DLL files is that the command prompt does not have the necessary administrator priviledge to change Windows' system settings.

Solution: Close the command prompt and re-open it in "elevated mode" by right-clicking on the icon and selecting "Run as administrator". Then repeat the registration process as described above.

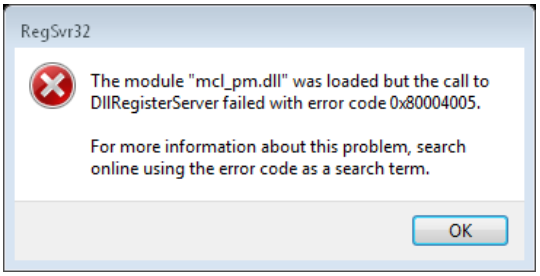


Fig 3.1-vii - "DLLRegisterServer failed" Error

Module Failed to Load

The below error indicates that the regsvr32 program was unable to find the DLL file.

Solution: Check that the DLL path and filename were entered correctly. On 64-bit machines, ensure that the command prompt is at the correct directory (`\Windows\SysWOW64`).

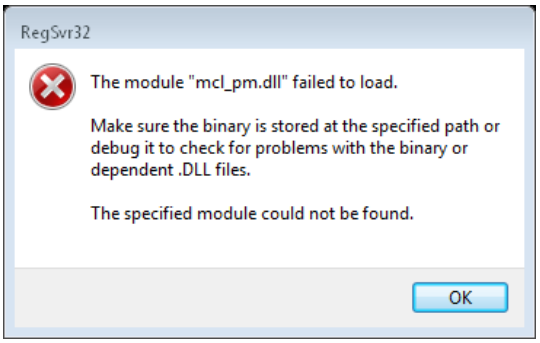


Fig 3.1-viii - "Module ... failed to load" Error