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SOFTWARE DEVELOPMENT, ITEM 0005 OF MICROPROCESSOR-BASED POWER C--ETC(U
FEB 79 DAAK70-78-C-0117
UNCLASSIFIED NL

1 OF 1
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LEVEL II

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SOFTWARE DEVELOPMENT,

ITEM 0005

OF

MICROPROCESSOR-BASED POWER

CONDITIONER CONTROLLER.

7 Feb 79

CONTRACT NO. DAAK70-78-C-0117

51

PREPARED FOR

U. S. ARMY MERADCOM

FORT BELVOIR, VIRGINIA 22060

PREPARED BY

YUCCA INTERNATIONAL INCORPORATED

14415 N. SCOTTSDALE ROAD

SUITE 700

SCOTTSDALE, ARIZONA 85260

FEBRUARY 1979

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LIST OF APPENDICES

1.0.0 SUMMARY

This report describes the efforts performed under Task 5 of U. S. Army contract no. DAAK70-78-C-0117 to develop a microprocessor-based controller for the Delco 15KW power conditioner.

Continuing from the hardware development, the previous task, the software necessary to perform voltage regulation of the converter section was developed using the Motorola Exorcisor development system and the MC6809 Assembler.

The assembled program was executed and debugged using the simulation capability provided by the Motorola MC6809 Simulator and Motorola Exorcisor.

2.0.0 PREFACE

Work described in this report was performed by Yucca International, Inc. under the direction of the U. S. Army Mobility Equipment Research & Development Command. This completes the fifth task of the first phase of the U. S. Army contract no. DAAK70-78-C-0117. The Contracting Officer's Representative is Dr. David Lee of the U. S. Army MERADCOM Headquarters at Fort Belvoir, Virginia.

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3.0.0 COPYRIGHT PERMISSION

No copyright permission is required.

4.0.0 INTRODUCTION

This is a report of the fifth of six tasks of the U. S. Army contract no. DAAK70-78-C-0117.

Performed during the previous tasks was the design and development of the controller hardware. The objective of this task was to generate the necessary software to perform voltage regulation of the converter section of the Delco 15 KW power conditioner.

This report details the voltage regulation routines. Contained in the report are flow charts and an assembled listing of the software.

5.0.0 INVESTIGATION

5.1.0 VOLTAGE REGULATION CONSIDERATIONS

The software generated during this task is intended to operate the controller hardware to perform voltage regulation of the AC to DC section in the power conditioner.

The power conditioner is designed to operate from a poor quality AC source, thus the AC input is allowed to fluctuate +19% and -15% from 120/208 VRMS.

The fluctuating AC input voltage, the converter operating frequency, and the load on the converter output determines the converter output voltage.

To regulate the converter output voltage at a steady DC level the controller varies the converter operating frequency.

5.2.0 VOLTAGE REGULATION ROUTINES

Two different converter output voltage error correction routines were employed in the controller software.

One corrects for small errors, the other corrects for large errors. Currently, a large error is defined as a measured voltage that differs greater than 10% from the reference value.

5.2.1 SMALL ERROR ROUTINE

The small error correction is based on a percentage of the error that was detected. The reference value and the measured value will both be an 8 bit binary value. A one bit difference between the two values corresponds approximately to a 0.5% error. The correction to the converter oscillator DAC value (which represents operating frequency) is calculated by shifting the 11 bit binary value (10 bits $\pm$ 1 overload offset bit) right the appropriate number of bit positions.

For instance, to correct a 0.5% error (1 bit error), a 0.1% correction is applied to the converter oscillator DAC value. This correction is found by dividing the DAC value by 1024, to produce a value that is approximately 0.1% of the DAC value. The division is performed by shifting right 10 places. Although it may take several times through the small error routine to correct the error to zero, a correction much less than the actual error avoids possible overcorrection. The overcorrection would be due to non-linearity of the converter output power versus operating frequency characteristics.

Table 2 in the listing shows the percent that the converter oscillator frequency will be adjusted given a particular converter output voltage error.

Table 2 can be expanded to correct for larger errors but it is expected that regulation would be slower compared to the large error correction routine described below.

5.2.2 LARGE ERROR ROUTINE

For large converter output voltage errors it may be inefficient to use the small error correction method.

An alternate method was devised to correct for large changes in converter output voltage due to application and removal of full loads.

This method utilizes a table which correlates a calculated value of converter output power with a corresponding converter operating frequency.

The frequency value obtained from the table assumes a converter input voltage of 300 volts DC and is subject to a correction factor when the input voltage deviates from 300 volts DC.

The converter output power requirements can be calculated by measuring the converter output voltage (V measured) and inverter input current (I measured) and using the equation derived below:

1) V Measured/I Measured = Resistance of converter load = V Reference/I Desired

2) I Desired = (V Reference/V Measured) (I Measured)

3) Power = (I Desired) (V Reference) = (I Desired) (Ratio)

To simplify equation 3, the V Reference term was replaced with Ratio. When the front panel voltage select switches are set to 120 VRMS out, the Ratio will be 1.00, otherwise it will be a normalized value relative to 120 VRMS.

The final equation actually used in the software is

Power = (V Nominal/V Measured) (I Measured) (Ratio)

This routine is intended to use the load vs. frequency table to correct a large converter output voltage error to an error within the range of the small error correction routine. If necessary, the range of the small error correction routine can be extended from 10% to 20% or greater to accomodate for inaccuracies of the load vs. frequency table.

6.0.0 DISCUSSION

The controller software was developed with the intent of making it a framework that will accomodate additional required tasks as development progresses. In addition to the routines that will regulate converter output voltage, there is programming intended for future required tasks.

The two regulation routines used in the controller software, each have their disadvantages when used for large error correction.

If the small error correction routine was expanded to correct for large errors also, the controller would be less vulnerable to changes in converter characteristics. The small error routine does not use a load vs. frequency table and will be relatively insensitive to converter design changes or parts replacement. It will also use less program memory because the involved calculation routines will not be needed. Since only the converter output voltage sense signal is required for regulation, the reliability is increased. Regulation is expected to be much slower. Regulation speed can become critical when removal of full loads or overloads occur, thus, if regulation is not fast, then transient overvoltage will result.

The large error correction routine will be utilized by the controller because it is expected to offer the best regulation performance. Should this be proven untrue as development progresses, then the large error routine will be discarded in favor of the expanded small error correction routine.

The controller software has been developed to the point that after system debug it can be tested with the converter section to perform voltage regulation under normal load conditions. No time-overload profile capability has been implemented in the software yet and the overload portion of the load vs. frequency table (Table 3 in the listing) has not been developed.

During periods of converter SCR commutation failure, the converter will be deactivated for a Delco recommended period of 22ms. The software necessary to regulate the converter with one phase disabled will be developed at a later date.

Miror modifications to the hardware have been implemented in an effort to simplify the software. These and any other modifications will be listed in the next report.

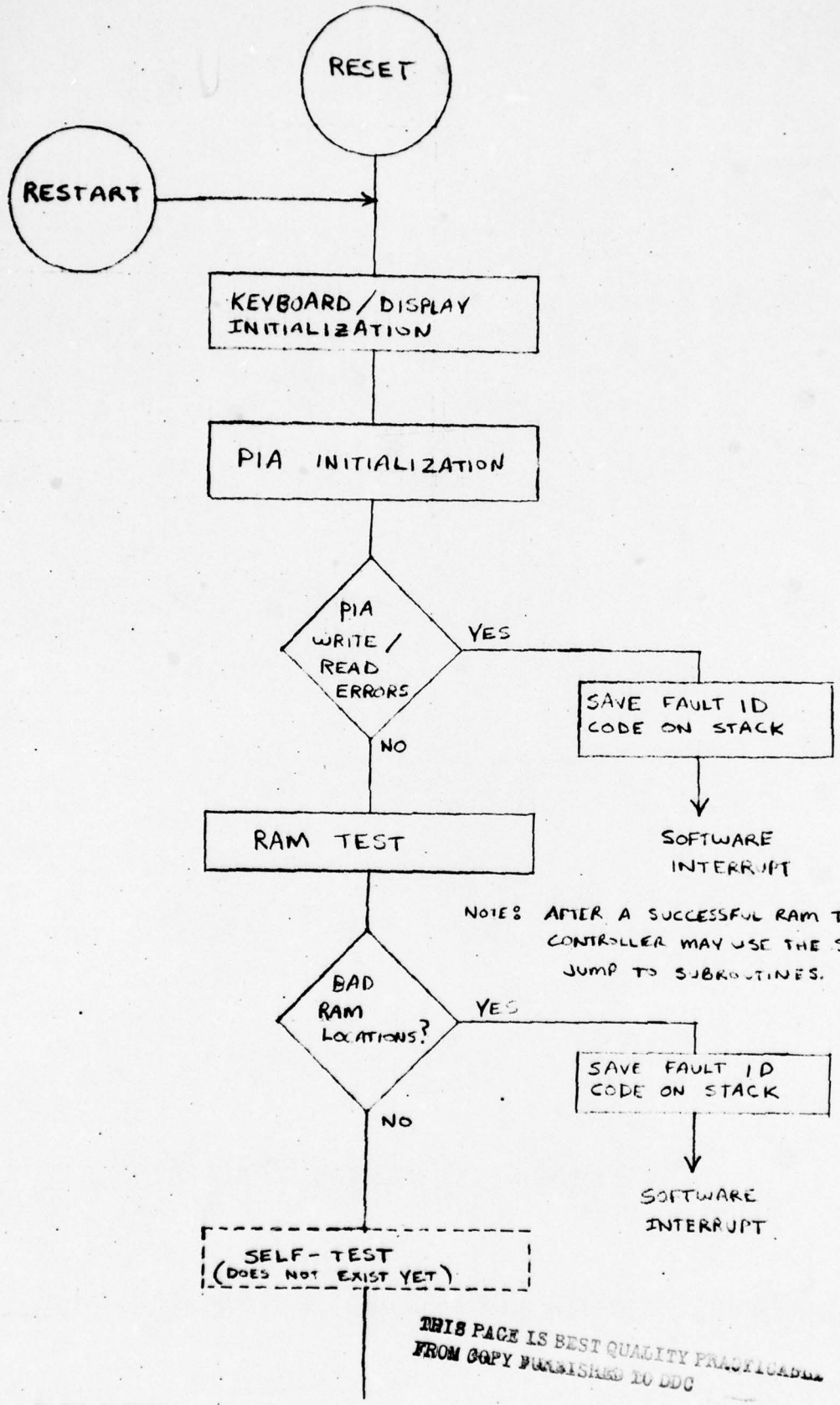
7.C.0 CONCLUSIONS

The software has been developed and is ready to be combined with the controller hardware for checkout and debug of the system.

8.C.0 RECOMMENDATIONS

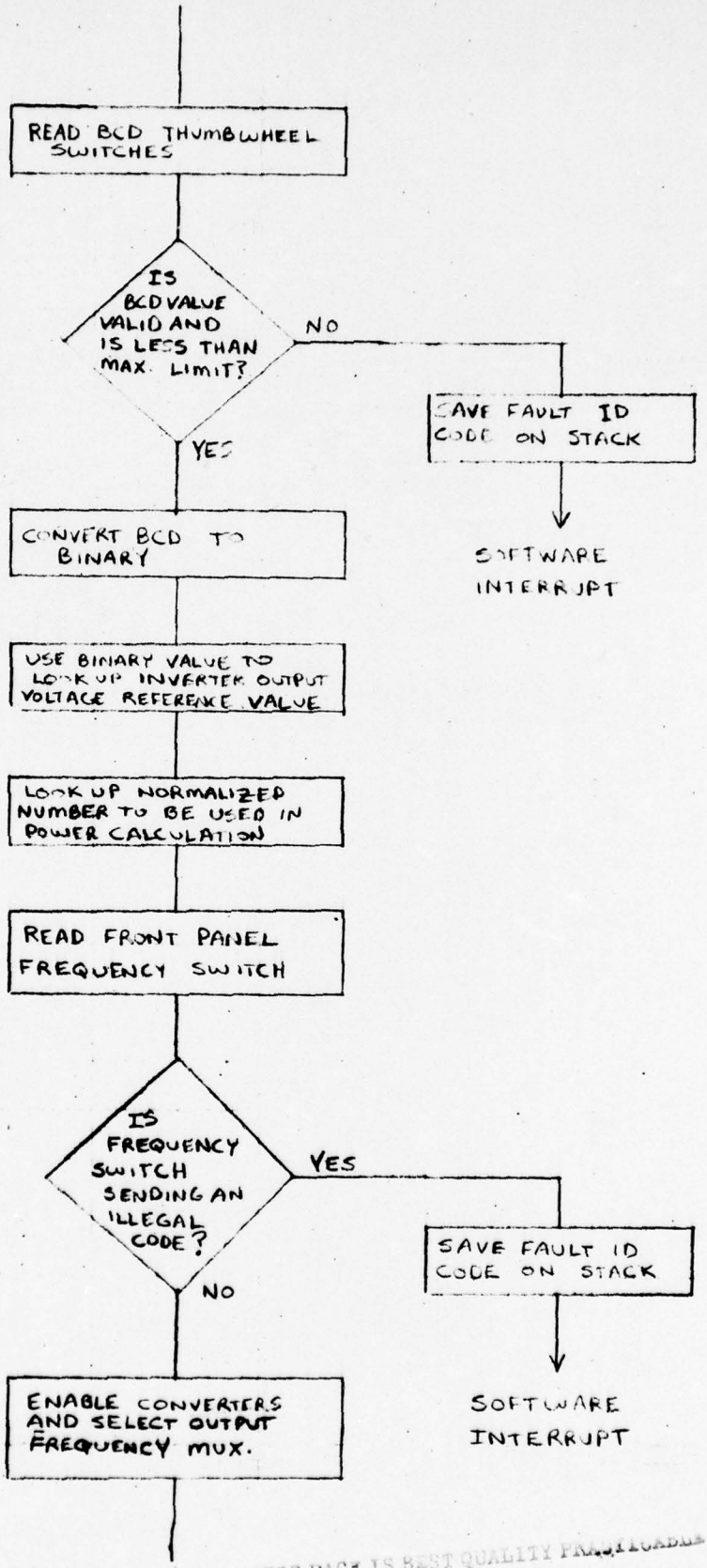
It is recommended that Yucca International, Inc. proceed immediately with the next task, System Debug.

APPENDIX A -- FLOW CHARTS



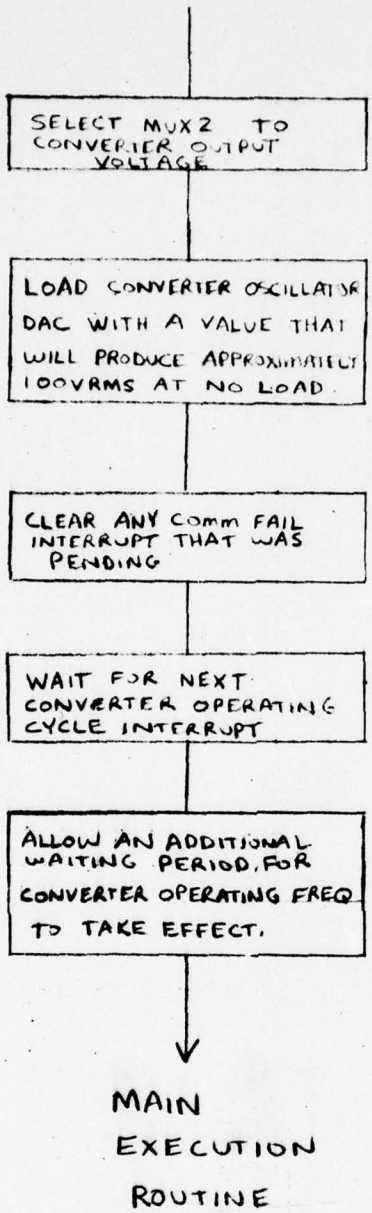
APPENDIX A FLOW CHARTS

PART 1 OF 7



APPENDIX A

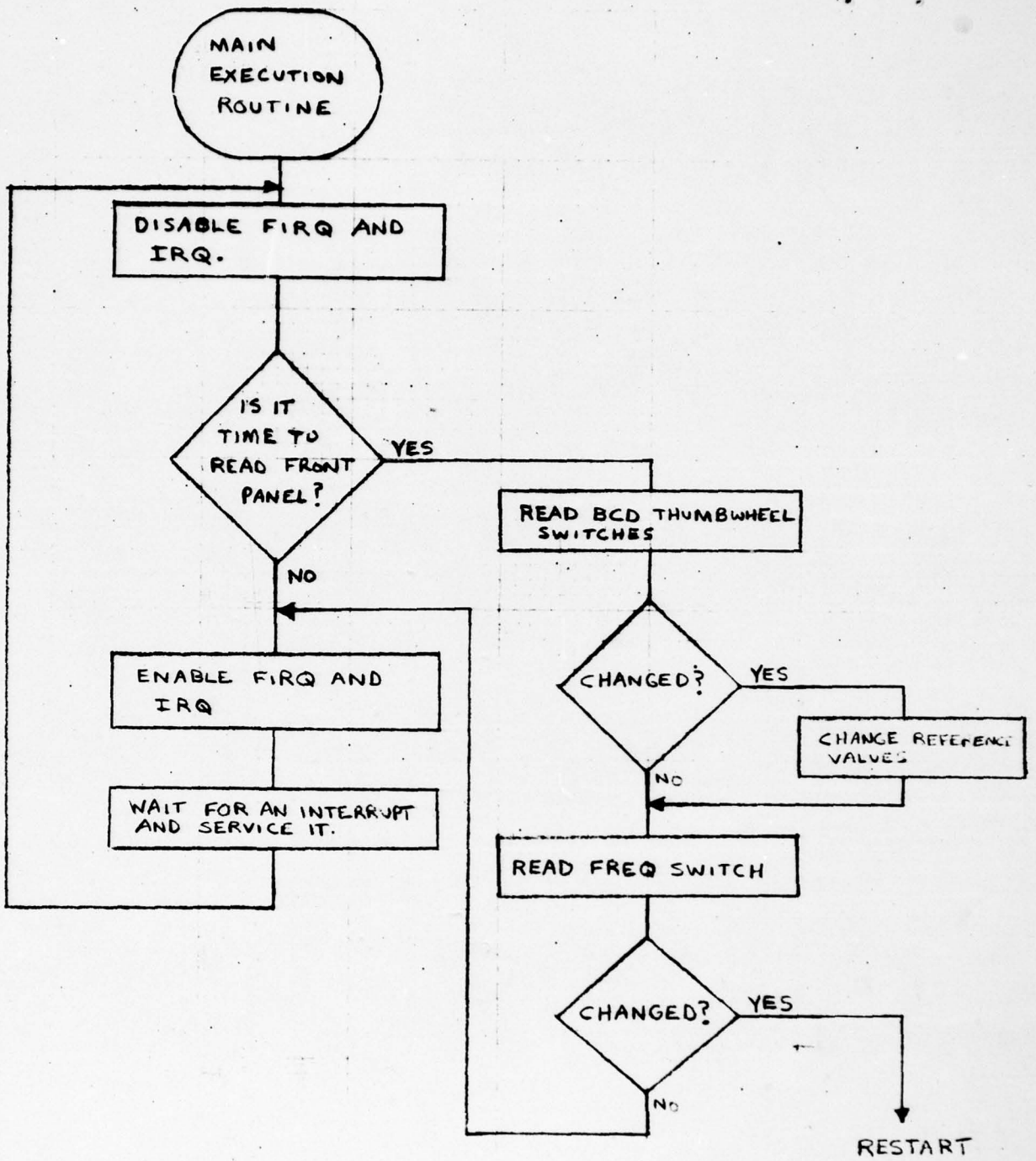
PART 2 OF 7



* INTERRUPT WILL NOT BE SERVICED BECAUSE INTERRUPTS ARE DISABLED.

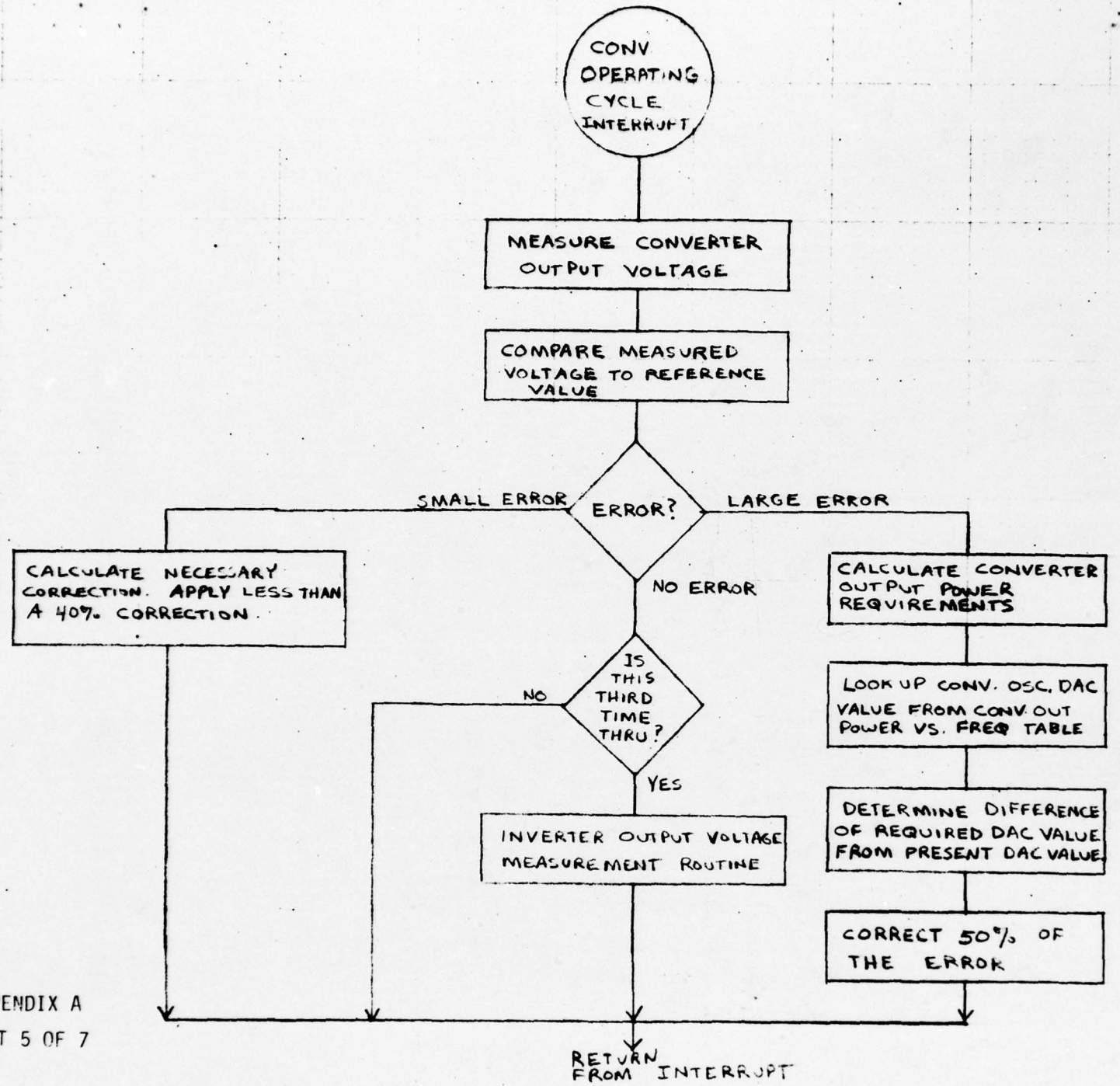
APPENDIX A

PART 3 OF 7



APPENDIX A

PART 4 OF 7



APPENDIX A

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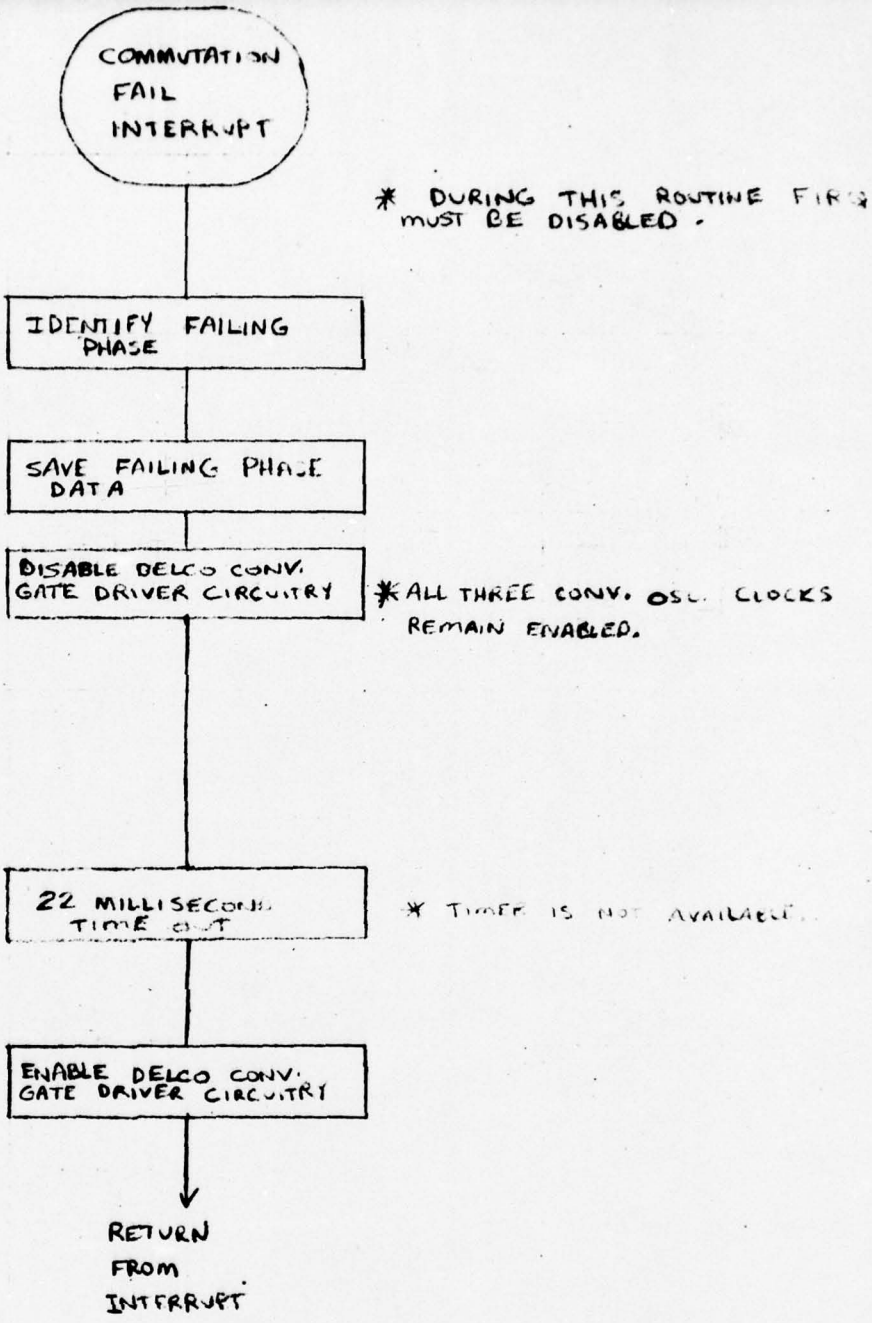
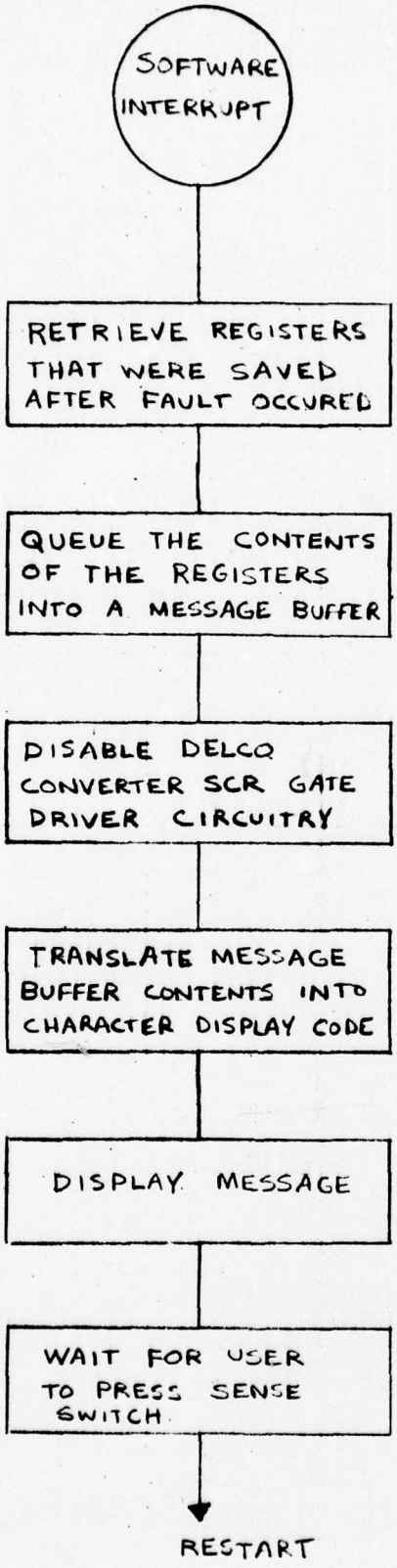


APPENDIX A

PART 6 OF 7



APPENDIX A

PART 7 OF 7

APPENDIX B -- SOFTWARE LISTING

APPENDIX B

```
PAGE 001  CNTR4    .SA:1  CNTRLR

                        NAM     CNTRLR.0
                        OPT     CRE
                ***************
                *
                *
                ******************************************
                * 15 KW POWER CONDITIONER CONTROLLER SOFTWARE
                ******************************************
                *
                *
                *  DEVELOPED BY YUCCA INTERNATIONAL ,INC.
                *
                *  REVISION 1      FEB. 16, 1979      R. KRAWL
                *
                *  DEVELOPED FOR U.S. ARMY MERADCOM
                *  CONTRACT NO. DAAK70-78-C-0117
                *  C.O.R.     DAVID LEE
                *
                *
                ******************************************
```

```
00023                          *
00024                          *
00025                          *
00026                          *
00027                          ***********************************************
00028                          *                PROGRAM EQUATES
00029                          ***********************************************
00030                          *
00031                          * WRITE ENABLE SIGNALS
00032                          *----------------------
00033          8000     A WE0     EQU     $8000     ;DAC HI BYTE(BITS 1-0)
00034          8001     A WE1     EQU     $8001     ;DAC LO BYTE
00035          8002     A WE2     EQU     $8002     ;SPARE
00036          8003     A WE3     EQU     $8003     ;SPARE
00037          8004     A WE4     EQU     $8004     ;LOAD DAC STROBE
00038          8005     A WE5     EQU     $8005     ;CLEAR COMM. FAIL INT.
00039          8006     A WE6     EQU     $8006     ;SPARE
00040          8007     A WE7     EQU     $8007     ;SPARE
00041                          *
00042                          *
00043                          *READ ENABLE SIGNALS
00044                          *--------------------
00045          8000     A RE0     EQU     $8000     ;SPARE
00046          8008     A RE1     EQU     $8008     ;A/D#2 BYTE
00047          8010     A RE2     EQU     $8010     ;A/D#1 LO BYTE
00048          8018     A RE3     EQU     $8018     ;A/D#1 HI BYTE
00049          8020     A RE4     EQU     $8020     ;1/4 DEG. CNTR LO BYTE
00050          8028     A RE5     EQU     $8028     ;1/4 DEG. CNTR HI BYTE
00051          8030     A RE6     EQU     $8030     ;UNASSIGNED
00052          8038     A RE7     EQU     $8038     ;BCD SW (DIG 2 AND 3)
00053          8040     A RE8     EQU     $8040     ;FREQ. SWITCH
00054          8048     A RE9     EQU     $8048     ;WAVEFORM EPROM
00055          8050     A RE10    EQU     $8050     ;SPARE
00056          8058     A RE11    EQU     $8058     ;SPARE
00057          8060     A RE12    EQU     $8060     ;SPARE
00058          8068     A RE13    EQU     $8068     ;SPARE
00059          8070     A RE14    EQU     $8070     ;SPARE
00060          8078     A RE15    EQU     $8078     ;SPARE
00061                          *
00062                          *
00063                          *OTHER EQUATES
00064                          *--------------
00065          4000     A DSPLYD  EQU     $4000     ;WRITE DATA TO DISPLAY
00066          4001     A DSPLYC  EQU     $4001     ;WRITE COMMAND TO DISP
00067          0000     A DMODE   EQU     $00       ;8CHARACTER,LEFT ENTRY
00068          0090     A WDISPL  EQU     $90       ;LOC. 0,AUTO-INC.
00069          00DF     A CLRDIS  EQU     $DF       ;CLEAR DISPLAY RAM
00070          00FF     A STAK    EQU     $00FF     ;STACK
00071                          *
00072                          *
00073                          *
00074          0039     A HILIM   EQU     $39       ;BCD THUMB SW MAX LIM
00075          0055     A TRUE    EQU     $55       ;TRUE
00076          00AA     A NTTRUE  EQU     $AA       ;NOT TRUE
```

```
00078                          *
00079                          ********************************************
00080                          *                PIA EQUATES
00081                          ********************************************
00082  40A1      A CNTRLA EQU     $40A1      ;CONTROL REG. A
00083  40A0      A PORTA  EQU     $40A0      ;PERIF REG. A( OR DDR
00084                          *
00085  00FF      A DREXN  EQU     $FF        ;MAKE PA0-PA7  OUTPUTS
00086                          *
00087                          * PERIPHERAL PORT A OUTPUT LINES
00088                          *-------------------------------
00089  0003      A PROMSL EQU     $03        ;PA1,PA0 = EPROM RD SL
00090  001C      A MUX1SL EQU     $1C        ;PA4,PA3,PA2
00091  00E0      A MUX2SL EQU     $E0        ;PA7,PA6,PA5
00092                          *
00093                          *
00094  40A3      A CNTRLB EQU     $40A3      ;CONTOL REG. B
00095  40A2      A PORTB  EQU     $40A2      ;PERIF REG. B( OR DDR
00096                          *
00097  00FF      A DREXNB EQU     $FF        ;MAKE PB0-PB7  OUTPUTS
00098                          *
00099                          * PERIPHERAL PORT B OUTPUT LINES
00100  00FC      A FREQSL EQU     $FC        ;PB1-PB0 = OUTPUT FREQ
00101  00FC      A ENABLA EQU     $FC        ;PHASE A CONV (PB2=0)
00102  0008      A ENABLB EQU     $08        ;PHASE B CONV (PB3=0)
00103  0010      A ENABLC EQU     $10        ;PHASE C CONV (PB4=0)
00104  001C      A ENALL  EQU     $1C        ;PHASE A,B,C CONV EN
00105  0020      A .33KHZ EQU     $20        ;CONV OSC. OFFSET EN
00106  0040      A ENBLCV EQU     $40        ;CONV ENABLE (PB6=0)
00107  0080      A CNVRT2 EQU     $80        ;A/D#2 CONVERT (PB7=0)
00108                          *
00109                          *
00110  40C1      A CNTRLC EQU     $40C1      ;CONTROL REG. C
00111  40C0      A PORTC  EQU     $40C0      ;PERIF REG. C( OR DDR
00112                          *
00113  0003      A DREXNC EQU     $03        ;MAKE PC0-PC1 OUTPUTS
00114                          *        $       AND PC2-PC7 INPUTS
00115                          *
00116                          * PERIPHERAL PORT C OUTPUT LINES
00117                          *-------------------------------
00118  0001      A CNVRT1 EQU     $01        ;A/D#1 CONVRT (PC0=0)
00119  0002      A NORMAL EQU     $02        ;NORMAL(PC1=0)
00120                          *                        10 DEG. (PC1=1)
00121                          *
00122                          * PERIPHERAL PORT C INPUT LINES
00123                          *------------------------------
00124  0008      A CMPLT1 EQU     $08        ;A/D#1 CMPLT (PC3=0)
00125  0010      A CMPLT2 EQU     $10        ;A/D#2  CMPLT (PC4=0)
00126  00E0      A COMFAL EQU     $E0        ;CNVRTR COMMUT. FAIL
00127                          *                       PHASE C FAIL (PC5 =0)
00128                          *                       PHASE B FAIL (PC6 =0)
00129                          *                       PHASE A FAIL (PC7 =0)
```

```
00131                          *
00132                          *
00133                          ***********************************************
00134                          *                MULTIPLEXER SELECT EQUATES
00135                          ***********************************************
00136                          * MUX#1 SELECT ;PA4,PA3,PA2
00137                          *--------------------------
00138              0000     A IVCURC EQU     $00        ;INV OUT CURR C
00139              0004     A IVCURB EQU     $04        ;INV OUT CURR B
00140              0008     A IVCURA EQU     $08        ;INV OUT CURR A
00141              000C     A IVVOLC EQU     $0C        ;INV OUT VOLT C
00142              0010     A IVVOLB EQU     $10        ;INV OUT VOLT B
00143              0014     A IVVOLA EQU     $14        ;INV OUT VOLT A
00144              0018     A IVNPT  EQU     $18        ;  INV INP CURR
00145              001C     A SPARE1 EQU     $1C        ;SPARE CHANNEL
00146                          *
00147                          *
00148                          * MUX#2 SELECT ;PA7,PA6,PA5
00149                          *---------------------------
00150              0000     A CVCURC EQU     $00        ;CONV OUT CURR C
00151              0020     A CVCURB EQU     $20        ;CONV OUT CURR B
00152              0040     A CVCURA EQU     $40        ;CONV OUT CURR A
00153              0060     A NPTVLC EQU     $60        ;INPUT VOLT C
00154              0080     A NPTVLB EQU     $80        ;INPUT VOLT B
00155              00A0     A NPTVLA EQU     $A0        ;INPUT VOLT A
00156              00C0     A CVOUT  EQU     $C0        ;CONV OUT VOLT
00157              00E0     A SPARE2 EQU     $E0        ;SPARE CHANNEL
00158                          *
00159                          *
00160                          * OUTPUT FREQUENCY MUX SELECT ;PB1,PB0
00161                          *----------------------------
00162              0000     A .50HZ  EQU     $00        ;PB1=0,PB0=0
00163              0001     A .60HZ  EQU     $01        ;PB1=0,PB0=1
00164              0002     A .400HZ EQU     $02        ;PB1=1,PB0=0
00165              0003     A EXTERN EQU     $03        ;EXTERNAL
00166                          *
```

```
00168                          ********** *. ***. **********
00169                          *          RAM MEMORY
00170                          *          ----------
00171P 0000      0001      A DVISOR RMB    1
00172P 0001      0001      A VMEASR RMB    1        ;CONVERTER OUTPUT VOLT
00173                          *                     MEASURED VALUE.
00174P 0002      0001      A DVIDND RMB    1
00175P 0003      0001      A VNOMNL RMB    1        ;NOMINAL CONVERTER OUT
00176                          *                     VOLTAGE REFERENCE VAL
00177P 0004      0001      A PLARTY RMB    1        ;POLARITY OF CONVERTER
00178                          *                     OUTPUT VOLTAGE ERROR.
00179P 0005      0001      A BCDVAL RMB    1        ;BCD VALUE READ FROM
00180                          *                      THUMBWHEEL SWITCHES.
00181P 0006      0001      A STABLE RMB    1        ;COUNTS INTERVALS THAT
00182                          *                    OUTPUT VOLTAGE HAS MAI
00183                          *                    TAINED A STEADY LEVEL.
00184P 0007      0001      A LOKOUT RMB    1        ;DON'T EXECUTE INV OUT
00185                          *                     MEASUREMENT ROUTINE.
00186P 0008      0001      A FQMODE RMB    1        ;OUTPUT FREQ. MODE
00187                          *                  04H=400HZ, 02H=60HZ, 01H=50H
00188P 0009      0002      A DACVAL RMB    2        ;CONVERTER OSCILLATOR
00189                          *                     DAC VALUE.
00190                          *                      000H - 3FFH = NORMAL
00191                          *                      400H - 7FFH = OVRLD
00192P 000B      0002      A SAVE1  RMB    2        ;TEMPORARY STORAGE
00193P 000D      0001      A COUNT1 RMB    1        ;TEMPORARY STORAGE
00194P 000E      0002      A IMEASR RMB    2        ;INVERTER INPUT CURREN
00195                          *                      MEASURED VALUE.
00196P 0010      0001      A OVERLD RMB    1        ;OVERLOAD FLAG
00197                          *                    55H=OVRLD AAH=NO OVRLD
00198P 0011      0002      A MLTCAN RMB    2        ;NUMBER TO BE MULTIPLI
00199P 0013      0001      A QUOTNT RMB    1        ;WHOLE UNITS TO BE MUL
00200P 0014      0001      A REMNDR RMB    1        ;FRACTIONAL NUMBER TO
00201                          *                      BE MULTIPLIED.
00202P 0015      0002      A RESULT RMB    2        ;RESULT OF MULTIPLICAT
00203P 0017      0002      A REFRNC RMB    2        ;INV OUT VOLT REF VALU
00204P 0019      0002      A RATIO  RMB    2        ;NORMALIZED VALUE
00205P 001B      0001      A FAILST RMB    1        ;CONV COMM. FAIL STAT.
00206                          *                     IF BIT 7 = 1 THEN PHS
00207                          *                     IF BIT 6 = 1 THEN PHS
00208                          *                     IF BIT 5 = 1 THEN PHS
00209P 001C      0001      A SERVIC RMB    1        ;FRNT PNL SERVICE CNT
00210P 001D      0004      A MESSBF RMB    4        ;MESSAGE BUFFER
00211P 0021      0008      A DSPBUF RMB    8        ;DISPLAY BUFFER
00212                          **********************************************
00213                          *         6809 VECTOR TABLE
00214                          *         -----------------
00215A CFF2                          ORG    $CFF2    ;BEGINNING ADDRESS
00216                          *
00217A CFF2      0000      A         FDB    $0000    ;UNUSED
00218A CFF4      0000      A         FDB    $0000    ;UNUSED
00219A CFF6      C11F      A         FDB    FIRQ     ;FAST INTERRUPT REQ.
00220                          *                     ( CONV. OPER. CYC. INT
00221A CFF8      C387      A         FDB    IRQ      ;INTERRUPT REQUEST.
00222                          *                     ( CONV. COMM. FAIL INT
00223A CFFA      C3C9      A         FDB    SWINT    ;SOFTWARE INTRUPT VECT
00224A CFFC      C3C1      A         FDB    NMI      ;NON-MASK INTRPT VECTR
00225A CFFE      C000      A         FDB    RESTRT   ;RESTART VECTOR
```

```
00227                                ***********************************************
00228                                *          BEGINNING OF PROGRAM
00229                                *          --------------------
00230A C000                                   ORG     $C000     ;BEGINNING ADDRESS
00231                                *
00232A C000 1A    50       A RESTRT ORCC    #$50      ;DISABLE FIRQ AND IRQ
00233A C002 10CE  00FF     A        LDS     #STAK     ;INITIALIZE STACK PTR.
00234                                *
00235                                * KEYBOARD/DISPLAY INITIALIZATION
00236                                * -------------------------------
00237A C006 86    00       A KEYDIS LDA     #DMODE
00238A C008 B7    4001     A        STA     DSPLYC    ;INIT. KYBD/DSPLY MODE
00239A C00B 86    2A       A        LDA     #$2A
00240A C00D B7    4001     A        STA     DSPLYC    ;PROG. 8279 INT. CLK
00241                                *                  TO 100KHZ.
00242A C010 86    90       A        LDA     #WDISPL
00243A C012 B7    4001     A        STA     DSPLYC    ;COUNTER INIT LOC. 0
00244A C015 86    DF       A        LDA     #CLRDIS
00245A C017 B7    4001     A        STA     DSPLYC    ;CLR DSPLY RAM TO "1'S
00246                                *
00247                                *
00248                                * PERIPHERAL INTERFACE ADAPTER ( PIA ) INIT.
00249                                *-----------------------------------------------
00250A C01A 86    04       A        LDA     #$04
00251A C01C B7    40A1     A        STA     CNTRLA    ;ENABLE PORT A
00252A C01F C6    FF       A        LDB     #$FF
00253A C021 F7    40A0     A        STB     PORTA     ;ALL PORT A LINES HIGH
00254A C024 7F    40A1     A        CLR     CNTRLA    ;ENABLE DATA DIR A
00255A C027 F7    40A0     A        STB     PORTA     ;ALL PORT A LINES ARE
00256                                *                       OUTPUT LINES.
00257A C02A B7    40A1     A        STA     CNTRLA    ;ENABLE PORT A
00258A C02D F1    40A0     A        CMPB    PORTA     ;READ BACK PORT A
00259A C030 27    06     C038       BEQ     OK3
00260A C032 34    07       A FAULT3 PSHS    B,A,CC    ;PORT A RD/WR ERROR
00261A C034 CC    5503     A        LDD     #$5503    ;
00262A C037 3F                      SWI
00263                                *
00264A C038 B7    40A3     A OK3    STA     CNTRLB    ;ENABLE PORT B
00265A C03B F7    40A2     A        STB     PORTB     ;ALL PORT B LINES HIGH
00266A C03E 7F    40A3     A        CLR     CNTRLB    ;ENABLE DATA DIR B
00267A C041 F7    40A2     A        STB     PORTB     ;ALL ARE OUTPUT LINES
00268A C044 B7    40A3     A        STA     CNTRLB    ;ENABLE PORT B
00269A C047 F1    40A2     A        CMPB    PORTB     ;READ BACK PORT B
00270A C04A 27    06     C052       BEQ     OK4
00271A C04C 34    07       A FAULT4 PSHS    B,A,CC    ;PORT B RD/WR ERROR
00272A C04E CC    5504     A        LDD     #$5504    ;
00273A C051 3F                      SWI
00274                                *
00275A C052 B7    40C1     A OK4    STA     CNTRLC    ;ENABLE PORT C
00276A C055 F7    40C0     A        STB     PORTC     ;ALL PORT C LINES HIGH
00277A C058 7F    40C1     A        CLR     CNTRLC    ;ENABLE DATA DIR C
00278A C05B C6    03       A        LDB     #DREXNC   ;PC1,PC0 ARE OUTPUTS
00279A C05D F7    40C0     A        STB     PORTC
00280A C060 B7    40C1     A        STA     CNTRLC    ;ENABLE PORT B
00281A C063 B6    40C0     A        LDA     PORTC     ;READ BACK PORT C
00282A C066 84    03       A        ANDA    #DREXNC   ;MASK OUTPUT LINES
00283A C068 81    03       A        CMPA    #DREXNC   ;IS DATA CORRECT?
00284A C06A 27    06     C072       BEQ     RAMTST    ;YES, THEN BRANCH.
```

```
00285A C06C 34   07       A FAULT5 PSHS   B,A,CC   ;PORT C RD/WR ERROR
00286A C06E CC   5505     A        LDD    #$5505   ;
00287A C071 3F                     SWI
00288                              *
00289                              *
00290                              * RAM TEST
00291                              * --------
00292                              *   EACH RAM LOCATION IS TESTED WITH AN AAH,
00293                              *   55H DATA PATTERN.  RAM IS THEN CLEARED.
00294A C072 C6   AA       A RAMTST LDB    #NTTRUE
00295A C074 108E 0080     A        LDY    #$0080
00296A C078 86   FF       A AGAIN2 LDA    #$FF
00297A C07A E7   A6       A AGAIN1 STB    A,Y
00298A C07C E1   A6       A        CMPB   A,Y
00299A C07E 27   06    C086        BEQ    OK6
00300                              *
00301A C080 34   07       A FAULT6 PSHS   B,A,CC   ;BAD RAM LOCATION.
00302A C082 CC   5506     A        LDD    #$5506
00303A C085 3F                     SWI
00304A C086 4A                   OK6   DECA
00305A C087 26   F1    C07A        BNE    AGAIN1
00306A C089 C1   55       A        CMPB   #TRUE
00307A C08B 27   04    C091        BEQ    CLRRAM   ;RAM IS OK! CLEAR RAM.
00308A C08D C6   55       A        LDB    #TRUE
00309A C08F 20   E7    C078        BRA    AGAIN2
00310                              *
00311A C091 86   FF       A CLRRAM LDA    #$FF
00312A C093 108E 0080     A        LDY    #$0080
00313A C097 6F   A6       A AGAIN8 CLR    A,Y
00314A C099 4A                     DECA
00315A C09A 26   FB    C097        BNE    AGAIN8
00316                              *
00317                              * SELF-TEST
00318                              *---------------
00319                              *                        JSR      SELFTS
00320                              *
00321                              *
```

```
00323                                *
00324                                * INITIALIZE RAM
00325                                * -------------
00326A C09C C6   AA       A          LDB    #NTTRUE
00327A C09E F7   0010     P          STB    OVERLD
00328A C0A1 C6   B5       A          LDB    #$B5
00329A C0A3 F7   0003     P          STB    VNOMNL.
00330                                *
00331                                * INITIALIZE CONVERTER OSC.  DAC
00332                                * ----------------------------
00333                                *
00334A C0A6 CC   0000     A          LDD    #$0000
00335A C0A9 BD   C253     A          JSR    DACDRV    ;SEND 000H TO DAC.
00336                                *
00337                                *
00338                                * READ BCD THUMBWHEEL SWITCHES
00339                                *-----------------------------
00340A C0AC BD   C33C     A          JSR    THUMB     ;READ BCD THUMB SWITCH
00341A C0AF B7   0005     P          STA    BCDVAL    ;SAVE IT
00342A C0B2 BD   C34A     A          JSR    VALID     ;VERIFY BCD VALUE IS V
00343                                *                      AND CONVERT IT TO BINARY.
00344                                *                      ALSO LOOKUP INV.  OUT VOLT
00345                                *                      REF VALUE AND NORMALIZED
00346                                *                       NUMBER FOR POWER CALCULAT.
00347                                *
00348                                *
00349                                *
00350                                *
00351                                * READ FREQUENCY SWITCH
00352                                *-----------------------
00353A C0B5 C6   FF       A          LDB    #$FF      ;PREPARE TO SEND DATA
00354                                *                        TO PORT B.
00355A C0B7 C4   FC       A          ANDB   #FREQSL   ;CLEAR FREQ SELECT BIT
00356A C0B9 B6   8040     A          LDA    RE8       ;READ FREQ SWITCH
00357A C0BC 84   07       A          ANDA   #$07      ;MASK FREQ BITS
00358A C0BE B7   0008     P          STA    FQMODE    ;SAVE FREQ MODE
00359A C0C1 81   04       A          CMPA   #$04      ;IS IT 400HZ?
00360A C0C3 27   0E     C0D3         BEQ    SET400    ;YES, THEN BRANCH.
00361A C0C5 81   02       A          CMPA   #$02      ;IS IT 60 HZ ?
00362A C0C7 27   0E     C0D7         BEQ    SET60     ;YES, THEN BRANCH.
00363A C0C9 81   01       A          CMPA   #$01      ;IS IT 50 HZ ?
00364A C0CB 27   0E     C0DB         BEQ    SET50     ;YES, THEN BRANCH.
00365A C0CD 34   07       A FAULT7   PSHS   B,A,CC    ;BAD FREQ SWITCH
00366A C0CF CC   5507     A          LDD    #$5507    ;
00367A C0D2 3F                       SWI
00368                                *
00369                                *
```

```
00371                                * OUTPUT FREQUENCY MODE SELECTION
00372                                *-----------------------------------
00373A C0D3 CA   02       A SET400   ORB    #.400HZ
00374A C0D5 20   06    C0DD          BRA    AHEAD1
00375A C0D7 CA   01       A SET60    ORB    #.60HZ    ;OR BITS TO SLCT 60 HZ
00376A C0D9 20   02    C0DD          BRA    AHEAD1
00377A C0DB CA   00       A SET50    ORB    #.50HZ    ;OR BITS TO SLCT 50 HZ
00378                                *
00379A C0DD C8   1C       A AHEAD1   EORB   #ENALL    ;EN CONV. OSC. CLOCKS
00380A C0DF C8   40       A          EORB   #ENBLCV   ;EN DELCO CNVERTER SCR
00381                                *                   GATE DRIVER CIRCUITR
00382A C0E1 F7   40A2     A          STB    PORTB     ;SEND ENABLE AND
00383                                *                  SELECT DATA.
00384                                *
00385A C0E4 C6   DC       A          LDB    #$DC
00386A C0E6 F7   40A0     A          STB    PORTA     ;SELECT MUX2 TO CONVER
00387                                *                   OUTPUT VOLTAGE.
00388                                *
00389                                *
00390                                * INCREASE CONVERTER OSC FREQ.  TO PRODUCE
00391                                * APPROX 100 VRMS AT INVERTER OUT AT NO LOAD.
00392                                *-------------------------------------------
00393A C0E9 CC   0070     A          LDD    #$0070
00394A C0EC BD   C253     A          JSR    DACDRV
00395                                *
00396                                * ALLOW TIME FOR CONV.  TO RESPOND TO NEW
00397                                * OPERATING FREQUENCY.
00398                                *-------------------------------------------
00399A C0EF B7   8005     A          STA    WE5       ;CLEAR COMM. FAIL INT.
00400A C0F2 13                      SYNC             ;WAIT FOR FIRQ, BUT
00401                                *                     DON'T SERVICE IT.
00402A C0F3 C6   0A       A          LDB    #$0A
00403A C0F5 BD   C381     A          JSR    DELAY     ;DELAY AT LEAST 25 US.
00404                                *                        TO ALLOW INTRPT TO CLEAR.
00405                                *
00406                                *
```

```
00408                          ***********************************************
00409                          *   MAIN EXECUTION ROUTINE
00410                          ***** ***********************************************
00411                          *
00412                          *
00413A C0F8 1A   50      A MAIN   ORCC   #$50      ;DISABLE FIRQ AND IRQ
00414A C0FA 7A   001C    P        DEC    SERVIC    ;IS IT TIME TO READ
00415                          *                     THE FRONT PANEL?
00416A C0FD 26   1B   C11A       BNE    MAIN1     ;NO, THEN BRANCH.
00417A C0FF BD   C33C    A       JSR    THUMB     ;READ THUMB SWITCHES.
00418A C102 B1   0005    P       CMPA   BCDVAL    ;DISTURBED?
00419A C105 27   03   C10A       BEQ    NOCHNG    ;NO, THEN BRANCH.
00420A C107 BD   C34A    A       JSR    VALID     ;VERIFY BCD AND CHANGE
00421                          *                     REFERENCES.
00422                          *
00423A C10A B6   8040    A NOCHNG LDA    RE8       ;READ FREQ SWITCH.
00424A C10D 84   07      A        ANDA   #$07      ;MASK FREQ BITS.
00425A C10F B1   0008    P        CMPA   FQMODE    ;CHANGED?
00426A C112 27   06   C11A       BEQ    MAIN1     ;NO, THEN BRANCH.
00427A C114 34   07      A FAULTD PSHS   B,A,CC    ;FREQ SWITCH CHANGED.
00428A C116 CC   550D    A        LDD    #$550D    ;
00429A C119 3F                    SWI
00430A C11A 1C   AF      A MAIN1  ANDCC  #$AF      ;ENABLE FIRQ AND IRQ.
00431A C11C 13                    SYNC
00432A C11D 20   D9   C0F8       BRA    MAIN
00433                          *
00434                          *   DATA PROCESSING ROUTINE AND CONV.  OUT
00435                          *   CURRENT CHECK AND CONV
00436                          *   INPUT VOLTAGE CHECK WILL BE INSERTED.
00437                          *   LATER.
```

```
00439                          ***********************************************
00440                          * CONVERTER OPERATING CYCLE INTERRUPT ( FIRQ
00441                          ***********************************************
00442                          *  THIS ROUTINE MEASURES THE CONVERTER
00443                          *   OUTPUT VOLTAGE AND DETERMINES THE
00444                          *   MAGNITUDE OF ERROR ( IF ANY ) FROM A
00445                          *   REFERENCE VALUE.  THE REFERENCE VALUE
00446                          *   "VNOMNL" IS MAINTAINED AND
00447                          *   MODIFIED ONLY BY THE INVERTER OUTPUT
00448                          *   VOLTAGE MEASUREMENT ROUTINE.
00449                          *
00450                          *   LARGE ERRORS ( >10% ) FROM NOMINAL WILL
00451                          *   BE CORRECTED BY CALCULATING CONV.  OUT
00452                          *   POWER REQUIREMENTS.
00453                          *
00454                          *
00455                          *   SMALL ERROR CORRECTION
00456                          *   METHODS INVOLVE FEW CALCULATIONS.
00457                          *
00458                          *   TO MINIMIZE POSSIBLE OVERSHOOT AND
00459                          *   UNDERSHOOT OF CONV OUT VOLTAGE, A 100%
00460                          *   CORRECTION IS NOT APPLIED IMMEDIATELY.
00461                          *   GENERALLY, LESS THAN 50% OF THE NECESSARY
00462                          *   CORRECTION IS MADE.  THEREFORE, THIS ROUT-
00463                          *   INE WILL EXECUTE FIVE OR MORE TIMES
00464                          *   BEFORE THE ERROR BECOMES ZERO.
00465                          *
00466                          *   DURING PERIODS OF CONVERTER OUTPUT VOLT-
00467                          *   AGE STABILITY ( ERRORS < 2 BITS ) THE
00468                          *   INVERTER OUT VOLT MEAS ROUTINE WILL BE
00469                          *   ALLOWED TO EXECUTE.  AN INV OUT VOLT
00470                          *   ERROR WILL BE CORRECTED BY ADJUSTING
00471                          *   THE CONV OUT VOLT REFERENCE "VNOMNL".
00472                          *
00473                          * MEASURE CONVERTER OUTPUT VOLTAGE
00474                          *---------------------------------
00475                          *   MUX#2 IS SELECTED TO CONV OUT VOLT
00476                          *   AT ALL TIMES WHEN INTERRUPTS
00477                          *   ARE ENABLED.
00478                          *
00479A C11F B6   40A2     A FIRQ   LDA    PORTB    ;READ PORT B
00480A C122 88   80       A        EORA   #CNVRT2  ;CLR B7 ( CONVERT A/D#
00481A C124 B7   40A2     A        STA    PORTB    ;HOLD ANALOG VALUE IN
00482                          *                     SAMPLE AND HOLD.  CONV
00483                          *
00484A C127 F6   40C0     A WAIT1  LDB    PORTC    ;READ PORT C
00485A C12A C4   10       A        ANDB   #CMPLT2  ;HAS A/D#2 FINISHED?
00486A C12C 26   F9    C127        BNE    WAIT1    ;NO, THEN WAIT.
00487                          *
00488A C12E F6   8008     A        LDB    RE1      ;READ A/D#2
00489A C131 8A   80       A        ORA    #CNVRT2  ;RETURN CONVERT A/D#2
00490A C133 B7   40A2     A        STA    PORTB    ;BLANK A/D#2 OUTPUTS A
00491                          *                     SAMPLE ANALOG INPUT.
00492A C136 F7   0001     P        STB    VMEASR   ;SAVE CONV.  OUT VOLT
00493                          *                     MEASURED VALUE.
```

```
00495                          *DETERMINE MAGNITUDE AND POLARITY OF CONV
00496                          * OUTPUT VOLTAGE ERROR.
00497                          *-----------------------------------------
00498A C139 F0   0003    P            SUBB    VNOMNL    ;DOES MEAS= NOMINAL?
00499A C13C 27   17   C155           BEQ     NOAJST    ;YES, THEN DON'T ADJUST
00500A C13E 2D   05   C145           BLT     TOOLOW    ;BRANCH IF LOW.
00501                          *
00502A C140 7F   0004    P TOOHI     CLR     PLARTY    ;INDICATE CONV VOLT HI
00503A C143 20   06   C14B           BRA     DTERM
00504                          *
00505A C145 50                 TOOLOW NEGB              ;2'S CMPLMNT NEG VAL
00506A C146 86   FF       A           LDA     #$FF
00507A C148 B7   0004    P           STA     PLARTY    ;INDICATE CONV VOLT LO
00508                          *
00509                          *
00510                          * DETERMINE IF ERROR IS LARGE OR SMALL
00511                          *-------------------------------------
00512A C14B C1   14       A DTERM     CMPB    #$14      ;IS ERROR > 20 BITS? (
00513A C14D 2A   7D   C1CC           BPL     LRGERR    ;YES, ADJ FOR LRG ERR.
00514                          *
00515A C14F 58                 SMLERR LSLB              ;MLTPLY ERR BITS BY 2
00516A C150 8E   C46F     A           LDX     #TABLE2
00517A C153 6E   95       A           JMP     [B,X]     ;JMP TO ADDR OF AJST
00518                          *                         ROUTINE.
00519                          *
00520                          ***********************************************
00521                          * NO ADJUSTMENT TO CONVERTER OPERATING FREQ.
00522                          * -----------------------------------------
00523A C155 B6   0006    P NOAJST LDA     STABLE    ;LOOK AT COUNT.
00524A C158 81   03       A           CMPA    #$03      ;HAS CONV OUT VOLT ERR
00525                          *                          REMAINED SMALL FOR 3
00526                          *                         CONSEC OPERATING CYC.
00527A C15A 102C 0259 C3B7           LBGE    INVOUT    ;YES, THEN BRANCH.
00528A C15E 7C   0006    P           INC     STABLE
00529A C161 16   00EE C252           LBRA    EXIT
00530                          *
00531                          ***********************************************
00532                          *     ADJUST ROUTINES
00533                          *    ----------------
00534                          *
00535                          * CORRECT FOR .5% ( 1 BIT ) ERROR ;
00536                          *-----------------------------------
00537                          *    THE CORRECTION IS MADE BY ADJUSTING
00538                          *    THE CONVERTER OSCILLATOR
00539                          *    FREQUENCY BY .1%.    1/1024 = .1% APPROX.
00540A C164 F6   0009    P E.1PC  LDB     DACVAL    ;LOAD MS BYTE .
00541A C167 54                   LSRB              ;MOVE BIT 8 TO CARRY.
00542                          *                         IS IT SET?
00543A C168 24   34   C19E           BCC     ADJUST    ;NO, THEN BRANCH.
00544A C16A 5C                   INCB              ;ROUND OFF.
00545A C16B 20   31   C19E           BRA     ADJUST    ;THE RESULT OF THE DIV  /
00546                          *                          BY 1024 IS IN ACC. B
00547                          *
00548                          *
00549                          * CORRECT FOR 1% ( 2 BIT ) ERROR.
00550                          *--------------------------------
00551A C16D F6   0009    P E.2PC  LDB     DACVAL    ;LOAD MS BYTE OF DACVA
00552A C170 7D   000A    P           TST     DACVAL+1  ;IS B7 OF LS BYTE SET?
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00553A C173 2A   29   C19E          BPL    ADJUST   ;NO, THEN BRANCH.
00554A C175 5C                      INCB            ;YES, ROUND OFF.
00555A C176 20   26   C19E          BRA    ADJUST   ;RESULT OF DIV BY 512
00556                     *                            IS IN ACCUMULATOR B.
00557                     *
00558                     *
00559A C178 86   01      A E.4PC    LDA    #$01     ;PREPARE TO DIV BY 256
00560A C17A 20   0C   C188          BRA    AHEADB
00561                     *
00562                     *
00563A C17C 86   02      A E.8PC    LDA    #$02     ;PREPARE TO DIV BY 128
00564A C17E 20   08   C188          BRA    AHEADB
00565                     *
00566                     *
00567A C180 86   03      A E1.5PC   LDA    #$03     ;PREPARE TO DIV BY 64.
00568A C182 20   04   C188          BRA    AHEADB
00569                     *
00570                     *
00571A C184 86   04      A E3.1PC   LDA    #$04     ;PREPARE TO DIV BY 32.
00572A C186 20   00   C188          BRA    AHEADB
00573                     *
00574                     *
00575A C188 7F   0006    P AHEADB   CLR    STABLE   ;ERROR IS SIGNIFICANT
00576                     *                            VOLTAGE  CAN NOT BE
00577                     *                           CONSIDERED STABLE.
00578A C18B B7   000D    P          STA    COUNT1
00579                     *
00580                     * SHIFT
00581                     *--------
00582                     *  COUNT1 SPECIFIES THE NUMBER OF PLACES TO
00583                     *  SHIFT THE ACC. D TO THE LEFT.
00584                     *  THE VALUE IN ACC. A BECOMES THE
00585                     *  CORRECTION TO BE APPLIED TO DAC.
00586A C18E FC   0009    P SHIFT    LDD    DACVAL
00587A C191 58             AGAIN3   LSLB
00588A C192 49                      ROLA
00589A C193 7A   000D    P          DEC    COUNT1
00590A C196 26   F9   C191          BNE    AGAIN3
00591A C198 1E   89      A          EXG    A,B
00592A C19A 4D                      TSTA            ;IS BIT 7 SET?
00593A C19B 2A   01   C19E          BPL    ADJUST   ;NO, THEN BRANCH.
00594A C19D 5C                      INCB            ;ROUND OFF.
```

```
00596                                   *
00597                                   * ADJUST ;
00598                                   *-----------
00599                                   * ACCUM B CONTAINS THE CORRECTION TO BE
00600                                   * APPLIED TO THE PRESENT DAC VALUE.
00601                                   *
00602A C19E 4F                          ADJUST CLRA
00603A C19F FD   000B    P                     STD     SAVE1     ;SAVE CALCULATED CORRE
00604A C1A2 27   16   C1BA                    BEQ     ZERO      ;BRA IF CORRECTION =0
00605A C1A4 FC   0009    P                     LDD     DACVAL
00606A C1A7 7D   0004    P                     TST     PLARTY    ;IS DAC VALUE TOO HIGH
00607                                   *                       TOO LOW?
00608A C1AA 27   05   C1B1                    BEQ     REDUCE    ;BRANCH IF TOO HIGH.
00609                                   *
00610A C1AC F3   000B    P INCRES      ADDD    SAVE1     ;ADD CORRECTION.
00611A C1AF 20   03   C1B4                    BRA     LOADAC
00612                                   *
00613A C1B1 B3   000B    P REDUCE      SUBD    SAVE1     ;SUBTRACT CORRECTION.
00614                                   *
00615A C1B4 BD   C253    A LOADAC      JSR     DACDRV    ;SEND NEW VAL TO DAC
00616A C1B7 16   0098 C252                    LBRA    EXIT
00617                                   *
00618                                   *
00619                                   * ZERO
00620                                   * -----
00621                                   * CALCULATED CORRECTION IS LESS THAN 1 BIT.
00622                                   * ADD OR SUBTRACT A BIT ANYWAY.
00623A C1BA FC   0009    P ZERO        LDD     DACVAL
00624A C1BD 7D   0004    P                     TST     PLARTY
00625A C1C0 27   05   C1C7                    BEQ     SUBTR1
00626                                   *
00627                                   *
00628A C1C2 C3   0001    A ADD1        ADDD    #$0001
00629A C1C5 20   ED   C1B4                    BRA     LOADAC
00630                                   *
00631                                   *
00632A C1C7 83   0001    A SUBTR1      SUBD    #$0001
00633A C1CA 20   E8   C1B4                    BRA     LOADAC
00634                                   *
00635                                   *
```

```
00637                                *
00638                                *
00639                                *
00640                                ***********************************************
00641                                * LARGE ERROR ;
00642                                *-----------------
00643                                *
00644                                *    THIS ROUTINE DETERMINES A NEW CONV. OSC.
00645                                *    DAC VALUE BASED ON POWER REQUIREMENTS.
00646                                *
00647                                *
00648A C1CC 7F   0006     P LRGERR CLR     STABLE   ;DUE TO UNSTABLE LOAD
00649                                *                         CLEAR STABLE.
00650A C1CF BD   C2F5     A        JSR     MEASR1   ;MEASURE INV INP CURR
00651                                *                           CONV OUT VOLTAGE.
00652A C1D2 F6   0003     P        LDB     VNOMNL   ;GET CONV VOLT REF
00653A C1D5 F0   0001     P        SUBB    VMEASR   ;DETERMINE DIFFERENCE
00654                                *                          FROM MEASURED VALUE.
00655A C1D8 2C   0C   C1E6        BGE     LOW      ;BRA IF CONV VOLT LOW
00656A C1DA 50                    NEGB             ;CONV VOLT IS HIGH
00657A C1DB 7D   0004     P        TST     PLARTY   ;DOES POLARITY AGREE
00658                                *                         WITH PREVIOUS MEASUREM
00659A C1DE 27   0D   C1ED        BEQ     AHEAD4   ;YES, THEN BRANCH.
00660A C1E0 34   07       A FAULT9 PSHS    B,A,CC   ;POLARITY OF CONV OUT
00661                                *                          VOLTAGE ERROR CHANGED
00662A C1E2 CC   5509     A        LDD     #$5509   ;
00663A C1E5 3F                    SWI
00664                                *
00665                                *
00666A C1E6 7D   0004     P LOW    TST     PLARTY   ;DOES POLARITY AGREE
00667                                *                          WITH PREVIOUS MEASURE
00668A C1E9 26   02   C1ED        BNE     AHEAD4   ;YES, THEN BRANCH.
00669A C1EB 20   F3   C1E0        BRA     FAULT9
00670                                *
00671                                *
00672                                *
00673A C1ED C0   10       A AHEAD4 SUBB    #$10     ;ERR > 15 BITS? (7.5%)
00674A C1EF 2E   06   C1F7        BGT     CALCUL   ;YES, CALCULATE POWER
00675                                *                          REQUIREMENTS.
00676                                *
00677A C1F1 34   07       A FAULTA PSHS    B,A,CC   ;ERR HAS DECREASED BY
00678                                *                          MORE THAN 5 BITS FROM
00679                                *                         PREVIOUS MEASUREMENT.
00680                                *                           THIS INDICATES NON-R
00681                                *                           ABILITY OF MEASUREME
00682A C1F3 CC   550A     A        LDD     #$550A   ;
00683A C1F6 3F                    SWI
00684                                *
00685                                *
```

```
00687                                *
00688                                *
00689                                ***********************************************
00690                                * CALCULATE POWER REQUIREMENTS
00691                                * -----------------------------
00692                                *
00693                                *
00694                                *  PREQ = ( VNOM / VMEAS )X (IMEAS)X(RATIO )
00695                                * PREQ = CONV OUT POWER REQUIRED
00696                                * VNOM = CONV OUT VOLT NOMINAL
00697                                * IMEAS = INV INPUT CURR MEASURED
00698                                * VMEAS = CONV OUT VOLT MEASURED
00699                                * RATIO = NORMALIZED VALUE.  IF DESIRED
00700                                *          INV OUT VOLT IS 120VRMS THEN
00701                                *          RATIO = 1.00
00702                                *
00703A C1F7 7F    0002     P CALCUL CLR     DVIDND
00704A C1FA 7F    0000     P        CLR     DVISOR
00705A C1FD 8E    0000     P        LDX     #DVISOR   ;POINT TO CONV OUT VOL
00706                                *                   MEASURED VALUE.
00707A C200 108E 0002     P        LDY     #DVIDND   ;POINT TO CONV OUT VOL
00708                                *                   REFERENCE VALUE.
00709A C204 BD    C2C7     A        JSR     DIVIDE    ;VNOMNL DIV BY VMEASR
00710                                *                   PRODUCES 8 BIT QUOTIEN
00711                                *                   AND 8 BIT REMAINDER.
00712A C207 FC    000E     P        LDD     IMEASR
00713A C20A BD    C292     A        JSR     MLTPLY    ;IMEASR X QUOTIENT
00714                                *                    AND REMAINDER.
00715                                *
00716                                *
00717A C20D FC    0019     P        LDD     RATIO
00718A C210 B7    0013     P        STA     QUOTNT
00719A C213 F7    0014     P        STB     REMNDR
00720A C216 FC    0015     P        LDD     RESULT
00721A C219 BD    C292     A        JSR     MLTPLY
00722A C21C 1E    89       A        EXG     A,B
00723A C21E 49                     ROLA
00724A C21F 59                     ROLB
00725A C220 49                     ROLA
00726A C221 84    01       A        ANDA    #$01
00727A C223 8E    CC00     A GETVAL LDX     #TABLE3
00728A C226 31    8B       A        LEAY    D,X
00729A C228 E6    A4       A        LDB     ,Y        ;LOAD LOWER 8 BITS OF
00730                                *                    11 BIT DAC VALUE.
00731A C22A 4F                     CLRA               ;CLEAR UPPER BITS.
00732A C22B 8E    CD05     A        LDX     #TABLE5   ;PREPARE TO DETERMINE
00733                                *                    UPPER 3 BITS.
00734                                *
00735A C22E 10AC 81       A TRYAGN CMPY    ,X++
00736A C231 2D    03    C236         BLT     AHED1
00737A C233 4C                     INCA
00738A C234 20    F8    C22E         BRA     TRYAGN
00739                                *
00740                                *
00741                                *INSERT ROUTINE TO APPLY
00742                                *A CORRECTION FACTOR IF CONV INPUT VOLT ABNOR
00743                                *
00744A C236 108E 0009     P AHED1  LDY     #DACVAL   ;POINT TO OLD DAC VALU
```

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00745A C23A 10A3 A4      A          CMPD    ,Y        ;VAL < OR > OLD VAL?
00746A C23D 2E   0A   C249            BGT     AHEAD5    ;BRA IF GREATER THAN.
00747A C23F FD   000B    P            STD     SAVE1
00748A C242 108E 000B    P            LDY     #SAVE1
00749A C246 FC   0009    P            LDD     DACVAL
00750                                 *
00751                                 *
00752A C249 A3   A4      A AHEAD5     SUBD    ,Y        ;DIFFERENCE BETWEEN VA
00753                                 *                   AND OLD DAC VALUE.
00754A C24B 44                        LSRA
00755A C24C 56                        RORB              ;DIV DIFFERENCE BY 2.
00756A C24D E3   A4      A            ADDD    ,Y        ;APPLY 50% CORRECTION
00757A C24F BD   C253    A            JSR     DACDRV    ;SEND ACC. D TO DAC.
00758                                 *
00759                                 *
00760                                 *
00761                                 ****************************************
00762                                 *  EXIT
00763                                 *  ----
00764                                 *
00765A C252 3B                        EXIT    RTI
00766                                 *
00767                                 *
00768                                 *
00769                                 *
00770                                 *
00771                                 *
00772                                 ************************************************
00773                                 * DAC DRIVER
00774                                 * ----------
00775                                 *
00776                                 *
00777A C253 FD   0009    P DACDRV     STD     DACVAL    ;SAVE CORRECTED DAC
00778                                 *                   VALUE.
00779A C256 81   04      A            CMPA    #$04      ;DACVAL EXCEED 3FFH?
00780A C258 2C   1B   C275            BGE     ACTVAT    ;YES, ACTVAT 33KHZ OFSE
00781A C25A B6   0010    P            LDA     OVERLD    ;NO, EXAMINE OVERLD FLG
00782A C25D 81   55      A            CMPA    #TRUE     ;IS OVERLOAD MODE SET?
00783A C25F 27   25   C286            BEQ     REMOVE    ;YES, REMOVE 33KHZ OFST
00784                                 *                   AND IGNORE TIMER.
00785A C261 81   AA      A            CMPA    #NTTRUE   ;IS OVERLD NOT SET?
00786A C263 27   06   C26B            BEQ     SENDIT    ;YES, THEN BRANCH.
00787A C265 34   07      A FAULTB     PSHS    B,A,CC    ;OVERLD MEM LOC. OR
00788                                 *                     DATA BUS IS BAD.
00789A C267 CC   550B    A            LDD     #$550B    ;
00790A C26A 3F                        SWI
00791                                 *
00792                                 *
00793A C26B FC   0009    P SENDIT     LDD     DACVAL
00794A C26E FD   8000    A            STD     WE0       ;LOAD DAC BUFFER.
00795A C271 B7   8004    A            STA     WE4       ;XFER DAC BUFF TO DAC.
00796A C274 39                        RTS
00797                                 *
00798                                 *
00799A C275 BD   C26B    A ACTVAT     JSR     SENDIT    ;SEND DAC VALUE FIRST
00800                                 *                  BEFORE APPLYING 33KHZ OFFSET.
00801A C278 B6   40A2    A            LDA     PORTB     ;READ PORT B
00802A C27B 84   DF      A            ANDA    #$DF      ;CLEAR PB5
```

```
00803A C27D B7  40A2    A         STA   PORTB    ;ACTIVATE 33KHZ OFFSET
00804A C280 86  55      A         LDA   #TRUE
00805A C282 B7  0010    P         STA   OVERLD   ;SET OVERLD FLAG.
00806                     *
00807                     *
00808                     *     INSERT ROUTINE TO START OR MAINTAIN TIME
00809                     *
00810A C285 39                    RTS
00811                     *
00812                     *
00813A C286 B6  40A2    A REMOVE  LDA   PORTB    ;READ PORT B
00814A C289 8A  20      A         ORA   #.33KHZ  ;SET PB5
00815A C28B B7  40A2    A         STA   PORTB    ;DEACTIVATE 33KHZ OFFS
00816A C28E BD  C26B    A         JSR   SENDIT   ;SEND DAC VALUE TO DAC
00817                     *
00818                     *  INSERT ROUTINE TO STOP TIMER SINCE OVERLOA
00819                     *  DEACTIVATED.
00820                     *
00821A C291 39                    RTS
00822                     *
00823                     *
00824                     *
00825                     ***********************************************
00826                     * MULTIPLY
00827                     * ---------
00828                     * THIS SUBROUTINE WILL MULTIPLY THE VALUE IN
00829                     * ACC.  D BY "QUOTNT" AND "REMNDR".
00830                     *
00831A C292 FD  0011    P MLTPLY  STD   MLTCAN
00832A C295 7D  0013    P         TST   QUOTNT   ;IS QUOTIENT ZERO?
00833A C298 27  0A  C2A4          BEQ   AHEAD6   ;YES, THEN BRANCH.
00834                     *
00835A C29A 7A  0013    P AGAIN4  DEC   QUOTNT
00836A C29D 27  0D  C2AC          BEQ   AGAIN5
00837A C29F F3  0011    P         ADDD  MLTCAN
00838A C2A2 20  F6  C29A          BRA   AGAIN4
00839                     *
00840A C2A4 FD  0015    P AHEAD6  STD   RESULT
00841A C2A7 CC  0000    A         LDD   #$0000
00842A C2AA 20  03  C2AF          BRA   AHEAD7
00843                     *
00844A C2AC FD  0015    P AGAIN5  STD   RESULT
00845                     *
00846A C2AF 74  0015    P AHEAD7  LSR   RESULT
00847A C2B2 76  0016    P         ROR   RESULT+1
00848A C2B5 78  0014    P         LSL   REMNDR
00849A C2B8 25  04  C2BE          BCS   AHEAD8
00850A C2BA 27  07  C2C3          BEQ   FINISH
00851A C2BC 20  F1  C2AF          BRA   AHEAD7
00852                     *
00853                     *
00854A C2BE F3  0015    P AHEAD8  ADDD  RESULT
00855A C2C1 20  EC  C2AF          BRA   AHEAD7
00856                     *
00857A C2C3 FD  0015    P FINISH  STD   RESULT
00858A C2C6 39                    RTS
00859                     *
00860                     *
```

```
00861                          *
00862                          ***********************************************
00863                          *  DIVIDE
00864                          *  ----------
00865                          * THE X REG POINTS TO 2 BYTE DIVISOR
00866                          * THE Y REG POINTS TO 2 BYTE DIVIDEND
00867                          * THE RESULT OF DIVISION WILL BE STORED
00868                          * IN TWO LOCATIONS.  "QUOTNT"= WHOLE UNITS
00869                          *                    "REMNDR"= FRACTION
00870                          *
00871A C2C7 7F   0014    P DIVIDE CLR    REMNDR
00872A C2CA 7F   0013    P        CLR    QUOTNT    ;
00873A C2CD 86   08      A        LDA    #$08      ;
00874A C2CF B7   000D    P        STA    COUNT1    ;
00875A C2D2 EC   A4      A        LDD    ,Y        ;LOAD DIVIDEND
00876A C2D4 10A3 84      A DIVID1 CMPD   ,X        ;COMPARE DIVISOR
00877A C2D7 2B   11    C2EA       BMI    NOINCR    ;BRA IF DVIDND<DIVISOR
00878A C2D9 A3   84      A        SUBD   ,X        ;SUBTRACT DIVISOR
00879A C2DB 7C   0013    P        INC    QUOTNT    ;
00880A C2DE 20   F4    C2D4       BRA    DIVID1    ;
00881                          *
00882A C2E0 10A3 84      A DIVID2 CMPD   ,X        ;COMPARE DIVISOR
00883A C2E3 2B   05    C2EA       BMI    NOINCR    ;
00884A C2E5 A3   84      A        SUBD   ,X        ;
00885A C2E7 7C   0014    P        INC    REMNDR    ;
00886                          *
00887A C2EA 78   0014    P NOINCR LSL    REMNDR    ;MULT REMNDR BY 2
00888A C2ED 58                    LSLB
00889A C2EE 49                    ROLA              ;MULT DVIDND BY 2
00890A C2EF 7A   000D    P        DEC    COUNT1    ;
00891A C2F2 26   EC    C2E0       BNE    DIVID2    ;
00892A C2F4 39                    RTS
00893                          *
00894                          *
00895                          *
00896                          *
00897                          *
00898                          *
00899                          ***********************************************
00900                          * MEASURE1
00901                          *
00902                          * THIS SUBROUTINE MEASURES INV INPUT CURR AND
00903                          * CONVERTER OUTPUT VOLTAGE, SIMULTANEOUSLY.
00904                          *
00905A C2F5 86   D8      A MEASR1 LDA    #$D8
00906A C2F7 B7   40A0    A        STA    PORTA
00907A C2FA 86   01      A        LDA    #$01
00908A C2FC B7   40C0    A        STA    PORTC
00909A C2FF B6   40A2    A        LDA    PORTB
00910A C302 88   80      A        EORA   #CNVRT2
00911A C304 C6   07      A        LDB    #$07
00912A C306 BD   C381    A        JSR    DELAY
00913A C309 7F   40C0    A        CLR    PORTC
00914A C30C B7   40A2    A        STA    PORTB
00915                          *
00916A C30F F6   40C0    A AGAIN7 LDB    PORTC
00917A C312 C4   18      A        ANDB   #$18
00918A C314 26   F9    C30F       BNE    AGAIN7
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00919A C316 86   06      A          LDA    #$06
00920A C318 B7   000D    P          STA    COUNT1
00921A C31B F6   8010    A          LDB    RE2        ;A/D#1 LO BYTE
00922A C31E B6   8018    A          LDA    RE3        ;A/D#1 HI BYTE
00923                              *
00924                              *
00925A C321 C4   C0      A          ANDB   #$C0
00926A C323 58                      LSLB
00927A C324 49                      ROLA
00928A C325 FD   000E    P          STD    IMEASR
00929A C328 F6   8008    A          LDB    RE1
00930A C32B F7   0001    P          STB    VMEASR
00931A C32E B6   40A2    A          LDA    PORTB
00932A C331 8A   80      A          ORA    #CNVRT2
00933A C333 B7   40A2    A          STA    PORTB      ;BLANK A/D#2 OUTPUTS,S
00934A C336 86   03      A          LDA    #$03
00935A C338 B7   40C0    A          STA    PORTC      ;BLANK A/D#1 OUTPUTS,S
00936                              *                        10 DEGREE MODE.
00937A C33B 39                      RTS
00938                              *
00939                              *
00940                              *
00941                              *
00942                              *
00943                              ************************************************
00944                              * READ BCD THUMBWHEEL SWITCHES
00945                              * -------------------------
00946A C33C B6   8038    A THUMB    LDA    RE7        ;READ 2ND AND 3RD DIGI
00947A C33F 81   39      A          CMPA   #HILIM     ;DOES SETTING EXCEED M
00948A C341 2E   01   C344          BGT    FAULT1     ;YES,THEN BRANCH.
00949A C343 39                      RTS
00950                              *
00951A C344 34   07      A FAULT1   PSHS   B,A,CC     ;SWITCH EXCEEDS MAX LI
00952A C346 CC   5501    A          LDD    #$5501     ;ERROR 1
00953A C349 3F                      SWI
00954                              *
00955                              * VERIFY BCD VALUE IS VALID
00956                              * -------------------------
00957A C34A 1F   89      A VALID    TFR    A,B
00958A C34C 84   0F      A          ANDA   #$0F       ;MASK 3RD DIGIT.
00959A C34E 81   0A      A          CMPA   #$0A       ;IS IT WITHIN THE DECI
00960A C350 2D   06   C358          BLT    BINARY     ;YES,THEN BRANCH.
00961                              *
00962A C352 34   07      A FAULT2   PSHS   B,A,CC     ;BCD SWITCH SENT AN IN
00963A C354 CC   5502    A          LDD    #$5502     ;ERROR 2
00964A C357 3F                      SWI
00965                              *
00966                              * CONVERT BCD TO BINARY
00967                              * -------------------------
00968A C358 C4   F0      A BINARY   ANDB   #$F0
00969A C35A 27   06   C362 BACK1    BEQ    LOOKUP
00970A C35C 8B   0A      A          ADDA   #$0A       ;ADD 10 BITS TO 3RD DI
00971                              *                                  EACH
00972A C35E C0   10      A          SUBB   #$10
00973A C360 20   F8   C35A          BRA    BACK1
00974                              *
00975                              *
00976                              * LOOKUP INV.  OUTPUT VOLT REF VALUE
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00977                                * ---------------------------------
00978A C362 B7   000B     P LOOKUP   STA     SAVE1      ;SAVE BCD SWITCH BINAR
00979A C365 8E   C447     A          LDX     #TABLE1    ;BEGINNING ADDR OF TAB
00980A C368 E6   86       A          LDB     A,X        ;FIND INV OUT VOLT REF
00981A C36A 86   01       A          LDA     #$01
00982A C36C FD   0017     P          STD     REFRNC
00983                                *
00984                                * LOOKUP NORMALIZED NUMBER FOR POWER CALCULAT
00985                                * ----------------------------------------
00986A C36F 8E   C499     A          LDX     #TABLE4
00987A C372 B6   000B     P          LDA     SAVE1      ;RETRIEVE BCD SWITCH B
00988A C375 E6   86       A          LDB     A,X        ;FIND NORMALIZED RATIO
00989A C377 4F                       CLRA
00990A C378 C1   50       A          CMPB    #$50
00991A C37A 2E   01       C37D       BGT     AHEADC
00992A C37C 4C                       INCA
00993A C37D FD   0019     P AHEADC   STD     RATIO      ;SAVE IT.
00994A C380 39                       RTS
00995                                *
00996                                *
00997                                *
00998                                ***********************************************
00999                                *  DELAY
01000                                *  ------
01001                                *
01002A C381 12                       DELAY   NOP
01003A C382 12                       NOP
01004A C383 5A                       DECB
01005A C384 26   FB       C381       BNE     DELAY
01006A C386 39                       RTS
01007                                *
01008                                *
01009                                ***********************************************
01010                                * COMMUTATION FAIL INTERRUPT SERVICE ROUTINE
01011                                *
01012A C387 B6   40C0     A IRQ      LDA     PORTC      ;READ PORT C
01013A C38A 84   E0       A          ANDA    #COMFAL    ;MASK FAIL BITS.
01014A C38C 88   E0       A          EORA    #COMFAL    ;IDENTIFY FAILING PHAS
01015A C38E B7   001B     P          STA     FAILST     ;SAVE FAIL STATUS
01016A C391 B6   40A2     A          LDA     PORTB
01017A C394 9A   40       A          ORA     ENBLCV
01018A C396 B7   40A2     A          STA     PORTB      DISABLE CONVERTER
01019                                ***********************************************
01020                                *
01021                                * THE FOLLOWING IS A 22 MILLISECOND DELAY
01022                                * ROUTINE BEFORE RE-ENABLING THE
01023                                * CONVERTER AFTER A COMMUTATION FAILURE.
01024                                *
01025                                ******
01026A C399 86   65       A          LDA     #$65       LOAD TIMER VARIABLE
01027A C39B 5F                       CLRB               CLEAR NMBR TMS REG.
01028A C39C 8E   001B     A CYCLE    LDX     #$001B     LOAD TIMING CONSTANT
01029A C39F 30   1F       A AGN      LEAX    -1,X       DEC X REG
01030A C3A1 26   FC       C39F       BNE     AGN        CYCLE COMPLETED?
01031A C3A3 5C                       INCB
01032A C3A4 34   04       A          PSHS    B
01033A C3A6 A1   E0       A          CMPA    ,S+
01034A C3A8 26   F2       C39C       BNE     CYCLE      NO TIME OUT?
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01035                                ***********************************************
01036A C3AA 96   40       A          LDA    ENBLCV
01037A C3AC 43                       COMA
01038A C3AD B4   40A2     A          ANDA   PORTB
01039A C3B0 B7   40A2     A          STA    PORTB     ENABLE CONVERTER
01040A C3B3 B7   8005     A          STA    WE5       ;CLEAR COMM FAIL INTRP
01041A C3B6 3B                       RTI
01042                                *
01043                                *
01044                                *
01045                                ***********************************************
01046                                * INVERTER OUTPUT VOLTAGE MEASUREMENT ROUTINE
01047                                *
01048                                *
01049A C3B7 7D   0007     P INVOUT   TST    LOKOUT
01050A C3BA 1026 FE94 C252           LBNE   EXIT
01051                                *
01052                                *
01053                                *
01054                                * REST OF ROUTINE GOES HERE.
01055                                *
01056A C3BE 16   FE91 C252           LBRA   EXIT
01057                                *
01058                                *
01059A C3C1 CC   550F     A NMI      LDD    #$550F    ;NMI WARNING
01060                                *
01061                                *  POWER SUPPLY FAILURE INT ROUT WILL
01062                                *  REPLACE THIS ERROR ROUTINE.
01063                                *
01064A C3C4 3F                       SWI
01065                                *
01066                                *
01067                                *
01068A C3C5 CC   550E     A FAULTE   LDD    #$550E    ;ILLEGAL SM ERR JMP
01069A C3C8 3F                       SWI
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01071                                *
01072                                ********************************************
01073                                * SOFTARE INTERRUPT ROUTINE
01074                                *
01075                                *THIS ROUT WILL SERVICE AN INTRPT GENERATED
01076                                *DUE TO A FAULT CONDITION.  THE VAL IN ACC B
01077                                *IDENTIFIES THE FAULT.  THE CC,A AND B REG
01078                                * WERE SAVED ON THE STACK.  THE ABOVE REG WILL
01079                                *  BE FORMATTED AND DISPLAYED.
01080                                *
01081                                *       REGISTER      [ FAULT ][ CC ][ A ][ B ]
01082                                *                       ------------------------
01083                                *                       !  !  !  !  !  !  !  !
01084                                *                       ------------------------
01085                                *       POSITION        1  2  3  4  5  6  7  8
01086                                *
01087                                *
01088                                * THE DISPLAY WILL NOT BE CLEARED AND NORMAL
01089                                *EXECUTION WILL NOT RESUME UNTIL THE USER HAS
01090                                * DEPRESSED THE SENSE SWITCH.
01091                                *
01092                                *
01093                                *
01094                                * FAULT1= BCD SWITCH SETTING EXCEEDS MAX LIM
01095                                * FAULT2= BCD SWITCH SENT ILLEGAL CODE
01096                                *FAULT3= PORT A READ/WRITE ERR
01097                                *FAULT4= PORT B READ/WRITE ERROR
01098                                *FAULT5= PORT C READ/WRITE ERROR
01099                                *FAULT6= BAD RAM LOCATION
01100                                *FAULT7= BAD FREQ SWITCH
01101                                *FAULT8= NOT USED
01102                                * FAULT9= NON-REPEATABILITY OF  MEASUREMENT
01103                                * FAULTA= NON-REPEATABILITY OF MEASUREMENT
01104                                * FAULTB= DATA BUS OR OVRLD MEM LOC BAD
01105                                * FAULTC= NOT USED
01106                                * FAULTD= FREQ SWITCH CHANGED
01107                                * FAULTE= ILLEGAL SM ERR JMP
01108                                * FAULTF= NMI INTERRUPT
01109                                *
01110                                *
01111A C3C9 30    6C       A SWINT  LEAX   $0C,S     ;ADDRESS OF 12TH BYTE
01112                                *                       INTO STACK.
01113A C3CB 108E 001D      P        LDY    #MESSBF
01114A C3CF E7    A0       A        STB    ,Y+       ;STORE FAULT CODE IN
01115                                *                       MESSAGE BUFFER.
01116A C3D1 E6    80       A        LDB    ,X+
01117A C3D3 E7    A0       A        STB    ,Y+       ;PUT PRE-INT COND CODE
01118                                *                       INTO MESSAGE BUFFER.
01119A C3D5 EC    84       A        LDD    ,X
01120A C3D7 ED    A4       A        STD    ,Y        ;PUT ACC. A AND ACC. B
01121                                *
01122A C3D9 B6    40A2     A        LDA    PORTB     ;
01123A C3DC 9A    40       A        ORA    ENBLCV    ;SET CONV ENBL BIT
01124A C3DE B7    40A2     A        STA    PORTB     ;DISABLE CONV
01125                                *
01126A C3E1 BD    C3ED     A        JSR    SETUP     ;TRANSLATE MESSAGE
01127A C3E4 BD    C412     A        JSR    PRINT     ;DISPLAY ALL CHARCTRS
01128A C3E7 BD    C420     A        JSR    SENSE     ;WAIT FOR SENSE SWITCH
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01129A C3EA 7E   C000     A          JMP     RESTRT
01130                      *
01131                      *
01132                      *
01133                      * SETUP
01134                      * -----
01135                      *        TRANSLATE MESSAGE INTO CHARACTER CODE
01136                      *
01137A C3ED 86   04       A SETUP    LDA     #$04      COUNT1
01138A C3EF 8E   001D     P          LDX     #MESSBF
01139A C3F2 CE   C42D     A          LDU     #DSPTBL
01140A C3F5 108E 0021     P          LDY     #DSPBUF
01141A C3F9 B7   000D     P          STA     COUNT1
01142                      *
01143A C3FC E6   80       A LOOP4    LDB     ,X+
01144A C3FE 1F   98       A          TFR     B,A
01145A C400 44                       LSRA
01146A C401 44                       LSRA
01147A C402 44                       LSRA
01148A C403 44                       LSRA
01149A C404 C4   0F       A          ANDB    #$0F
01150A C406 A6   C6       A          LDA     A,U
01151A C408 E6   C5       A          LDB     B,U
01152A C40A ED   A1       A          STD     ,Y++
01153A C40C 7A   000D     P          DEC     COUNT1
01154A C40F 26   EB   C3FC           BNE     LOOP4
01155A C411 39                       RTS
01156                      *
01157A C412 8E   0021     P PRINT    LDX     #DSPBUF
01158A C415 C6   08       A          LDB     #$08
01159A C417 A6   80       A PRINT8   LDA     ,X+
01160A C419 B7   4000     A          STA     DSPLYD
01161A C41C 5A                       DECB
01162A C41D 26   F8   C417           BNE     PRINT8
01163A C41F 39                       RTS
01164                      *
01165A C420 B6   8040     A SENSE    LDA     RE8
01166A C423 84   08       A          ANDA    #$08      ;IS SENSE SWITCH DEPRE
01167A C425 27   F9   C420           BEQ     SENSE     ;NO, THEN WAIT.
01168A C427 86   DF       A          LDA     #CLRDIS
01169A C429 B7   4001     A          STA     DSPLYC    ;CLEAR DISPLAY
01170A C42C 39                       RTS
01171                      ********************************************
01172                      * THIS INDICATES SEGMENT VS. BIT POSITION
01173                      * IN LABEL "DSPLYD".
01174
01175                      * "DSPLYD" MSB,-,-,-,-,-,-,LSB
01176                      * SEGMENT   D  C,B,A, ,G,F, E
01177
01178                      * NOTE: A ZERO IN A BIT
01179                      * POSITION TURNS ON THE
01180                      * CORRESPONDING LED SEGMENT.
01181                      * B3 POSITION IS DEC. POINT.
01182                      *
01183                      *
01184                      *
01185                      *
01186                      *
```

```
01187                          * DISPLAY CHARACTER TABLE
01188                          *
01189A C42D      0C        A DSPTBL FCB    $0C       ;0
01190A C42E      9F        A ONE    FCB    $9F
01191A C42F      4A        A TWO    FCB    $4A
01192A C430      0B        A THREE  FCB    $0B       ;3
01193A C431      99        A FOUR   FCB    $99       ;4
01194A C432      29        A FIVE   FCB    $29       ;5
01195A C433      28        A SIX    FCB    $28       ;6
01196A C434      8F        A SEVEN  FCB    $8F       ;7
01197A C435      08        A EIGHT  FCB    $08       ;8
01198A C436      89        A NINE   FCB    $89       ;9
01199A C437      88        A LETTRA FCB    $88       ;A
01200A C438      38        A LETTRB FCB    $38       ;B ( LOWER CASE )
01201A C439      6C        A LETTRC FCB    $6C       ;C
01202A C43A      1A        A LETTRD FCB    $1A       ;D ( LOWER CASE )
01203A C43B      68        A LETTRE FCB    $68       ;E
01204A C43C      E8        A LETTRF FCB    $E8       ;F
01205A C43D      98        A LETTRH FCB    $98       ;H
01206A C43E      1A        A LETTRJ FCB    $1A       ;J
01207A C43F      7C        A LETTRL FCB    $7C       ;L
01208A C440      C8        A LETTRP FCB    $C8       ;P
01209A C441      9F        A LETTRI FCB    $9F       ;I
01210A C442      BA        A LETTRN FCB    $BA       ;N ( LOWER CASE )
01211A C443      FA        A LETTRR FCB    $FA       ;R  ( LOWER CASE )
01212A C444      1C        A LETTRU FCB    $1C       ;U
01213A C445      FF        A BLANK  FCB    $FF       ;BLANK
01214A C446      F7        A POINT  FCB    $F7       ;DECIMAL POINT
01215                          *
01216                          *
01217                          *
```

```
01219                                   *
01220                                   ************************************************
01221                                   *  TABLE 1 ; INVERTER OUTPUT VOLTAGE REF TABLE
01222                                   *  ALL VALUES ARE PRECEEDED BY A "1".
01223                                   *    1FFH = 210 VOLTS PEAK
01224                                   *
01225A C447      58      A TABLE1 FCB    $58     ; 100VRMS, 141.42 V PK
01226A C448      5C      A        FCB    $5C
01227A C449      5F      A        FCB    $5F
01228A C44A      62      A        FCB    $62
01229A C44B      66      A        FCB    $66
01230A C44C      69      A        FCB    $69
01231A C44D      6D      A        FCB    $6D
01232A C44E      70      A        FCB    $70
01233A C44F      74      A        FCB    $74
01234A C450      77      A        FCB    $77
01235A C451      7B      A        FCB    $7B     ; 110VRMS, 155.6 V PK
01236A C452      7E      A        FCB    $7E
01237A C453      81      A        FCB    $81
01238A C454      85      A        FCB    $85
01239A C455      88      A        FCB    $88
01240A C456      8C      A        FCB    $8C
01241A C457      8F      A        FCB    $8F
01242A C458      93      A        FCB    $93
01243A C459      96      A        FCB    $96
01244A C45A      9A      A        FCB    $9A
01245A C45B      9D      A        FCB    $9D     ; 120VRMS, 169.7 V PK
01246A C45C      A0      A        FCB    $A0
01247A C45D      A3      A        FCB    $A3
01248A C45E      A7      A        FCB    $A7
01249A C45F      AB      A        FCB    $AB
01250A C460      AE      A        FCB    $AE
01251A C461      B1      A        FCB    $B1
01252A C462      B5      A        FCB    $B5
01253A C463      B8      A        FCB    $B8
01254A C464      BC      A        FCB    $BC
01255A C465      BF      A        FCB    $BF     ; 130VRMS, 183.85 V PK
01256A C466      C3      A        FCB    $C3
01257A C467      C6      A        FCB    $C6
01258A C468      CA      A        FCB    $CA
01259A C469      CD      A        FCB    $CD
01260A C46A      D0      A        FCB    $D0
01261A C46B      D4      A        FCB    $D4
01262A C46C      D7      A        FCB    $D7
01263A C46D      DB      A        FCB    $DB
01264A C46E      DE      A        FCB    $DE     ; 139V, 196.6 V PK
01265                                   *
```

```
01267                                *
01268                                *
01269                                ***********************************************
01270                                * TABLE 2  ;SMALL ERROR CORRECTION JMP TABLE
01271                                * --------
01272                                *   A SMALL ERROR OF 15 BITS WILL CAUSE
01273                                *    THE E3.1PC ROUTINE TO BE EXECUTED.
01274                                *    THIS ROUTINE WILL ADJUST THE CONV
01275                                *    OSC FREQ 3.1% TO PARTIALLY CORRECT
01276                                *    THE CONV OUT VOLT ERROR.
01277                                *
01278A C46F      C3C5    A TABLE2 FDB    FAULTE   ;ILLEGAL ADDRESS
01279A C471      C164    A        FDB    E.1PC    ;1 BIT ERROR  .52%
01280A C473      C16D    A        FDB    E.2PC    ;2 BIT ERROR 1.045
01281A C475      C178    A        FDB    E.4PC    ;3 BIT ERROR  1.56%
01282A C477      C17C    A        FDB    E.8PC    ;4 BIT ERROR  2.08%
01283A C479      C17C    A        FDB    E.8PC    ;5 BIT ERROR  2.60%
01284A C47B      C17C    A        FDB    E.8PC    ;6 BIT ERROR  3.12%
01285A C47D      C180    A        FDB    E1.5PC   ;7 BIT ERROR  3.64%
01286A C47F      C180    A        FDB    E1.5PC   ;8 BIT ERROR  4.16%
01287A C481      C180    A        FDB    E1.5PC   ;9 BIT ERROR  4.68%
01288A C483      C180    A        FDB    E1.5PC   ;10 BIT ERROR  5.20%
01289A C485      C180    A        FDB    E1.5PC   ;11 BIT ERROR  5.72%
01290A C487      C180    A        FDB    E1.5PC   ;12 BIT ERROR  6.24%
01291A C489      C180    A        FDB    E1.5PC   ;13 BIT ERROR  6.76%
01292A C48B      C184    A        FDB    E3.1PC   ;14 BIT ERROR  7.28%
01293A C48D      C184    A        FDB    E3.1PC   ;15 BIT ERROR  7.80%
01294A C48F      C184    A        FDB    E3.1PC   ;16 BIT ERROR  8.32%
01295A C491      C184    A        FDB    E3.1PC   ;17 BIT ERROR  8.84%
01296A C493      C184    A        FDB    E3.1PC   ;18 BIT ERROR  9.36%
01297A C495      C184    A        FDB    E3.1PC   ;19 BIT ERROR  9.88%
01298A C497      C184    A        FDB    E3.1PC   ;20 BIT ERROR  10.40%
01299                                *
01300                                *
01301                                *
01302                                ***********************************************
01303                                *  TABLE 4
01304                                *  -------
01305                                *
01306                                *  ALL VALUES IN TABLE ARE NORMALIZED
01307                                *  TO 120V RMS.  THE TABLE BEGINS WITH
01308                                *  0D5H AND ENDS WITH 128H .
01309                                *  THESE VALUES BECOME A MULTIPLIER IN
01310                                *  CONV OUT POWER CALCULATIONS.
01311                                * VALUES D5H AND FEH REPRESENT 0.D5H AND 0.FE
01312                                * VALUES 00H AND 28H REPRESENT 1.00H AND 1.28
01313                                *
01314A C499      D5      A TABLE4 FCB    $D5      ;100 VRMS
01315A C49A      D7      A        FCB    $D7
01316A C49B      DA      A        FCB    $DA
01317A C49C      DC      A        FCB    $DC
01318A C49D      DE      A        FCB    $DE
01319A C49E      E0      A        FCB    $E0
01320A C49F      E2      A        FCB    $E2
01321A C4A0      E4      A        FCB    $E4
01322A C4A1      E6      A        FCB    $E6
01323A C4A2      E9      A        FCB    $E9
01324A C4A3      EB      A        FCB    $EB      ;110 VRMS
```

```
01325A C4A4       ED       A          FCB    $ED
01326A C4A5       EF       A          FCB    $EF
01327A C4A6       F1       A          FCB    $F1
01328A C4A7       F3       A          FCB    $F3
01329A C4A8       F5       A          FCB    $F5
01330A C4A9       F7       A          FCB    $F7
01331A C4AA       FA       A          FCB    $FA
01332A C4AB       FC       A          FCB    $FC
01333A C4AC       FE       A          FCB    $FE
01334A C4AD       00       A          FCB    $00
01335A C4AE       02       A          FCB    $02       ;120 VRMS
01336A C4AF       04       A          FCB    $04
01337A C4B0       06       A          FCB    $06
01338A C4B1       08       A          FCB    $08
01339A C4B2       0B       A          FCB    $0B
01340A C4B3       0D       A          FCB    $0D
01341A C4B4       0F       A          FCB    $0F
01342A C4B5       11       A          FCB    $11
01343A C4B6       13       A          FCB    $13
01344A C4B7       15       A          FCB    $15       ;130 VRMS
01345A C4B8       18       A          FCB    $18
01346A C4B9       1A       A          FCB    $1A
01347A C4BA       1C       A          FCB    $1C
01348A C4BB       1E       A          FCB    $1E
01349A C4BC       20       A          FCB    $20
01350A C4BD       22       A          FCB    $22
01351A C4BE       24       A          FCB    $24
01352A C4BF       26       A          FCB    $26
01353A C4C0       28       A          FCB    $28       ;139 VRMS
01354                                 *
01355                                 *
01356                                 *
01357                                 ************************************************
01358                                 * TABLE 3  ;CONV OUT POWER VS. CONV OSC FREQ.
01359                                 * --------
01360                                 *  CONV OUTPUT POWER IS REPRESENTED
01361                                 * BY A 9 BIT HEX VALUE.
01362                                 *  POWER CAN RANGE FROM 000H TO 1FFH.
01363                                 *  THIS RANGE WILL CORRESPOND TO A CONV OUT
01364                                 *  POWER OF OKW TO 36KW.
01365                                 *  THE 512 VALUES IN THE TABLE CAN
01366                                 *  RANGE FROM 000H TO 7FFH.  THIS WILL RESULT
01367                                 *  CONVERTER OPERATING FREQ RANGE OF APPROX.
01368                                 *  5HZ TO 10.4KHZ .
01369                                 *  THE UPPER 3 BITS OF FREQ ARE
01370                                 *  SUPPRESSED IN THE TABLE.  THESE ARE
01371                                 *  RECONSTRUCTED IN THE PROGRAM.
01372A CC00                               ORG    $CC00
01373A CC00       03       A TABLE3   FCB    $03,$07,$0B,$0F,$13,$17,$1B,$1F
01374A CC08       23       A          FCB    $23,$27,$2B,$2F,$33,$37,$3B,$3F
01375A CC10       43       A          FCB    $43,$47,$4B,$4F,$53,$57,$5B,$5F
01376A CC18       63       A          FCB    $63,$67,$6B,$6F,$73,$77,$7B,$7F
01377A CC20       83       A          FCB    $83,$87,$8B,$8F,$93,$97,$9B,$9F
01378A CC28       A3       A          FCB    $A3,$A7,$AB,$AF,$B3,$B7,$BB,$BF
01379A CC30       C3       A          FCB    $C3,$C7,$CB,$CF,$D3,$D7,$DB,$DF
01380A CC38       E3       A          FCB    $E3,$E7,$EB,$EF,$F3,$F7,$FB,$FF
01381A CC40       03       A MSB1XX   FCB    $03,$07,$0B,$0F,$13,$17,$1B,$1F
01382A CC48       23       A          FCB    $23,$27,$2B,$2F,$33,$37,$3B,$3F
```

```
01383A CC50       43       A          FCB    $43,$47,$4B,$4F,$53,$57,$5B,$5F
01384A CC58       63       A          FCB    $63,$67,$6B,$6F,$73,$77,$7B,$7F
01385A CC60       83       A          FCB    $83,$87,$8B,$8F,$93,$97,$9B,$9F
01386A CC68       A3       A          FCB    $A3,$A7,$AB,$AF,$B3,$B7,$BB,$BF
01387A CC70       C3       A          FCB    $C3,$C7,$CB,$CF,$D3,$D7,$DB,$DF
01388A CC78       E3       A          FCB    $E3,$E7,$EB,$EF,$F3,$F7,$FB,$FF
01389A CC80       03       A MSB2XX   FCB    $03,$07,$0B,$0F,$13,$17,$1B,$1F
01390A CC88       23       A          FCB    $23,$27,$2B,$2F,$33,$37,$3B,$3F
01391A CC90       43       A          FCB    $43,$47,$4B,$4F,$53,$57,$5B,$5F
01392A CC98       63       A          FCB    $63,$67,$6B,$6F,$73,$77,$7B,$7F
01393A CCA0       83       A          FCB    $83,$87,$8B,$8F,$93,$97,$9B,$9F
01394A CCA8       A3       A          FCB    $A3,$A7,$AB,$AF,$B3,$B7,$BB,$BF
01395A CCB0       C3       A          FCB    $C3,$C7,$CB,$CF,$D3,$D7,$DB,$DF
01396A CCB8       E3       A          FCB    $E3,$E7,$EB,$EF,$F3,$F7,$FB,$FF
01397A CCC0       03       A MSB3XX   FCB    $03,$07,$0B,$0F,$13,$17,$1B,$1F
01398A CCC8       23       A          FCB    $23,$27,$2B,$2F,$33,$37,$3B,$3F
01399A CCD0       43       A          FCB    $43,$47,$4B,$4F,$53,$57,$5B,$5F
01400A CCD8       63       A          FCB    $63,$67,$6B,$6F,$73,$77,$7B,$7F
01401A CCE0       83       A          FCB    $83,$87,$8B,$8F,$93,$97,$9B,$9F
01402A CCE8       A3       A          FCB    $A3,$A7,$AB,$AF,$B3,$B7,$BB,$BF
01403A CCF0       C3       A          FCB    $C3,$C7,$CB,$CF,$D3,$D7,$DB,$DF
01404A CCF8       E3       A          FCB    $E3,$E7,$EB,$EF,$F3,$F7,$FB,$FF
01405A CD00       00       A MSB4XX   FCB    $00
01406A CD01       00       A MSB5XX   FCB    $00
01407A CD02       00       A MSB6XX   FCB    $00
01408A CD03       00       A MSB7XX   FCB    $00
01409A CD04       00       A MSB8XX   FCB    $00          ;ILLEGAL
01410                        *
01411                        *
01412                        * THE VALUES IN THIS TABLE WILL BE
01413                        * REPLACED WITH VALUES THAT WILL MORE
01414                        * ACCURATELY REPRESENT THE NON-
01415                        * LINEARITY OF THE CONVERTER.
01416                        * THE VALUES WILL ALSO BE SUBJECT TO A
01417                        * NORMALIZED MULTIPLICATION FACTOR
01418                        * THAT WILL BE BASED ON CONV INPUT
01419                        * VOLTAGE.
01420                        *  THE NON-LINEAR PORTION OF THE TABLE WILL
01421                        *  BE ADDED AT A LATER DATE.
01422                        *
01423                        *
01424                        *
01425                        *
01426                        ****************************
01427                        * TABLE 5
01428                        * -------
01429A CD05       CC40     A TABLE5   FDB    MSB1XX
01430A CD07       CC80     A          FDB    MSB2XX
01431A CD09       CCC0     A          FDB    MSB3XX
01432A CD0B       CD00     A          FDB    MSB4XX
01433A CD0D       CD01     A          FDB    MSB5XX
01434A CD0F       CD02     A          FDB    MSB6XX
01435A CD11       CD03     A          FDB    MSB7XX
01436A CD13       CD04     A          FDB    MSB8XX
01437                      *
01438                      *
01439                      *
01440                           END
```

TOTAL ERRORS 00000--00000
TOTAL WARNINGS 00000--00000

```
    0020 .33KHZ 00105*00814
    0002 .400HZ 00164*00373
    0000 .50HZ  00162*00377
    0001 .60HZ  00163*00375
    C275 ACTVAT 00780 00799*
    C1C2 ADD1   00628*
    C19E ADJUST 00543 00545 00553 00555 00593 00602*
    C07A AGAIN1 00297*00305
    C078 AGAIN2 00296*00309
    C191 AGAIN3 00587*00590
    C29A AGAIN4 00835*00838
    C2AC AGAIN5 00836 00844*
    C30F AGAIN7 00916*00918
    C097 AGAIN8 00313*00315
    C39F AGN    01029*01030
    C0DD AHEAD1 00374 00376 00379*
    C1ED AHEAD4 00659 00668 00673*
    C249 AHEAD5 00746 00752*
    C2A4 AHEAD6 00833 00840*
    C2AF AHEAD7 00842 00846*00851 00855
    C2BE AHEAD8 00849 00854*
    C188 AHEADB 00560 00564 00568 00572 00575*
    C37D AHEADC 00991 00993*
    C236 AHED1  00736 00744*
    C35A BACK1  00969*00973
  P 0005 BCDVAL 00179*00341 00418
    C358 BINARY 00960 00968*
    C445 BLANK  01213*
    C1F7 CALCUL 00674 00703*
    00DF CLRDIS 00069*00244 01168
    C091 CLRRAM 00307 00311*
    0008 CMPLT1 00124*
    0010 CMPLT2 00125*00485
    40A1 CNTRLA 00082*00251 00254 00257
    40A3 CNTRLB 00094*00264 00266 00268
    40C1 CNTRLC 00110*00275 00277 00280
    0001 CNVRT1 00118*
    0080 CNVRT2 00107*00480 00489 00910 00932
    00E0 COMFAL 00126*01013 01014
  P 000D COUNT1 00193*00578 00589 00874 00890 00920 01141 01153
    0040 CVCURA 00152*
    0020 CVCURB 00151*
    0000 CVCURC 00150*
    00C0 CVOUT  00156*
    C39C CYCLE  01028*01034
    C253 DACDRV 00335 00394 00615 00757 00777*
  P 0009 DACVAL 00188*00540 00551 00552 00586 00605 00623 00744 00749
                00777 00793
    C381 DELAY  00403 00912 01002*01005
    C2D4 DIVID1 00876*00880
    C2E0 DIVID2 00882*00891
    C2C7 DIVIDE 00709 00871*
    0000 DMODE  00067*00237
```

```
   00FF DREXN  00085*
   00FF DREXNB 00097*
   0003 DREXNC 00113*00278 00282 00283
 P 0021 DSPBUF 00211*01140 01157
   4001 DSPLYC 00066*00238 00240 00243 00245 01169
   4000 DSPLYD 00065*01160
   C42D DSPTBL 01139 01189*
   C14B DTERM  00503 00512*
 P 0002 DVIDND 00174*00703 00707
 P 0000 DVISOR 00171*00704 00705
   C164 E. 1PC 00540*01279
   C16D E. 2PC 00551*01280
   C178 E. 4PC 00559*01281
   C17C E. 8PC 00563*01282 01283 01284
   C180 E1. 5PC 00567*01285 01286 01287 01288 01289 01290 01291
   C184 E3. 1PC 00571*01292 01293 01294 01295 01296 01297 01298
   C435 EIGHT  01197*
   00FC ENABLA 00101*
   0008 ENABLB 00102*
   0010 ENABLC 00103*
   001C ENALL  00104*00379
   0040 ENBLCV 00106*00380 01017 01036 01123
   C252 EXIT   00529 00616 00765*01050 01056
   0003 EXTERN 00165*
 P 001B FAILST 00205*01015
   C344 FAULT1 00948 00951*
   C352 FAULT2 00962*
   C032 FAULT3 00260*
   C04C FAULT4 00271*
   C06C FAULT5 00285*
   C080 FAULT6 00301*
   C0CD FAULT7 00365*
   C1E0 FAULT9 00660*00669
   C1F1 FAULTA 00677*
   C265 FAULTB 00787*
   C114 FAULTD 00427*
   C3C5 FAULTE 01068*01278
   C2C3 FINISH 00850 00857*
   C11F FIRQ   00219 00479*
   C432 FIVE   01194*
   C431 FOUR   01193*
 P 0008 FQMODE 00186*00358 00425
   00FC FREQSL 00100*00355
   C223 GETVAL 00727*
   0039 HILIM  00074*00947
 P 000E IMEASR 00194*00712 00928
   C1AC INCRES 00610*
   C3B7 INVOUT 00527 01049*
   C387 IRQ    00221 01012*
   0008 IVCURA 00140*
   0004 IVCURB 00139*
   0000 IVCURC 00138*
   0018 IVNPT  00144*
   0014 IVVOLA 00143*
   0010 IVVOLB 00142*
   000C IVVOLC 00141*
   C006 KEYDIS 00237*
   C437 LETTRA 01199*
```

```
   C438 LETTRB 01200*
   C439 LETTRC 01201*
   C43A LETTRD 01202*
   C43B LETTRE 01203*
   C43C LETTRF 01204*
   C43D LETTRH 01205*
   C441 LETTRI 01209*
   C43E LETTRJ 01206*
   C43F LETTRL 01207*
   C442 LETTRN 01210*
   C440 LETTRP 01208*
   C443 LETTRR 01211*
   C444 LETTRU 01212*
   C1B4 LOADAC 00611 00615*00629 00633
 P 0007 LOKOUT 00184*01049
   C362 LOOKUP 00969 00978*
   C3FC LOOP4  01143*01154
   C1E6 LOW    00655 00666*
   C1CC LRGERR 00513 00648*
   C0F8 MAIN   00413*00432
   C11A MAIN1  00416 00426 00430*
   C2F5 MEASR1 00650 00905*
 P 001D MESSBF 00210*01113 01138
 P 0011 MLTCAN 00198*00831 00837
   C292 MLTPLY 00713 00721 00831*
   CC40 MSB1XX 01381*01429
   CC80 MSB2XX 01389*01430
   CCC0 MSB3XX 01397*01431
   CD00 MSB4XX 01405*01432
   CD01 MSB5XX 01406*01433
   CD02 MSB6XX 01407*01434
   CD03 MSB7XX 01408*01435
   CD04 MSB8XX 01409*01436
   001C MUX1SL 00090*
   00E0 MUX2SL 00091*
   C436 NINE   01198*
   C3C1 NMI    00224 01059*
   C155 NOAJST 00499 00523*
   C10A NOCHNG 00419 00423*
   C2EA NOINCR 00877 00883 00887*
   0002 NORMAL 00119*
   00A0 NPTVLA 00155*
   0080 NPTVLB 00154*
   0060 NPTVLC 00153*
   00AA NTTRUE 00076*00294 00326 00785
   C038 OK3    00259 00264*
   C052 OK4    00270 00275*
   C086 OK6    00299 00304*
   C42E ONE    01190*
 P 0010 OVERLD 00196*00327 00781 00805
 P 0004 PLARTY 00177*00502 00507 00606 00624 00657 00666
   C446 POINT  01214*
   40A0 PORTA  00083*00253 00255 00258 00386 00906
   40A2 PORTB  00095*00265 00267 00269 00382 00479 00481 00490 00801
               00803 00813 00815 00909 00914 00931 00933 01016 01018
               01038 01039 01122 01124
   40C0 PORTC  00111*00276 00279 00281 00484 00908 00913 00916 00935
               01012
```

```
   C412 PRINT  01127 01157*
   C417 PRINT8 01159*01162
   0003 PROMSL 00089*
 P 0013 QUOTNT 00199*00718 00832 00835 00872 00879
   C072 RAMTST 00284 00294*
 P 0019 RATIO  00204*00717 00993
   8000 RE0    00045*
   8008 RE1    00046*00488 00929
   8050 RE10   00055*
   8058 RE11   00056*
   8060 RE12   00057*
   8068 RE13   00058*
   8070 RE14   00059*
   8078 RE15   00060*
   8010 RE2    00047*00921
   8018 RE3    00048*00922
   8020 RE4    00049*
   8028 RE5    00050*
   8030 RE6    00051*
   8038 RE7    00052*00946
   8040 RE8    00053*00356 00423 01165
   8048 RE9    00054*
   C1B1 REDUCE 00608 00613*
 P 0017 REFRNC 00203*00982
 P 0014 REMNDR 00200*00719 00848 00871 00885 00887
   C286 REMOVE 00783 00813*
   C000 RESTRT 00225 00232*01129
 P 0015 RESULT 00202*00720 00840 00844 00846 00847 00854 00857
 P 000B SAVE1  00192*00603 00610 00613 00747 00748 00978 00987
   C26B SENDIT 00786 00793*00799 00816
   C420 SENSE  01128 01165*01167
 P 001C SERVIC 00209*00414
   C0D3 SET400 00360 00373*
   C0DB SET50  00364 00377*
   C0D7 SET60  00362 00375*
   C3ED SETUP  01126 01137*
   C434 SEVEN  01196*
   C18E SHIFT  00586*
   C433 SIX    01195*
   C14F SMLERR 00515*
   001C SPARE1 00145*
   00E0 SPARE2 00157*
 P 0006 STABLE 00181*00523 00528 00575 00648
   00FF STAK   00070*00233
   C1C7 SUBTR1 00625 00632*
   C3C9 SWINT  00223 01111*
   C447 TABLE1 00979 01225*
   C46F TABLE2 00516 01278*
   CC00 TABLE3 00727 01373*
   C499 TABLE4 00986 01314*
   CD05 TABLE5 00732 01429*
   C430 THREE  01192*
   C33C THUMB  00340 00417 00946*
   C140 TOOHI  00502*
   C145 TOOLOW 00500 00505*
   0055 TRUE   00075*00306 00308 00782 00804
   C22E TRYAGN 00735*00738
   C42F TWO    01191*
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     C34A VALID   00342 00420 00957*
   P 0001 VMEASR  00172*00493 00653 00930
   P 0003 VNOMNL  00175*00329 00498 00652
     C127 WAIT1   00484*00486
     0090 WDISPL  00068*00242
     8000 WE0     00033*00794
     8001 WE1     00034*
     8002 WE2     00035*
     8003 WE3     00036*
     8004 WE4     00037*00795
     8005 WE5     00038*00399 01040
     8006 WE6     00039*
     8007 WE7     00040*
     C1BA ZERO    00604 00623*
```