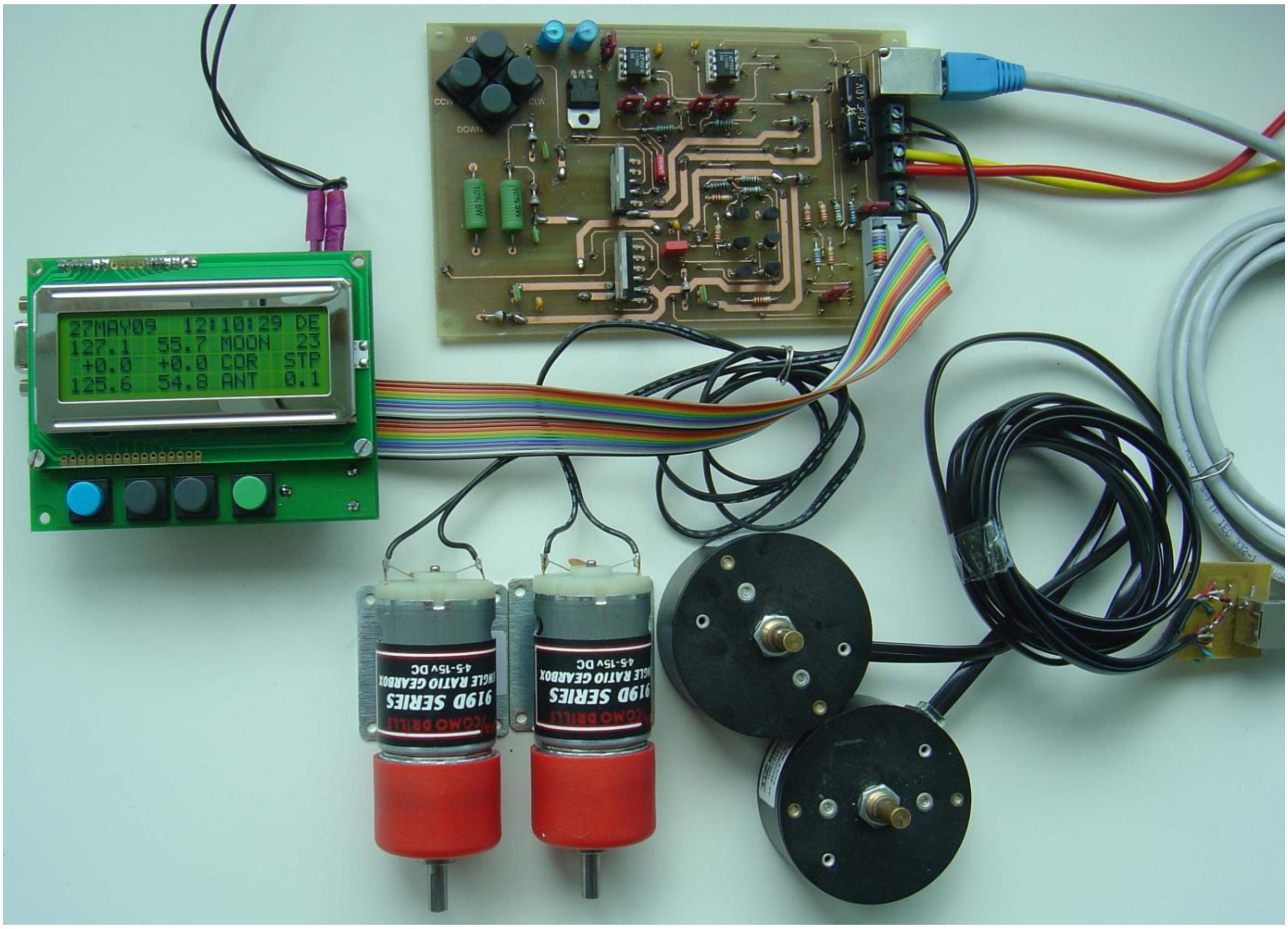
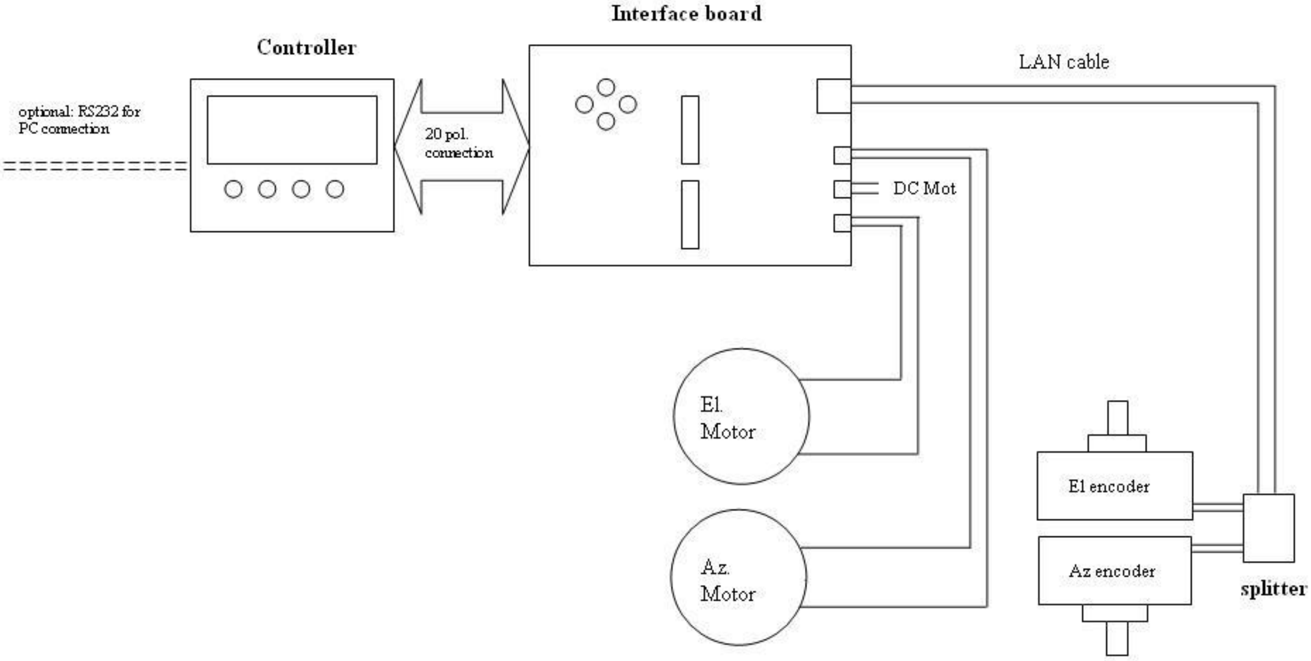
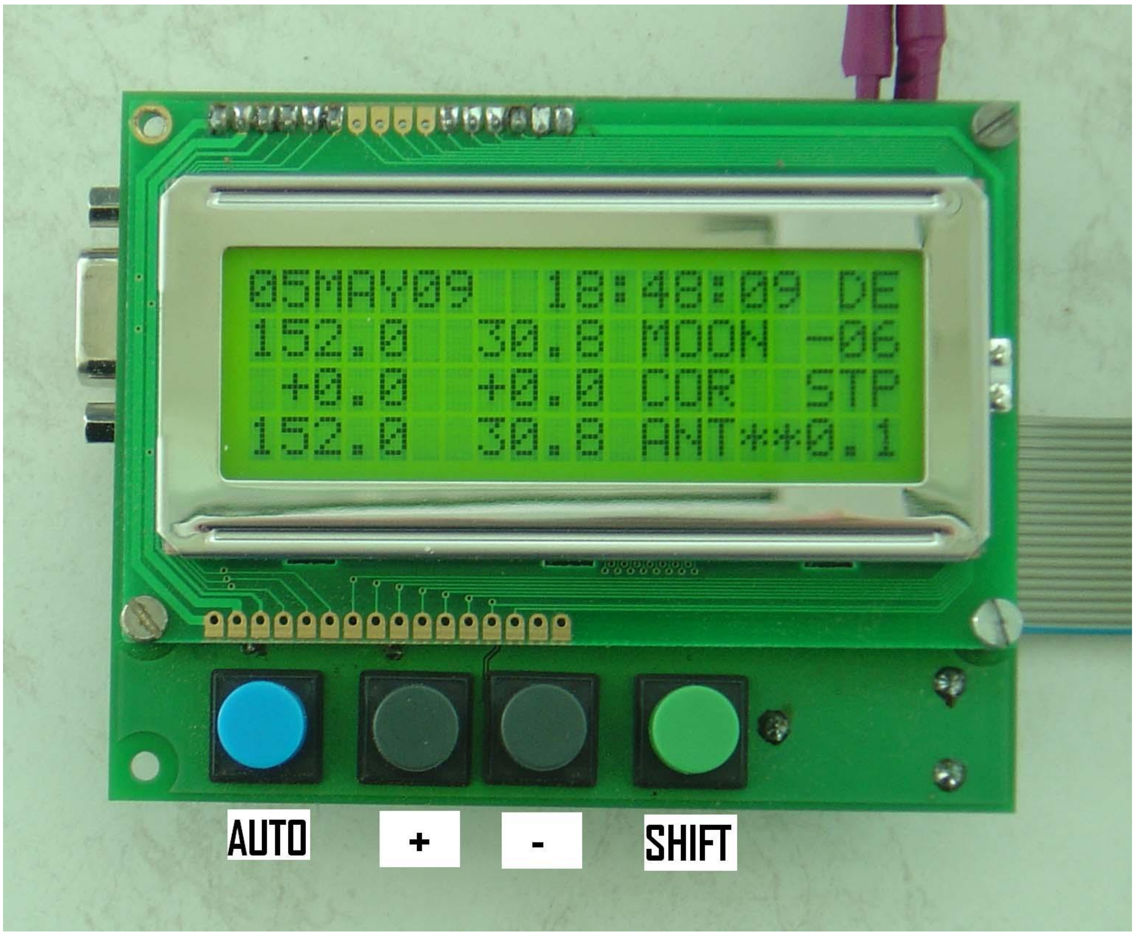
E M E - Antenna Controller System - *OE5JFL*

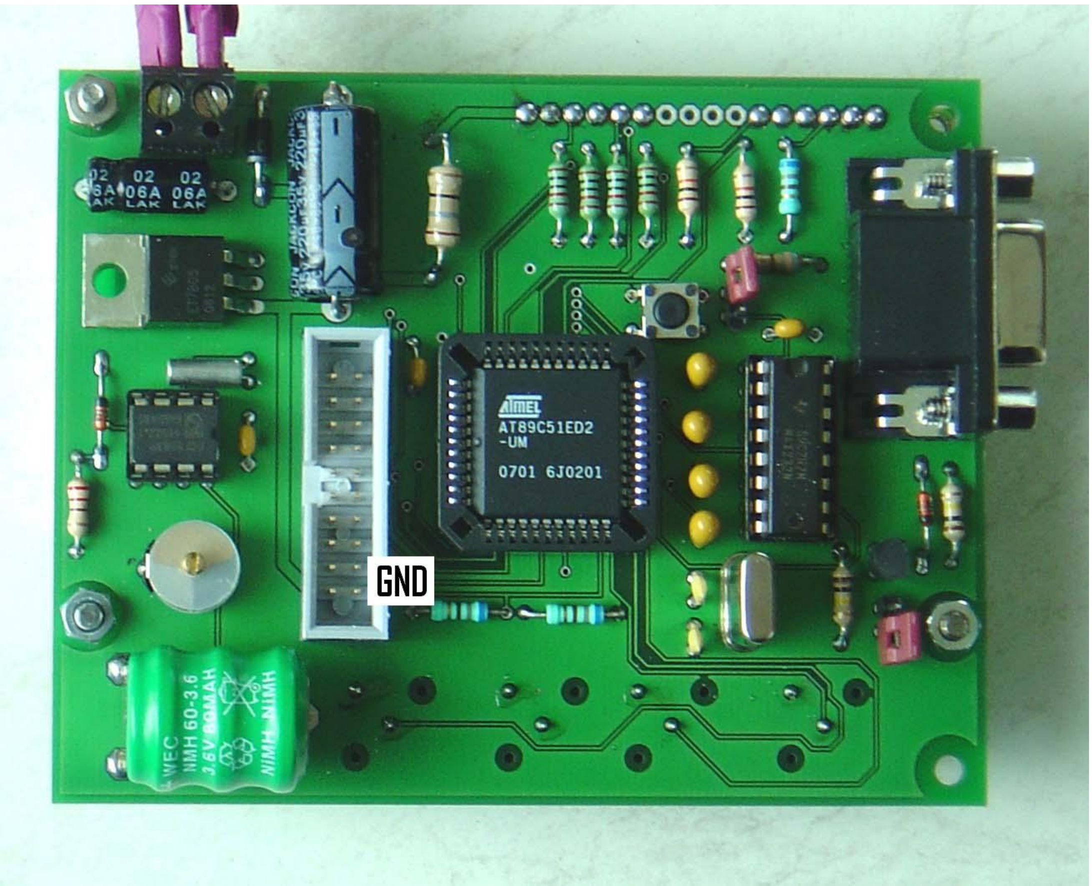


Block diagram



1.Controller board





Short description of the features

- **Computation of position (without PC !)** for Moon, Sun, Cassiopeia, Cygnus, Sagittarius, Taurus, Leo, Aquarius and a RA/DEC value of free choice
- **Azimuth and elevation motor controlling** for all targets plus two free choice AZ/EL positions
- **Interfacing with different absolute encoders:** ETS25, HH12, HH16, A2-S-S
- **Selectable step size for tracking** (full, half, quarter resolution)
- **Selectable offset for azimuth and elevation** (+/- 9.9 degrees)
- **Operation by 4 buttons at controller**
- **Nonvolatile storage of all parameters**
- **Real time clock**
- **4 x 20 character LCD - display**

Settings:

- All functions and parameters can be set by four buttons on the controller named: SHIFT, + , - , AUTO
  To run through the setting menu, keep the SHIFT key pressed and press + or – key. You will see the cursor blinking at the parameter you choose.
  For changing the parameter itself, just press + or – (SHIFT released).
  For the first 10 increments or decrements the least significant digit is changed, then the next higher digit is selected.
  If you press (only) the SHIFT key for more than 5 seconds, Doppler shift is displayed instead of date. For switching back to date display again, press SHIFT for another 5 seconds.
  To switch between automatic mode on/off, press AUTO key (toggle switch) After changing target, you are always in AUTO OFF mode. In AUTO ON mode you see arrows blinking (output switching signals activated) or 'asterix' when the antenna is in position.

Following parameters can be set:

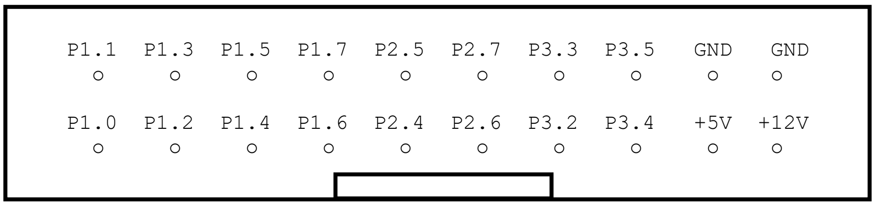
antenna offset: +/-9.9 deg in **az**imuth and **el**evation
step size: full,half,quarter resolution, depending on encoder
target: Moon, Sun, Cassiopeia, Cygnus, Sagittarius,
Taurus, Leo, Aquarius, RA/DEC, AZ/EL2, AZ/EL1
AZ1,EL1 and AZ2,EL2: free choice antenna positions
Right **A**scension and **Dec**lination for free choice target
QTH: **lon**gitude, **lat**itude
encoder type: (in the moment) SSI for 10,11,12 bit binary,
SSI 12bit gray, A2-S-S, MAB25 10,11,12 bit
band: for Doppler shift display
second, **minute**, **hour**, **day**, **month**, **year**

MAIN RESET: In some cases (battery empty,..) you might need to make a MAIN RESET: Hold **SHIFT key pressed during power on** (or together with pressing reset shortly)
In that case you have to set again most of the parameters (date, time,..) by running through the menu, because values in the memory were reset to original parameters.

FIRMWARE UPDATE: The firmware can be updated via the RS232 port. You need to run Flip software from Atmel (freeware) to load a new HEX-file to the 89C51ED2. Before you have to set the two jumpers on the PCB. Flip settings are at preferences, AutoISP (More) RST(DTR) active Low. When the update is done, remove the jumpers again.

REMOTE BY PC: By ASCII commands listed at the end of this documentation it is possible to read and write parameters via a PC COM port.

Input/Output: For encoder and motor connection the necessary I/O lines of the controller are provided at a 20pin connector.



P1.0 ... P1.2 : Az encoder, P1.3 : Az PWM
P1.4 ... P1.6 : El encoder, P1.7 : El PWM

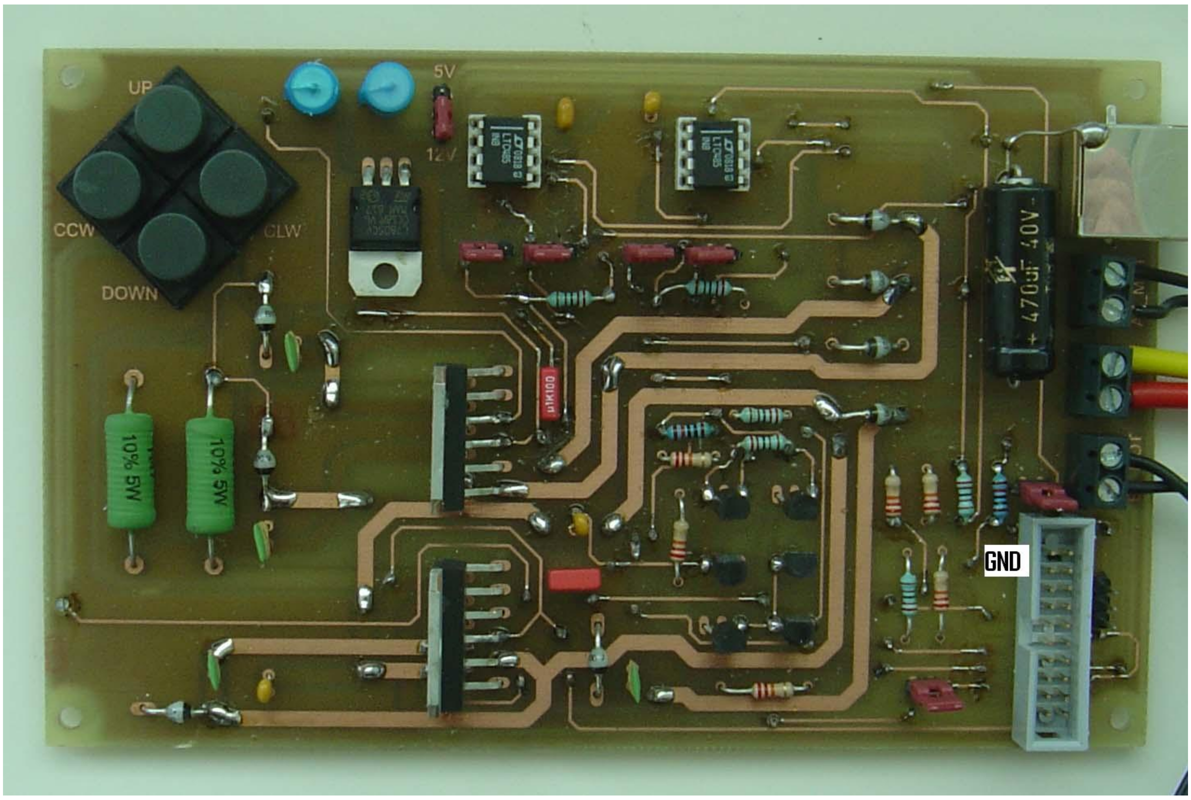
P2.4, P2.5 : Az motor clw,ccw P2.6, P2.7 : El motor up,down

P3.2, P3.3, P3.4, P3.5: future applications

You can design your own input/output drivers, or use the interface board described below.

2.Interface board

The interface board is connected to the controller board via the 20pin connector.



Motor output:

The four controller output signals (P2.4 - P2.7) are activated (low) in **automatic mode.** They are amplified by two MOS H-bridges which can drive DC motors up to 36V/2A. The DC motor inputs must both be isolated from GND!!
By setting the two jumpers JP6, JP7 a PWM signal for soft start and slowing down is activated.
If you want to move the antenna in **manual mode,** switch auto mode off at the controller, and press the corresponding buttons on the interface board.

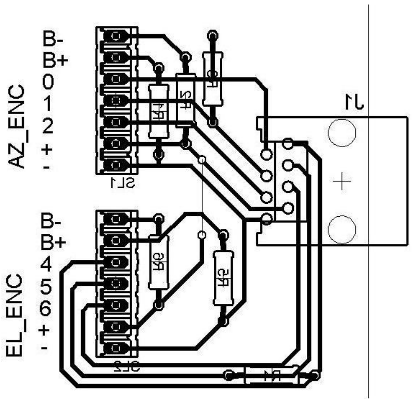
Encoder Input:

It is possible to connect 10bit, 11bit and 12bit binary encoders with 0.5deg, 0.2deg, 0.1deg resolution and 12bit Graycode encoders with the widely used **SSI-protocol**. To prevent the controller inputs from damage, there are switching transistor stages for each clock output and data input. You have to set the 4 jumpers JP1..JP4 at the transistors, but must let the RS485 sockets without the ICs. You can also connect the well known **A2-S-S** encoders from US-digital via RS485. In that case the **SEI-protocol** is used and you have to unplug the four jumpers JP1..JP4 on the board and instead plug the two RS485 drivers into the sockets.
I developed an easy to build 0.5deg 10bit encoder, which fits nicely to the controller. But meanwhile a cheap 12bit encoder is available, the **ETS25 (mechanically improved replacement of the discontinued MAB25)**. It´s accuracy is worse compared to the A2-S-S, but first measurements showed a maximum deviation of only 0.2deg.
DF1SR offers encoders similar to the ETS25, named **HH12 and HH16.** The HH16 has 16 bits, but only 12 bits can be used by the system, and you need special firmware for using it. He also offers an Inclinometer **HH12-INC**, electrically the same as the HH12.
Occasionally there was an unstable indication with the MAB25, probably because of pulse reflections. Adding 1k resistors from each encoder pin (CLK,DATA,CS) to GND directly at the encoder or at the splitter board cured the problem.
Different encoders will need an updated firmware and maybe a modified hardware connection.

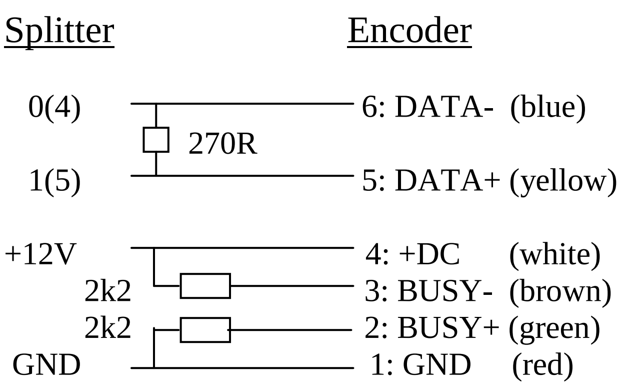
If you want reversed indication direction of azimuth (for example if the axis of the encoder is looking downwards), connect pin2(center) and pin3(right) of SL2 (placed in front of CON1) by setting a jumper. The 0…360deg of the elevation encoder is converted to -90…0…+90…0…-90. So if the indication is in the wrong direction, just turn the mounting of the encoder by 180deg.

You can teach the system to compensate a not correct mounting of the encoders. Point the antenna exactly at a target with well defined position, for example the sun. Connecting pin1 and pin3 of SL2 for five seconds (P3.3 of the controller grounded) will store the indicated target position into antenna position, and always take the difference to the encoder position into account from that moment. Connecting the two pins for a short moment only, will toggle the system between normal indication and compensation mode. The teaching and toggle functions are provided as well as remote commands via the COM port. See details about that on page 13.

A LAN cable is used to connect the encoders. With another jumper you can select the DC for the encoders between 5V or 12V.
At the other end of the LAN cable, there is a small splitter PCB for encoder connections.



A2-S-S connection



MAB25 /ETS25 connection

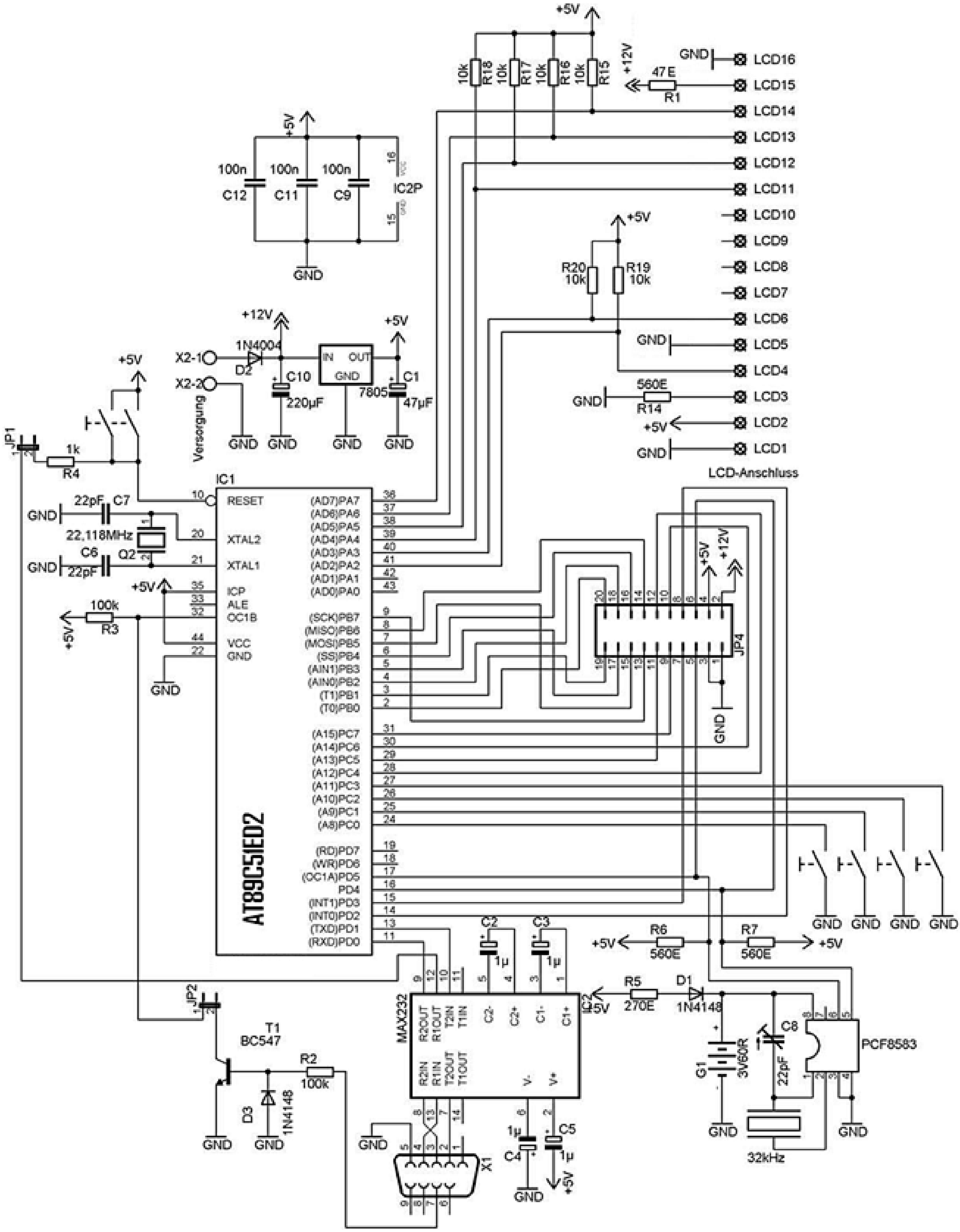
Splitter	Encoder
+5V	VDD
2(6)	CS
0(4)	CLK
1(5)	DATA
GND	GND

(no resistors needed!)

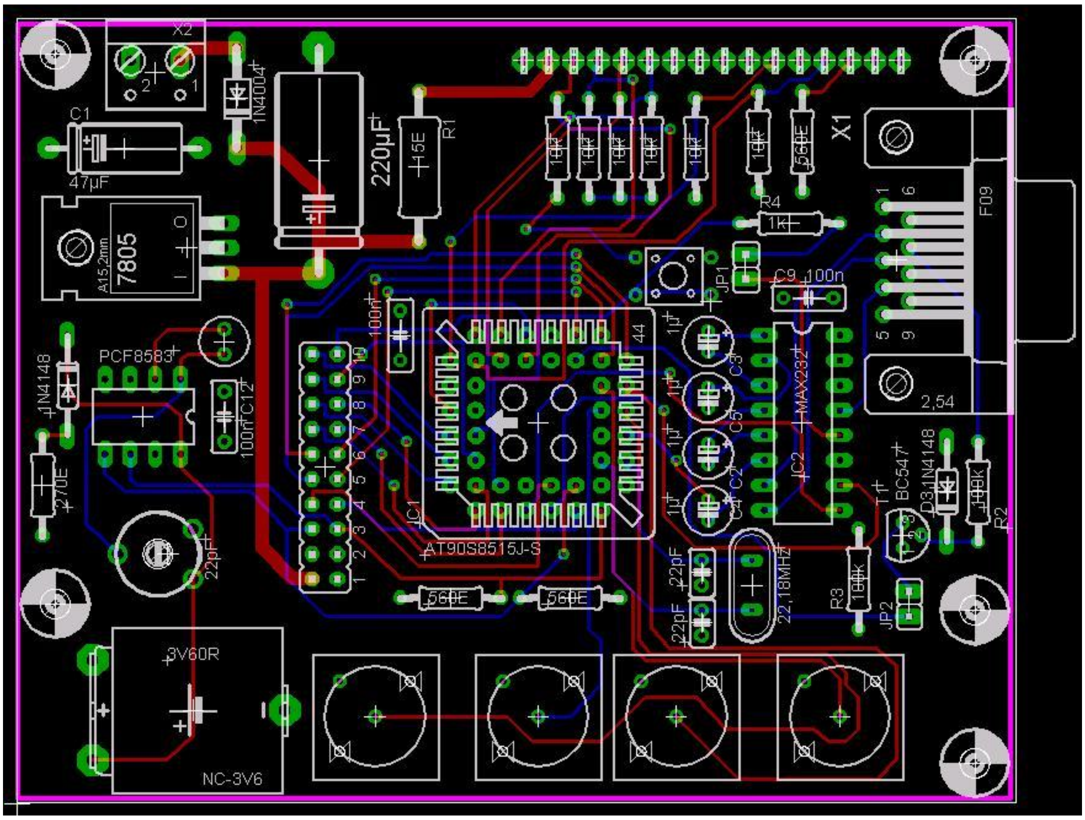
At the splitter the pin numbers 0,1,2 for Az and 4,5,6 (in brackets) for El are connected via the LAN cable and the switching transistors to P1.0,..,P1.6 of the 20pin connector.

3.Circuit diagrams, PCBs and parts lists

Circuit diagram controller board



PCB controller



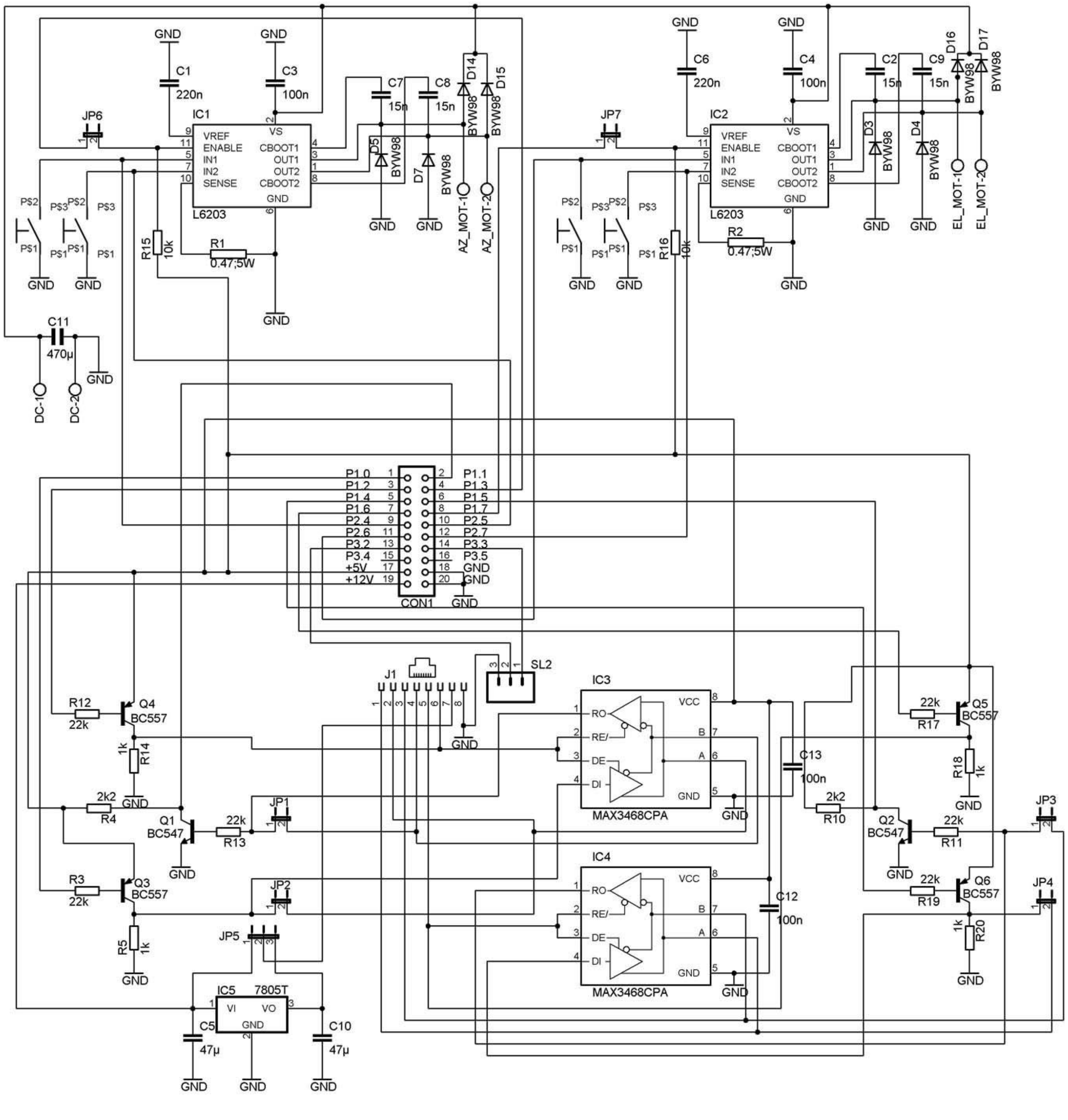
Parts list controller board

1x	PCB
1x	LCD-Display 4x20
1x	14 pin connector LCD
4x	Button
6x	10 k
1x	47 Ohm, 1W
3x	560 Ohm
1x	270 Ohm
1x	7805
1x	47µF Elko
1x	220µF Elko
1x	1N4004
1x	AT89C51ED2 PLCC44
1x	IC Socket PLCC44
1x	22,118 MHz XTAL
2x	22pF Ker.Ko.
3x	100nF
1x	Button RESET
1x	DC connector 2pin
1x	Connector 2x10 pin
1x	PCF8583 DIL8
1x	IC Socket DIL8
1x	3V60R Akku
1x	32.768 kHz XTAL
1x	22pF Trimmer capacitor
1x	1N4148

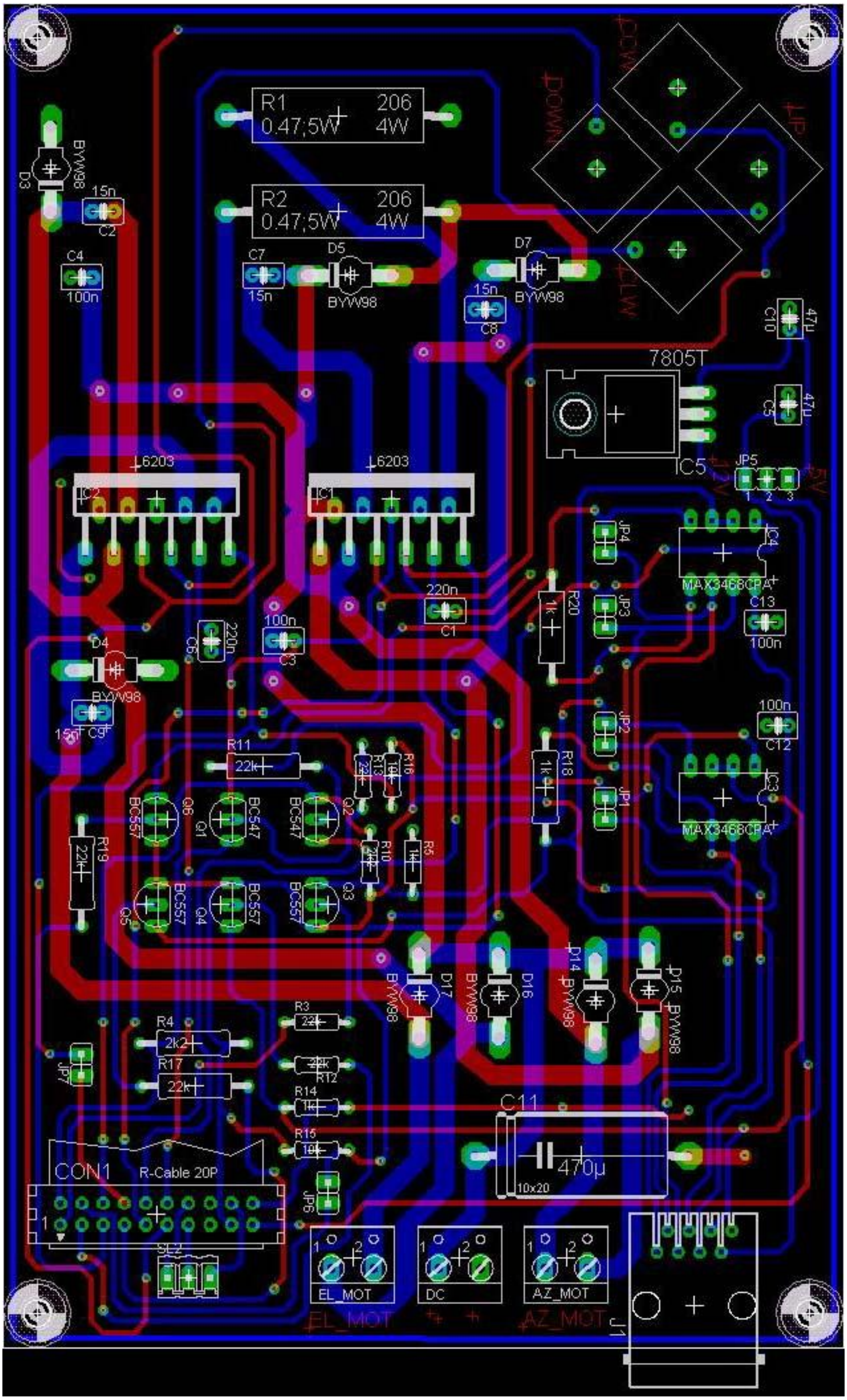
Additionally needed if you want to interface the controller to a PC:

1x	1N4148
1x	MAX232
1x	IC Socket DIL16
4x	1µF Elko
1x	SUB-D 9 fem
1x	BC547
2x	100 k
1x	1 k
2x	Jumper

Circuit diagram motor/encoder interface board



PCB interface

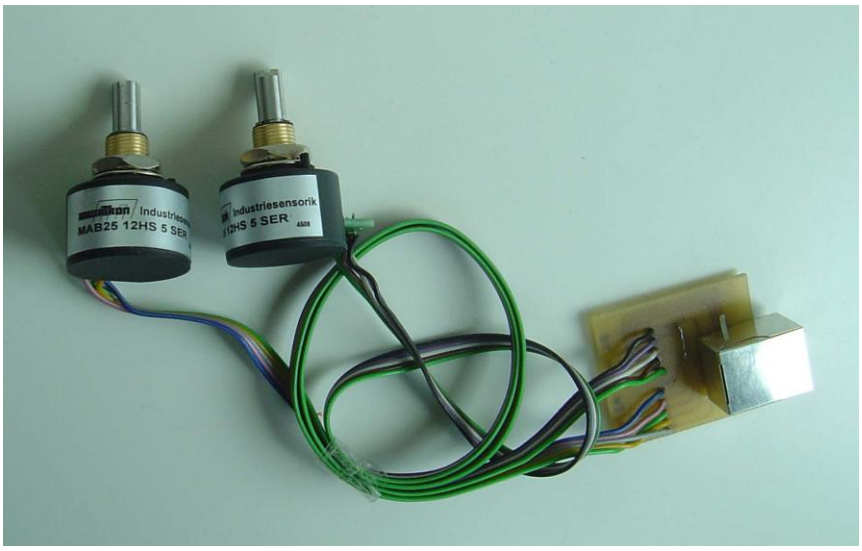


Parts list motor/encoder interface board

1 x	PCB
2 x	L6203
8 x	BYW98
2 x	LTC485 ***
2 x	IC socket 8pin ***
1 x	7805
6 x	Jumper 2pin
1 x	Jumper 3pin
1 x	RJ45 LAN connector (fem) 8pin
1 x	connector 2x10 pin
3 x	connector 2pin (DC, 2x motor)
4 x	button
1 x	3pin connector (future application)
1 x	1000µF, 40V
2 x	47µF
2 x	220nF
4 x	100nF
4 x	15nF
2 x	0.5 Ohm, 5W
2 x	2k2
4 x	1k
6 x	22k
2 x	10k
2 x	BC547
4 x	BC557

*** Only necessary if you are using RS485 for A2-S-S encoders. In that case leave the four jumpers JP1..4 (close to the transistors) open.

When using other encoders (MAB25,…), unplug the LTC485 drivers and close the jumpers JP1..4



For Az/El encoder connection you additionally need the small splitter PCB and a 8 pin LAN connector.

On the picture two (cheap) MAB25 12bit encoders are connected to the splitter board.

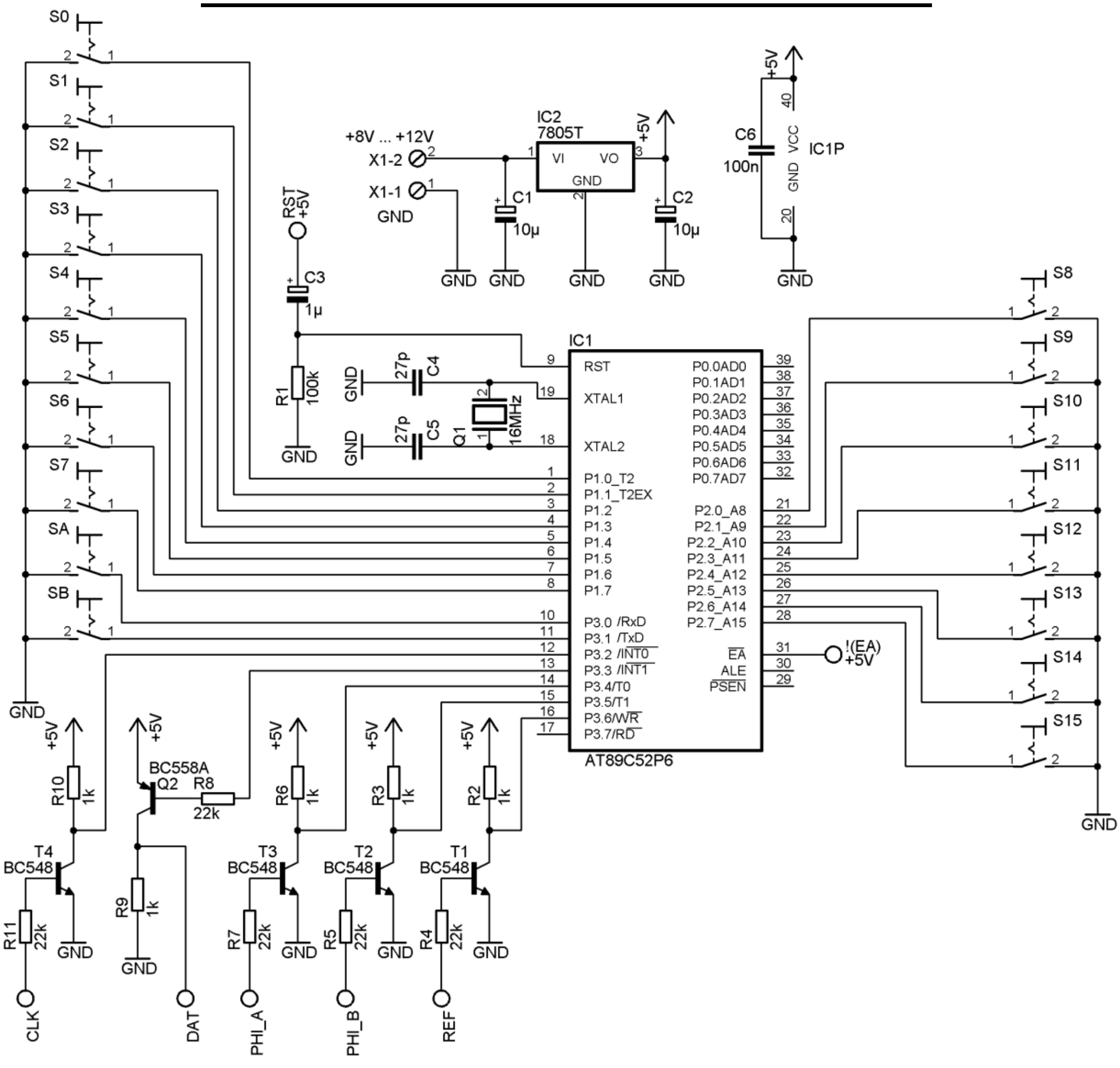
*** If you use the A2-S-S, you need additionally on the splitter board:
2 x 270 Ohm, 4 x 2k2

The PCBs were designed with EagleCAD, the files for all boards are available.

Connecting incremental encoders

Although I do not recommend the use of incremental encoders, I have developed a simple microcontroller converter circuit to plug in between each encoder and the splitter board. It reads the encoder output and converts the information to the SSI protocol used by the controller.
The circuit needs a quadrature phase signal from the encoder (PHI_A, PHI_B) and a positive reference pulse (REF). The connections to the interface board are the same as for the MAB25 (+DC, GND, CLK, DAT), exception is CS because it is not used here.
On the interface board select 12V DC instead of 5V with the jumper.
In the controller menu choose SSI_12bit, SSI_11bit or SSI_10bit, depending on the resolution you want to have. Switches SA and SB in the circuit must correspond as follows: both open → 12bit, only SA closed to GND →11bit, only SB closed →10bit.
With S15 to S0 you have to choose the pulse number per 90 deg of you encoder in binary form. Example: 1024 pulses per 360deg means 256 pulses per 90deg. 256=0000 0001 0000 0000 . There is only a single ‘1’ at position 8, therefore S8 has to be switched on, S0…S7 and S9…S15 remain off. As all connections will be permanent, simply connect a wire at the position of S8 to GND, leave all other pins open (including SA, SB positions) and you have 0.1deg resolution.
Of course you can not expect a higher resolution than your encoder is providing. The output is limited to a maximum of 12bits.
The firmware for the 89C52 microcontroller you can download from the webpage.

Circuit diaram for incremental to SSI converter



ASCII command set for remoting the controller via PC

Although the main intention for this controller was to have a system independent of a PC, it might be useful sometimes to remote it.
You can read/set each parameter by a row of 6 ASCII characters via the serial port. The speed is fixed to 115200 Baud.

The principle is, to send from the PC to the controller a question mark (?) if you want to read a parameter, an exclamation mark (!) if you want to set a parameter. Then one letter (a…z) must follow to specify the parameter. In the case of reading you will get back four ASCII coded digits for the parameter itself, when setting you have to send four ASCII digits after the letter.

For not overloading the controller with commands, you should wait at least 20ms between each read/set action. When reading many parameters, limit it to 20 per second.

Parameter table: (a….m, u….z both read with ? and write with !)
a: OffsetAz(+100) b: OffsetEl(+100) c: Step d: Target
e: Az 1 f: El 1 g: Az 2 h: El 2
i: RA man j: DE man(+900) k: Lon(+1800) l: Lat(+900)
m: Encoder
u: Sec v: Min w: Hour x: Day y: Month z: Year

?n: Dopp1G(+5000) : read only ?o: Az Ant : read only ?p: El Ant(+900) : read only
?q: Az Target : read only ?r: El Target(+900) : read ?s: Decl (+900) : read
?t: Comp*32+Auto*16+motorbits : read

!r: calculate antenna position offset for compensation : write (without number)
!s: toggle antenna position indication comp./no comp : write (without number)
!t: toggle automatic mode on/off: write (without number)

Most parameters are in 1/10deg.

c: 0000,0001,0002 means High, Medium, Low resolution
d: Target 0000:moon, 0001:sun …. 0010:Az1/El1
m: Encoder 0004:A2-S-S, … 0008:MAB28_12bit

Examples:
read antenna Az: send ?o, wait for 4 ASCII digits. 1234 means 123.4 deg
set target to sun: send !d0002
set longitude to 13.4 deg East: send !k1666 (1666= -134+1800)
toggle AUT/MAN status: send !t