

SPROG DCC Decoder Programmer

Specification, User Guide and Assembly Instructions

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© 2004 Andrew Crosland

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Disclaimer

You build, test and use SPROG entirely at your own risk. No responsibility is/can be accepted for any loss or damage whatsoever arising from any attempt to build, test or use any item described in this document.

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1 Introduction

SPROG is a DCC decoder programmer for connection to a USB or serial port of a personal computer or similar device. It was inspired by the MERG standalone programmer.

SPROG is supported by DecoderPro (<http://jmri.sourceforge.net/>) which, by use of the java programming language, allows platform independent support of a wide range of DCC hardware. DecoderPro is shareware available as a free download.

All SPROG design data is freely available on the web at <http://www.sheerstock.fsnet.co.uk/dcc/sprog>. PCBs, programmed PICs, the USB interface chip, complete kits and ready built modules are also available, see the web site for details. The PCB uses surface mount components requiring moderate soldering skills.

1.1 Features

- USB or COM (serial) port versions
- Enables computer based programming of DCC decoders
- On-board 1A rectifier and regulator can accept AC or DC input
- Can generate arbitrary DCC packets from ASCII command line
- Supported by DecoderPro
- USB version uses Virtual COM Port (VCP) drivers
- DecoderPro throttle allows use as a mini command station/booster for decoder testing

1.2 Connector Pinouts

SPROG connector and switch positions are shown in Figure 1 as viewed with the connectors towards the observer (surface mount components away from the observer).

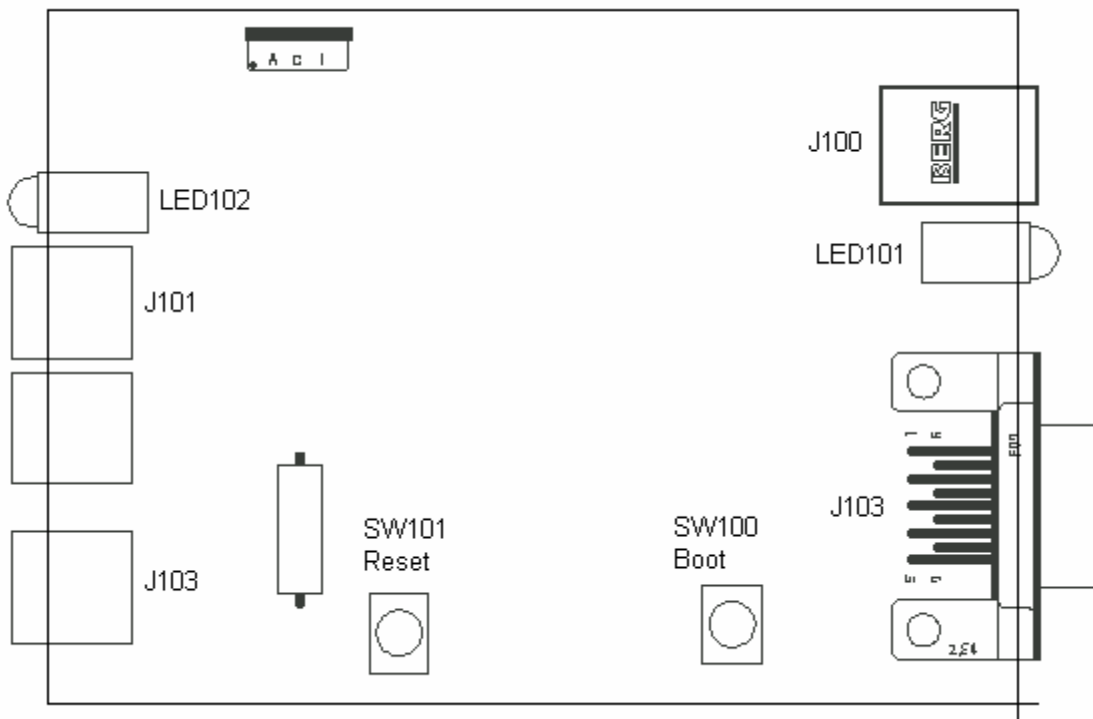


Figure 1 Connector and switch Locations

1.2.1 J101 Power Input

SPROG can accept an AC or DC input. See Table 2. Connection polarity is not important.

The minimum input voltage is dependent upon the required DCC voltage, the drop-out voltage of the adjustable regulator and the voltage drop in the rectifier. As a rule-of-thumb, a DC power supply should be (DCC voltage required + 5V). An AC power supply should be (DCC voltage required + 5V)/1.4.

A 500mA supply should be more than adequate. SPROG has successfully been used to program decoders with a no-frills “wall wart” power supply rated at 12V/300mA.

1.2.2 J103 DCC Output

There is no requirement to observe any particular polarity when connecting SPROG to a programming track.

An on-board adjustable regulator allows the DCC output voltage to be adjusted.

During programming the track current is sensed 100ms after the programming track is powered up. If the current exceeds 250mA then the programming track power is removed to avoid potential damage to an incorrectly installed decoder.

1.2.3 J102 RS-232

SPROG is configured as a DCE (Data Communication Equipment) and has a 9-pin female connector (socket) with the pinout shown in Table 1.

| J3 Pin | Function | Direction |
|--------|-----------------------|-----------|
| 1 | - | |
| 2 | RXD – Receive Data | Output |
| 3 | TXD – Transmit Data | Input |
| 4 | | See Note |
| 5 | 0V | - |
| 6 | | See Note |
| 7 | RTS – Request To send | Input |
| 8 | CTS – Clear To Send | Output |
| 9 | - | |

Table 1 J102 RS-232 Connector Pinout

Note: Pins 4 and 6 are connected together by SPROG.

For normal operation only Transmit data, Receive Data and ground need be connected in the serial cable. To use the bootloader to download new firmware, RTS and CTS must also be connected in the serial cable and must be enabled in the terminal emulator (hardware flow control). Depending upon the configuration of the computers serial port, a null modem cable may be required which swaps Receive data and transmit data (and RTS and CTS for the bootloader). For use with a standard PC COM port, a straight through serial cable is provided with SPROG kits and ready built modules.

The kit allows *either* the USB or RS232 version to be built. Only those components required for a particular interface should be fitted. You may wish to retain those components not used to allow modification at a later date.

1.2.4 J100 USB Connector

A B type USB connector is fitted to SPROG for use with an A-to-B cable (supplied with SPROG kits and ready built modules) between SPROG and the host or hub. SPROG is a self-powered USB device and is suitable for use with low power USB hubs.

The kit allows *either* the USB or RS232 version to be built. Only those components required for a particular interface should be fitted. You may wish to retain those components not used to allow modification at a later date.

1.2.5 Switches

SW101 is used to reset SPROG. Reset will occur automatically during power on and should not normally be required during operation.

SW100 is used in conjunction with the reset switch to start the bootloader to accept new firmware via RS-232 or USB see the SPROG firmware guide for more details of the bootloader.

1.3 Specification

Table 2 gives the operating conditions for SPROG.

| Parameter | Minimum | Nominal | Maximum | Units | Note |
|--|---------|---------|---------|-------|------|
| AC Input supply voltage | 9V | | 15V | V | 1 |
| DC Input supply voltage | 11V | | 18V | V | 1 |
| Vin supply current – not programming | | 50 | | | |
| Vin supply current – programming | | 300 | | mA | 2 |
| Vin supply current – Rolling road mode | | 1 | | A | 3,4 |
| Operating Temperature Range | | 25 | | °C | |
| Output Load - programming | | | 250 | mA | 2 |
| Output Load – rolling road mode | | 1 | | A | 3,4 |

Notes:

1. Minimum depends upon decoder being programmed, see 1.2.1. Figure given is sufficient to guarantee correct regulation of on-board 5V supply.
2. SPROG will remove track power if output current exceeds 250mA as measured 100mS after applying power. Surge current during decoder power-up may be considerably greater than this.
3. Depends upon required DCC current.
4. Booster mode DCC current limit may be set by user (***) *not implemented yet*

Table 2 Operating Conditions

2 Theory of Operation

SPROG uses a PIC microcontroller to translate commands sent over the USB or RS-232 interface into DCC packets to be driven by a power MOSFET output stage configured as a H bridge. The PIC forms an integral part of the booster, generating the correct switching waveforms for the MOSFETs and sensing the output current through it's internal A/D (analogue-to-digital) converter.

The MOSFETS in the output stage are chosen to have a very low on-resistance and thus dissipate very little power even with high output currents.

The lower half of the output H-bridge uses N-channel MOSFETS with logic level gate threshold, the upper half uses P-channel devices. To avoid problems with the P-channel MOSFET in one half of the bridge not having turned off when the associated N-channel MOSFET turns on (shoot-through), the PIC inserts a small dead period between each transition when neither MOSFET is turned on. The transistors in the output stage convert the logic level outputs of the PIC to the correct levels to drive the P-channel MOSFETS. This results in relatively fast turn-on when the transistor is on but a slow turn off controlled by the 560R collector resistors.

Output current is sensed by a small value resistor in the ground of the H-bridge. The voltage developed across this resistor is filtered and sampled by the PICs A/D converter to detect programming acknowledge pulses and short circuit conditions. A number of readings are taken and averaged to avoid false overload detection due to noise.

3 Construction

If you have obtained your SPROG ready built then you may skip this section.

There are two suggested ways of assembling a SPROG kit. If you are confident in your soldering abilities then the easiest method is to assemble all of the surface mount components on the top side starting with the smallest resistors and capacitors. Finish by assembling the through hole components from the bottom side. This method has the advantage that most of the work is on one side of the board which can be laid flat to work on. A careful and thorough check must be made for shorts, especially in the power supply section, before first powering up a SPROG assembled in this way.

An alternative method is to assemble the SPROG in stages, testing as each stage is completed. This requires that a mix of surface mount and through-hole components be assembled. This is slightly less convenient as the board will not lay flat so easily. Instructions for this method are given in more detail in the following sections. The instructions assume the use of the SPROG PCB, either purchased or home made from the layout available from the SPROG web site.

3.1 Parts List

Note that R12 – 16, R24, R25, and R34 do not exist in the design. J104 is not used.

The kit allows *either* the USB or RS232 version to be built. Only those components required for a particular interface should be fitted. You may wish to retain those components not used to allow modification at a later date.

3.1.1 PIC Programming

The PIC U5 must be programmed with the SPROG firmware. PICs supplied with a SPROG kit are pre-programmed. Alternatively, individual pre-programmed PICs may be purchased. A blank PIC may be programmed after it has been soldered to the board by connecting a programmer to the 6-pin header (J1) as shown in Table 3. You should check with you programmer specification as to which connections should be made. If the programmer does not supply 5V or cannot supply sufficient current to power SPROG (not just the PIC) then isolate pin 4 of J1 and power up the board using a power supply during programming.

A completed SPROG may be updated to the latest firmware version using the bootloader feature, described in the SPROG firmware guide.

| Pin | Function | |
|-----|-----------|---------------------|
| 1 | PGD (RB7) | Programming data |
| 2 | PGC (RB6) | Programming clock |
| 3 | PGM (RB3) | Program mode |
| 4 | 5V | |
| 5 | Gnd | |
| 6 | MCLRn/Vpp | Programming voltage |

Table 3 PIC programming Header J1

3.2 Assembling SPROG (Initial Stage)

Please read these instructions right through before starting on your SPROG, noting especially where only some components are to be mounted, depending on whether the build is to be for RS-232 or USB interfacing. Also, note that the orientation of the ICs is not always conventional: that is, with pin 1 at top left. Highlighting these ‘points to note’ will help you to avoid difficult-to-correct errors, particularly if you have to spread the build over several days.

The term U_x/y means U_x pin y, e.g. U1/3 refers to pin 3 of U1.

Most of the components are fitted on the side of the board marked “TOP”. Components numbered greater than 100 (e.g. SW100) are fitted on the side of the board marked “BOTTOM”. Please download the latest top and bottom component placements from the SPROG website.

Testing generally involves connecting the chosen power supply to the power input J101.

- **Always double check component placement and orientation before applying power.**
- **Always check for solder bridges or short circuits before applying power.**
- **Always disconnect the power supply before proceeding to the next stage of assembly.**

The surface mount resistors and capacitors supplied in the SPROG kit are small and easily lost – look after them! If you need a few spares then send me two first class stamps with a list of values required. I can also provide other replacement components (or even for your own projects if they’re used on SPROG) - prices on request.

3.2.1 Identifying Components

The low value decoupling capacitors are unmarked and the different values cannot be differentiated once removed from their carrier strip. Similarly, the transistors and diode look very similar, with both being SOT-23 packages. Checking the quantity provided against the parts list will identify the individual components.

Surface mount resistors are marked with a numeric version of the familiar resistor colour code, e.g. a resistor marked 152 is 1.5k ohms. If you cannot find the resistor you need try reading them the other way around! E.g. “251” is not a “preferred value”, turn it around and it becomes “152”, which is.

Tantalum capacitors (C7, C12 and C21) are polarized and **must** be fitted the correct way round as shown on the placement diagrams. Unfortunately, the polarity is not marked on the PCB silkscreen.

The electrolytic capacitor C100 is also polarized and must be fitted correctly. The “-” terminal is identified on the component, the “+” terminal on the PCB.

The ICs (Integrated circuits) U1, U3-7 must be fitted the correct way round. On the PCB there is a small circle next to pin 1 on the silkscreen marking or a semi-circle at one end of the body and a line along one edge. U1 and U5 have semi-circles embossed in the packages. These must be aligned with the silkscreen.

U3, U6 and U7 have a chamfer along one edge which must be aligned with the line in the silkscreen body. U4 has an almost insignificant chamfer but also has an embossed semi-circle to indicate pin 1. **As a further check, note that U5 (the PIC16F870) is fitted in the opposite orientation to U3-4 and U6-7.**

Note also that U1 is mounted with the pin 1 'dot' at top RIGHT and not top LEFT as might be thought. It may be a good idea to highlight both U1 and U5 on the schematic and component overkay to remind yourself of their orientation.

3.2.2 Soldering Surface Mount Components

The USB interface is the most difficult device to solder having 0.35mm pins on a 0.8mm pitch. It is possible to solder this device with 22 AWG solder (not included in the SPROG kit) and a fine tipped soldering iron, but many people prefer, and I recommend, the use of solder paste (not included in the SPROG kit).

3.2.2.1 Soldering With Solder Wire

To solder the 0805 resistors and capacitors apply a small amount of solder to one pad. Hold the device in a pair of tweezers and position whilst reflowing the solder with the iron. Solder the second pad.

For the ICs, apply a small amount of solder to a corner pad of the IC location on the PCB (enough to cover the pad without leaving a large bump). Position the IC correctly and reflow the just applied solder using the soldering iron allowing the IC to seat itself on the PCB. When the joint is set, the IC may be gently twisted to ensure the other legs are aligned with their pads (assuming the first leg just soldered is aligned). Solder the opposite corner leg to secure the IC and then solder the other legs.

Solder wick or de-soldering braid is useful for removing any shorts between adjacent pins.

3.2.2.2 Soldering With Solder Paste

To solder the 0805 resistors and capacitors apply a small amount of solder paste to both pads. Place the component in position and reflow the solder paste with the iron. You may find it necessary to hold the component to prevent it being pulled out of place by the molten solder. Solder the second pad.

For the ICs, apply a small amount of solder to each pad of the IC location on the PCB (enough to cover the pad without leaving a large bump). Position the IC correctly and reflow a corner pad with the soldering iron allowing the IC to seat itself on the PCB. It may be necessary to hold the component in place. When the joint is set, the IC may be gently twisted to ensure the other legs are aligned with their pads (assuming the first leg just soldered is aligned). Solder the opposite corner leg to secure the IC and then solder the other legs.

3.2.3 Power Supplies

1. Fit the power connector (J101), bridge Rectifier (BR1) and smoothing capacitor (C100), referring to the placement diagram for polarity. Connect a suitable power supply and check for appropriate rectified voltage across (C100).
Always disconnect the power supply before proceeding to the next stage of assembly.
2. Fit adjustable regulator (IC100), feedback resistors and preset (R7, R8, VR1) and decoupling capacitors (C6, C7), paying attention to the polarity of C7. With the preset (VR1) turned fully anti-clockwise the voltage across C7 should be approx 8V when the power supply is connected. The maximum voltage with VR1 fully clock-wise depends upon the input supply voltage, see 1.2.1.
3. Fit the 5V regulator (U3), series resistors (R29, R21) and decoupling capacitors (C19, C12), paying attention to polarity of C12. Check for 5V across C12.
4. Fit the remaining decoupling capacitors (C4, C21-24), LED102 and R11, paying attention to polarity of C21. Check that the lower element of LED102 lights when power is applied.

3.2.4 PIC and Related Components

1. Fit R17, R23, R26, R30 - R33, C11, C16, C17, C18, C20, D1, SW100, SW101 and X2. Check the input sense divider at the junction of R32 and R33. This should be V_{in} (input voltage) * 0.175 and always less than 5 Volts. Check that U5/1 and U5/21 are pulled to ground when SW101 and SW100, respectively, are closed.
2. Fit the PIC U5.

3.2.5 RS-233 Interface

Skip this section if you are building a USB SPROG.

Fit R22, C9, C10, C13 – C15, J102 and U4. The RS-232 interface generates its own positive and negative supply voltages. Check that U4/2 and U4/6 are approximately +9V and -9V respectively.

3.2.6 USB Interface

Skip this section if you are building a serial SPROG.

Fit R1 – R6, R9, R10, R18 – R20, C1 - C5, C8, J100, LED101, X1, and U1. Check the 3.3V output at U1/6.

3.3 Initial Testing

3.3.1 Serial SPROG Initial Testing

Skip this section if you are building a USB SPROG.

For initial testing of a serial SPROG you need a terminal emulator package such as Windows HyperTerm. Connect SPROG to a spare COM port on your host computer and start the terminal emulator which should be configured to use that COM port as follows:

- 8 bits
- No Parity
- 1 Stop bit
- Hardware handshake

Power up SPROG and you should see the reset message and prompt similar to:

```
SPROG Ver 3.4
```

```
P>
```

Type ?<return>. The characters you type will not be echoed by SPROG (you may configure your terminal emulator for local echo if you wish). SPROG should display the reset message once again.

Type '+<return>' (without the quotes) to turn on the DCC output. LED101 (upper) should light.

Type '-<return>' (without the quotes) to turn off the DCC output. LED101 (upper) should extinguish.

3.3.2 USB SPROG Initial Testing

Skip this section if you are building a serial SPROG.

The USB SPROG requires FTDI's Virtual COM Port (VCP) drivers to be installed. These drivers appear to the computer as extra COM ports. To keep installation simple, SPROG kits are not supplied with the USB EEPROM (U2), which would require programming. This means that a kit built SPROG must use the unmodified VCP drivers, which will result in SPROG being enumerated as a generic FTDI USB-serial device.

3.3.2.1 Installing USB Drivers

The latest version of the VCP drivers, appropriate to your operating system, should be downloaded from the drivers page of the FTDI website <http://www.ftdichip.com/FTWinDriver.htm>. FTDI also have an app note available for download (<http://www.ftdichip.com/Documents/AN232-03.PDF>) detailing the installation process. This is based upon earlier generation devices but may still be found useful.

For MAC OS, drivers are also available from the FTDI website (<http://www.ftdichip.com/FTMacDriver.htm>).

Power up SPROG and connect to your computer using the provided USB cable.

When using windows, the computer should detect the new device and prompt you to supply the drivers for it, if they are not already installed in your system. Refer to FTDI AN232-03.

3.3.2.2 USB COM Port Assignment

To check the COM port assigned to the SPROG drivers, right click on “My Computer”, select “properties” then the “Device Manager” tab. Open up “Ports(COM & LPT)”. SPROG will be listed as “USB Serial Port (COMx)”.

The current version of DecoderPro, when run under Windows98, only supports COM1-4. If SPROG has been assigned to a higher numbered COM port then this will need to be changed as follows: Open “Ports (COM & LPT)” in “My Computer” (previous paragraph). Double click on the COM port assigned to SPROG. Select the “Port Settings” tab and click “Advanced” from where you may select a different COM port. Be sure to only select a COM port that is not already used on your computer. Click “OK” three times.

3.4 Final Assembly

3.4.1 DCC Output Stage

Fit the remaining components: R27 – R28, R35 - R38, R100, Q1, Q2, U6, U7 and J103.

3.5 Final Testing

Your SPROG is now ready for final testing, which requires a short length of track and a known to be good decoder equipped locomotive (or a bare decoder with motor or load resistor attached to the motor outputs) with a known value in CV1.

Warning: At this stage there is still a risk that an incorrectly assembled unit will cause damage to either the power supply, SPROG or the DCC decoder and loco used to test SPROG. Carefully check that all components are fitted correctly and that there are no short circuits on the PCB. You are referred to the disclaimer at the front of this document.

Connect SPROG to the host computer as for initial testing and to the power supply. Connect SPROG’s DCC output to the track or decoder. Place a decoder equipped locomotive on the track.

Power up SPROG and press the reset button. You should see the reset message and prompt similar to:
SPROG Ver 3.4

P>

If the decoder supports direct mode programming then type ‘C 1<return>’ to read the value of CV1, otherwise use ‘V 1<return>’ for paged mode. After a short delay (longer with paged mode) you should see
> =hnn

in the terminal window where nn is the value read from CV1 (the decoder’s short address). You may hear clicks from the locomotive motor and/or see the locomotive creep as the decoder sends acknowledge pulse(s). If nn is indeed the value previously programmed into CV1 then your SPROG is now functional.

3.6 Troubleshooting

To Be Written.

4 Mechanical Assembly

Both SPROG kits and assembled boards are supplied with a two-part aluminium case which must be drilled and cut to fit the PCB. The two halves of the case are held together with four self-tapping screws. All the necessary fixings are supplied.

The bottom of the case needs two 3mm holes in the positions shown in Figure 2 (viewed from the bottom). Take care to measure from the flat face of the case as the edges are somewhat rounded. The PCB can be fitted using the two M3x12 screws with a 4mm spacer and flat washer to provide a standoff. The board can then be secured using a crinkle washer and nut, see Figure 3.

In normal use, the voltage regulator, IC100, does not require a heat sink. When fitted in the case, **it is important that the body of U100 is isolated from the case.** A mica washer and insulating bush are provided for this purpose and should be fitted as shown in Figure 4.

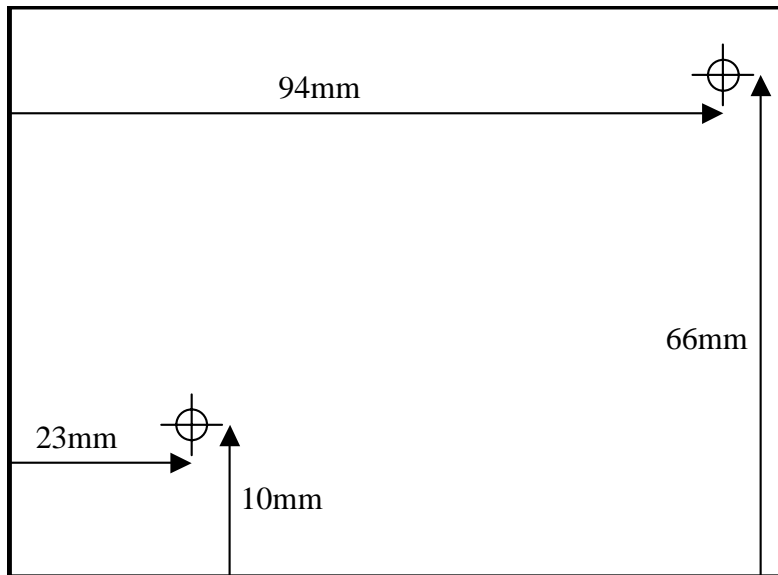


Figure 2 Drill Positions For Bottom of Case

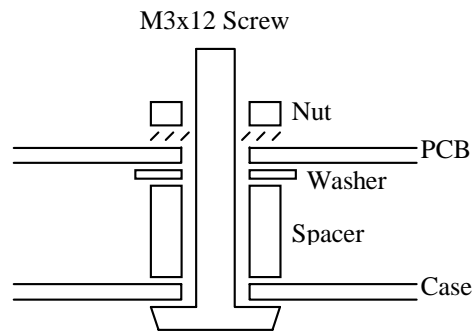


Figure 3 Fixing PCB to Bottom of Case

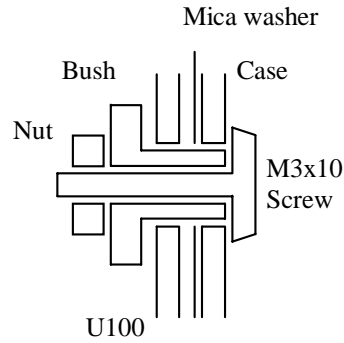
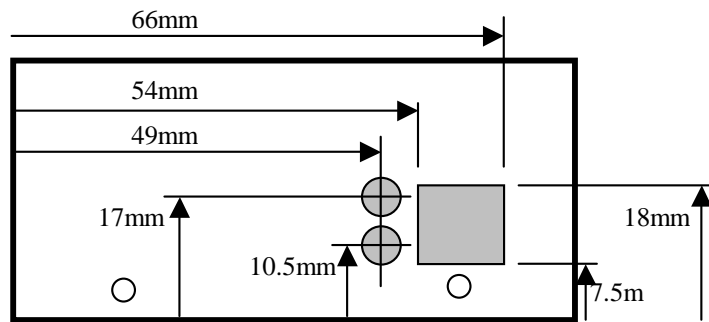


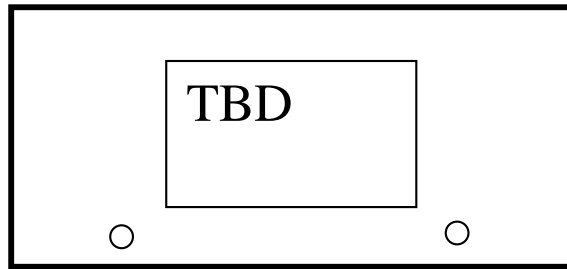
Figure 4 Assembly of Mica Washer and Insulating bush for U100

Figure 5 shows the positions of the cutouts for the communications end of the case for the USB version. Figure 6 shows the same end of the case for the serial version.



Two holes 5mm dia. For LEDs
Cutout 12x10.5mm for USB

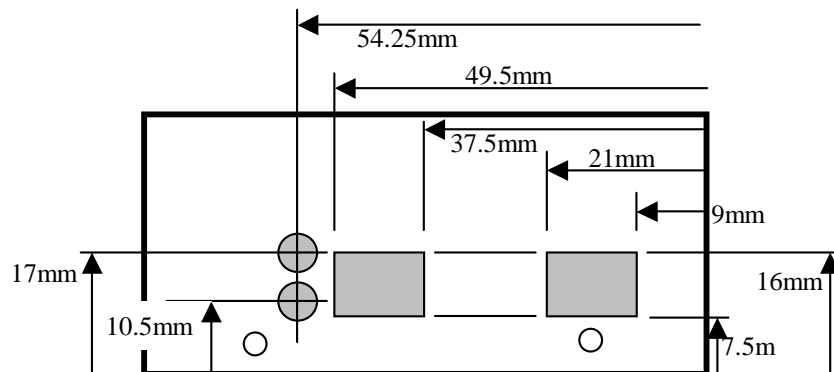
Figure 5 Communications End Cutouts – USB



Cutout XxXmm for 9-pin D

Figure 6 Communications End Cutouts – Serial

Figure 7 shows the cutouts for the power and DCC connectors. Note that measurements are taken from the same side of the case as previous measurements in Figure 5 and Figure 6.



Two holes 5mm dia. For LEDs
Two cutouts 12x8.5mm for terminal blocks

Figure 7 Power/DCC End Cutouts

5 Useful Links

SPROG homepage <http://www.sheerstock.fsnet.co.uk/dcc/sprog.htm>

FTDI <http://www.ftdichip.com>

Microchip <http://www.microchip.com>

Model Electronics Railway Group (MERG), <http://www.merg.org.uk>.

Java Model railroad Interface (for DecoderPro) <http://jmri.sourceforge.net/>

Sun Microsystems (for Java) <http://java.sun.com>