

Tucson Amateur Packet Radio
Deviation Meter Kit Rev 1



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***** CAUTION *****

We recommend that you use a very fine pointed soldering tip on an iron of relatively low wattage (25 watts maximum, 15 watts is ideal) when assembling the TAPR DevMtr kit. The iron should preferably be temperature-controlled. Due to the proximity of some of the traces on the PC board, solder bridges are a very distinct possibility. A low wattage soldering iron, fine pointed tip, clean rosin core solder (60/40, small size) is the order of the day. Following these points could eliminate several hours of trouble-shooting (or worse). This is good practice when working on any electronic kit.

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INTRODUCTION

The TAPR Deviation Meter (DevMtr) is a tool for packet experimenters. It may be used to properly set a transmitter's FM or FSK deviation. Setting proper deviation is essential for optimum station performance. Over-deviation can result in transmissions requiring many retries, degrading the packet channel for everyone. Higher-speed links, such as 9600 bps, likewise require correct deviation for best operation. Until now, setting deviation has required expensive communications analyzers, well-calibrated signal generators and oscilloscopes, or a friend with the right equipment!

This is an original design from TAPR.

This kit includes all parts and components necessary to fully populate the PC board. It is intended as a module to be added to an existing receiver -- therefore, it does not include a case, front panel, rear panel power connector, knobs, fuses, etc.

Access to a voltmeter is required to verify power supply operation. An ohmmeter may prove helpful in identifying some resistor values.

Please check the shipment for any possible errata sheet(s) and/or additions/corrections to instructions provided in this manual.

NOTE: Please note any errors, and send this information along with any suggestions you may have for improving this manual, to TAPR, P.O. Box 12925, Tucson, AZ 85732-2925.

PARTS LIST

Sort the parts into egg cartons, muffin tins or other compartmented containers as you inventory them. This will aid you in building.

Check off the parts in the () spaces provided as you locate and verify them against this list.

Capacitors

TAPR Part Number

Ceramic, Monolithic

() 02	10 pF	100 or 10J or 10K	1111-331-1000
() 02	22 pF	220 or 22J or 22K	1111-331-2200
() 02	47 pF	470 or 47J or 47K	1111-331-4700
() 01	100 pF	101	1111-331-1010
() 01	470 pF	471	1111-331-4710
() 01	680 pF	681	1111-331-6810
() 04	0.001 uF	102	1111-321-1020
() 01	0.01 uF	103	1111-311-1030
() 13	0.1 uF	104	1111-311-1040
() 02	0.15 uF	154	1111-321-1540
() 02	0.33 uF	334	1111-311-3340

Electrolytic, Radial lead

() 08	10 uF	106	1113-001-1064
--------	-------	-----	---------------

Connectors

() 02	2 pin male header	1250-302-0001
() 01	DE9S PC mount right angle	1251-809-0002

Diodes

() 03	1N4148 Switching	1130-000-4148
() 01	1N4002 100V 1A Silicon	1130-000-4002
() 01	MV104 Varactor	1130-000-0104

IC Sockets

() 01	06 pin	1157-006-0003
() 02	14 pin	1157-014-0003
() 02	14 pin Wire Wrap	1157-014-1003
() 02	16 pin	1157-016-0003
() 02	20 pin	1157-020-0003
() 02	28 pin	1157-028-0006
() 01	48 pin	1157-048-0006

ICs

TAPR Part Number

ICs are inserted in anti-static foam. Please do not remove them until they are called out in the construction steps that follow.

ICs often contain many numbers, and the "core" number may have a prefix and/or a suffix. A 74HC14, for example, may be marked MC74HC14P or SN74HC14N.

A four-digit number starting with 90, 91 or 92 is probably a date code, not the part number. A date code might be 9123 or 9004.

() 01	74HC164 Shift Register	1160-221-4164
() 01	74HC573 Octal Latch	1160-221-4573
() 01	LM7805CT Voltage Regulator	1162-313-7805
() 01	MC34064 Reset Generator	1162-013-4064
() 01	LM324 Quad Op Amp	1162-313-0324
() 01	MAX232 or TSC232 or DS1228 RS232 Conv.	1162-313-0232
() 01	MC145170 Synthesizer	1162-313-5170
() 01	68HC11A1 Microcontroller	1164-001-6811
() 01	16V8 or 18CV8 labelled "DEVMTR"	1163-004-0188
() 01	27C256 labelled "DEVMTR 1.0"	1163-004-7256
() 02	LTS312AR 7 Segment Display	1180-400-0312
() 01	4N26 Opto-Isolator	1180-400-0426

Resistors

1/4 Watt, 5% Carbon Film

() 11	470 ohm	(red-red-brn-gld)	1121-111-4700
() 07	1K ohm	(brn-blk-red-gld)	1121-111-1001
() 10	10K ohm	(brn-blk-orn-gld)	1121-111-1002
() 04	16K ohm	(brn-blu-orn-gld)	1121-111-1602
() 04	100K ohm	(brn-blk-yel-gld)	1121-111-1003
() 02	300K ohm	(orn-blk-yel-gld)	1121-111-3003
() 01	10M ohm	(brn-blk-blu-gld)	1121-111-1005

Network

() 01	10K ohm	103	1122-110-1002
--------	---------	-----	---------------

Miscellaneous

() 04	2N3904 Transistor	1170-120-3904
() 02	2N3906 Transistor	1170-120-3906
() 01	TK1413 Variable Inductor	1138-000-1413
() 01	8.0000 MHz Crystal	1150-210-0800
() 02	SPST Pushbutton Switch	1227-111-0001
() 01	DEVMTR PC Board	8805-000-0008
() 01	DEVMTR Assembly/Reference Manual	6610-000-0008

CONSTRUCTION NOTES

The accompanying component placement drawing shows the placement of all parts on the circuit board. Pay particularly close attention to:

- 1) Some resistor values may seem unclear as to color and value. Be very sure of value prior to installation. Access to an ohm meter will be very helpful.
- 2) Save the clipped leads from the resistors and capacitors as some of these will be used to fabricate test lead points.
- 3) Read this entire document prior to starting construction of your kit.

CONSTRUCTION

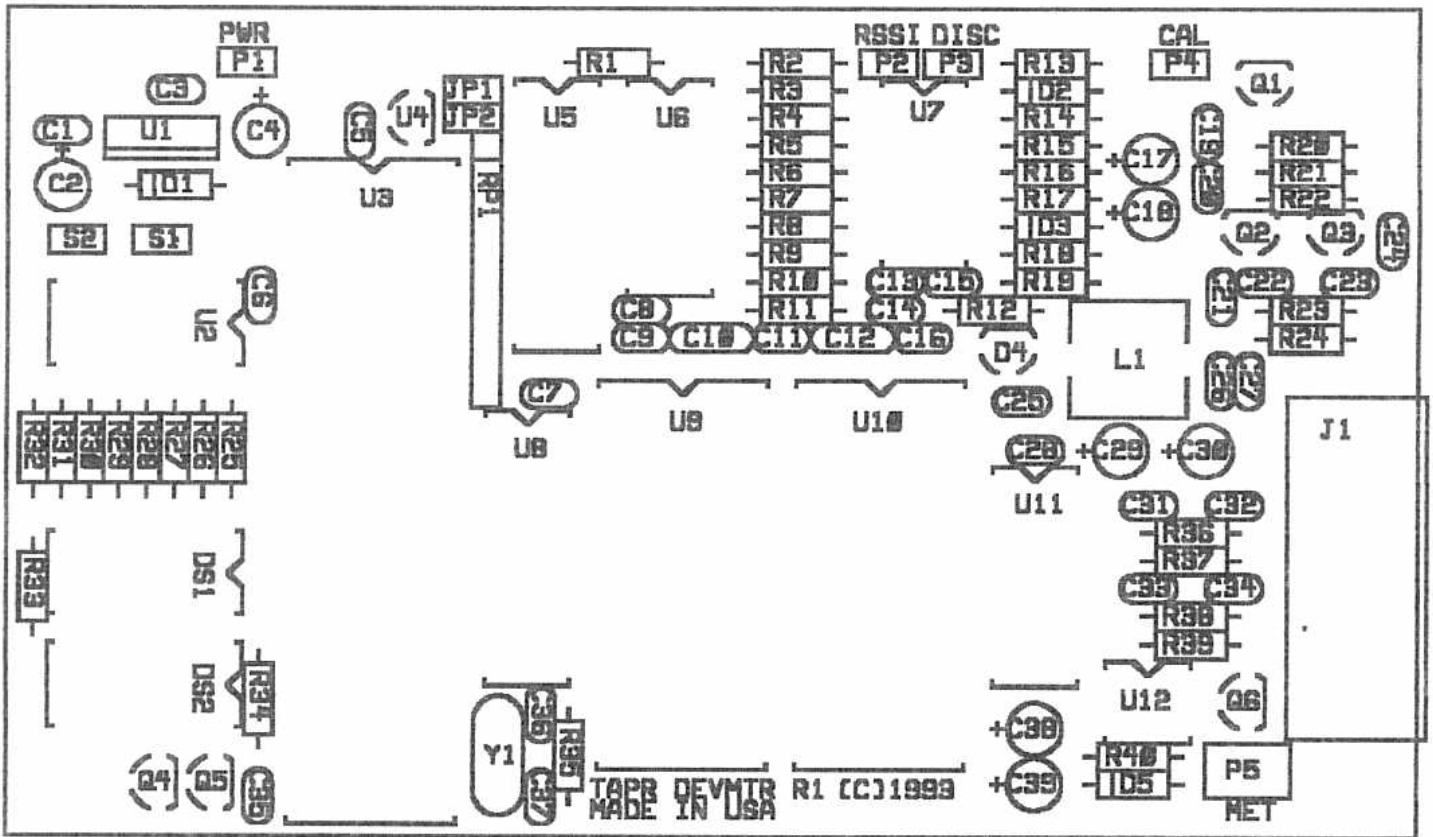


Figure 1 - Component Layout

Check the PC Board and verify that the exposed, tinned pads are clean and shiny. If they are not, scrub the board LIGHTLY with a household cleanser (such as "AJAX" or "COMET") and rinse with clean water, then dry with a clean soft towel.

() PC board clean

Refer to the layout diagram in Figure 1 for clarification of parts placement.

NOTE: The IC sockets are polarized, with the end nearest pin 1 marked with a notch, beveled corner or numeral 1 embossed in the body of the socket.

IC Sockets

NOTE: The IC sockets will have a notch on the silkscreened board at the pin-1 end of the socket.

()	U2	14 pin IC socket
()	U3	48 pin IC socket
()	U5	20 pin IC socket
()	U6	16 pin IC socket
()	U7	14 pin IC socket
()	U8	20 pin IC socket
()	U9	28 pin IC socket
()	U10	28 pin IC socket
()	U11	16 pin IC socket
()	U12	06 pin IC socket

Resistors

Resistor leads are on 0.4" centers. A lead-bending jig may be used to help ensure best appearance of the completed kit.

NOTE: The resistors mount flat against the PC board.

() R1 1K ohm brown-black-red-gold

() Solder and clip two (2) leads.

()	R2	1K ohm	brown-black-red-gold
()	R3	(short)	(use a clipped lead from R1)
()	R4	(open)	
()	R5	16K ohm	brown-blue-orange-gold
()	R6	16K ohm	brown-blue-orange-gold
()	R7	300K ohm	orange-black-yellow-gold
()	R8	16K ohm	brown-blue-orange-gold
()	R9	16K ohm	brown-blue-orange-gold
()	R10	300K ohm	orange-black-yellow-gold
()	R11	10K ohm	brown-black-orange-gold

() Solder and clip eighteen (18) leads.

()	R13	1K ohm	brown-black-red-gold	
()	R14	1K ohm	brown-black-red-gold	Not D2!
()	R15	10K ohm	brown-black-orange-gold	
()	R16	10K ohm	brown-black-orange-gold	
()	R17	10K ohm	brown-black-orange-gold	
()	R18	1K ohm	brown-black-red-gold	Not D3!
()	R19	10K ohm	brown-black-orange-gold	
()	R12	100K ohm	brown-black-yellow-gold	

() Solder and clip sixteen (16) leads.

() R20 10K ohm brown-black-orange-gold
 () R21 1K ohm brown-black-red-gold
 () R22 470 ohm yellow-violet-brown-gold
 () R23 100K ohm brown-black-yellow-gold
 () R24 100K ohm brown-black-yellow-gold

() Solder and clip ten (10) leads.

() R25 470 ohm yellow-violet-brown-gold
 () R26 470 ohm yellow-violet-brown-gold
 () R27 470 ohm yellow-violet-brown-gold
 () R28 470 ohm yellow-violet-brown-gold
 () R29 470 ohm yellow-violet-brown-gold
 () R30 470 ohm yellow-violet-brown-gold
 () R31 470 ohm yellow-violet-brown-gold
 () R32 470 ohm yellow-violet-brown-gold

() Solder and clip sixteen (16) leads.

() R33 10K ohm brown-black-orange-gold
 () R34 10K ohm brown-black-orange-gold
 () R35 10M ohm brown-black-blue-gold

() Solder and clip six (6) leads.

() R36 470 ohm yellow-violet-brown-gold
 () R37 470 ohm yellow-violet-brown-gold
 () R38 10K ohm brown-black-orange-gold
 () R39 1K ohm brown-black-red-gold
 () R40 100K ohm brown-black-yellow-gold

() Solder and clip ten (10) leads.

Resistor Network

The next part is the SIP (single inline package) network. This is a **polarized** part; the end with the dot or stripe goes into the square pad.

When installing the SIP, tack solder the end pins, verify placement against the PCB, then solder the remaining pins. Finally, resolder the two end pins.

() RP1 10K ohm SIP (103)

You should have one 10K (brown-black-orange-gold) resistor remaining.

() One 10K resistor left.

Capacitors

Electrolytic capacitors are polarized. The positive lead goes in the hole location on the board marked with a "+". The PCB pad is square for the positive lead. The capacitors themselves usually have the negative lead marked, so be careful!

Install the following capacitors:

- () C1 0.1 uF (104)
- () C2 10 uF (106) Polarized
- () C3 0.1 uF (104)
- () C4 10 uF (106) Polarized
- () C5 0.1 uF (104)
- () C6 0.1 uF (104)

- () Solder and clip twelve (12) leads.

- () C7 0.1 uF (104)
- () C8 0.1 uF (104)
- () C9 0.33 uF (334)
- () C10 0.15 uF (154)
- () C11 0.33 uF (334)

- () Solder and clip ten (10) leads.

- () C12 0.15 uF (154)
- () C13 0.1 uF (104)
- () C14 0.1 uF (104)
- () C15 0.1 uF (104)
- () C16 0.1 uF (104)

- () Solder and clip ten (10) leads.

- () C17 10 uF (106) Polarized
- () C18 10 uF (106) Polarized
- () C19 10 pF (100 or 10J or 10K)
- () C20 100 pF (101)

- () Solder and clip eight (8) leads.

- () C21 0.1 uF (104)
- () C22 470 pF (471)
- () C23 680 pF (681)
- () C24 0.01 uF (103)
- () C26 47 pF (470 or 47J or 47K)
- () C27 47 pF (470 or 47J or 47K)

- () Solder and clip twelve (12) leads.

() C25 10 pF (100 or 10J or 10K)
 () C28 0.1 uF (104)
 () C29 10 uF (106) Polarized
 () C30 10 uF (106) Polarized
 () C31 0.001 uF (102)
 () C32 0.001 uF (102)

() Solder and clip twelve (12) leads.

() C33 0.001 uF (102)
 () C34 0.001 uF (102)
 () C38 10 uF (106) Polarized
 () C39 10 uF (106) Polarized

() Solder and clip eight (8) leads.

() C35 0.1 uF (104)
 () C36 22 pF (220 or 22J or 22K)
 () C37 22 pF (220 or 22J or 22K)

() Solder and clip six (6) leads.

This completes the capacitor installation. You should have no remaining capacitors.

() No capacitors remaining.

Diodes

NOTE: Diodes are polarity sensitive devices. Diodes are mounted flat near the surface of the board like the resistors previously installed. The cathode end of the diode is banded, and corresponds to the banded silkscreen legend and the square pad on the PCB.

Install the following diodes:

- () D1 1N4002
- () D2 1N4148
- () D3 1N4148
- () D5 1N4148

- () Solder and clip eight (8) leads.

Transistors and TO-92 Devices

Transistors are polarity sensitive devices. When installing, match the outline on the PC board silkscreen with the body of the transistor. Insert the transistor leads through the PC board and continue pressing the transistor down to the board until the body of the transistor is about 1/4" (6 mm) or so from the surface of the PC board. Then, solder the three leads before proceeding to the next device.

Install the following components:

- () U4 MC34064
- () D4 MV104
- () Q1 2N3904
- () Q2 2N3904
- () Q3 2N3904
- () Q4 2N3906
- () Q5 2N3906
- () Q6 2N3904

- () Twenty-four (24) leads soldered and clipped!

Voltage Regulator

NOTE: The metal tab on the regulator body is connected to ground. Be sure this tab does not come in contact with any internal circuitry in the radio which the DevMtr will be installed in!

Be sure to line up the metal tab of the part with the silkscreen outline (tab toward D1).

- () U1 LM7805

- () Solder and clip three (3) leads.

Male Headers

The 2-pin male headers will next be installed. The plastic body of the part should rest flush with the top surface of the PC board. The short end of the pins goes into the PC board, the long end sticks up.

WARNING: Do not hold these parts with your fingers as they quickly get very hot while soldering in place.

- () JP1
- () JP2

Crystal

The crystal should stand perpendicular to the surface of the PC board.

- () Y1 Crystal 8.0000 MHz
- () Solder and clip two (2) leads.

Connectors

The serial port connector, J1, should mount flush to the surface of the PC board. All nine (9) pins should be soldered. If you wish, you may secure the connector to the PC board with #4 OR #5 hardware. The hardware should be tightened **before** the pins are soldered!

- () J1 DE9S

Inductor

Inductor L1 fits snugly into the PC board. Be sure it is seated squarely to the PC board, then solder all five (5) pins **and the two (2) case mounting tabs** to the PC board.

NOTE: The inductor has plastic embossings that stand the case slightly above the PC board. This is normal. **Do not force the inductor when mounting it!**

- () L1 Inductor

Displays

The displays mount in 14-pin wire-wrap sockets. You should determine the mechanical spacing required for your installation, then solder the sockets to the correct height. For the Radio Shack "PRO-59" scanner, we suggest you mount the sockets at their maximum

height from the PC board and level with it. The tails from the sockets should just protrude through the bottom of the PC board.

- () DS1 14-pin wire-wrap socket
- () DS2 14-pin wire-wrap socket

Switches

The two switches should be wired to locations "S1" and "S2". If you do not intend to use the switches, you should temporarily wire them up as they will be required during initial checkout of the DevMtr.

- () Both switches wired.

Initial Checkout

- () Attach a 12 volt DC power source to the DevMtr at P1. Plus goes to the square pad (near the label "C3") and minus to the round pad (near the label "PWR").
- () Apply power to the DevMtr and verify that +5 volts appears across pins 20 (+) and 10 (-) of IC socket U5.
- () Remove power from the DevMtr.

Observing static handling precautions, install the following ICs on the DevMtr:

- () U2 74HC164
 - () U3 68HC11A1
 - () U5 16V8 or 18CV8 labelled "DevMtr"
 - () U6 MC145170
 - () U7 LM324
 - () U8 74HC573
 - () U9 27C256 labelled "DevMtr 1.0"
 - () U10 (empty)
 - () U11 MAX232 or TSC232 or DS1228
 - () U12 4N26
- () Clip the lead at pin 6 of the LTS312AR display that will be installed at DS1.
- () DS1 LTS312AR
 - () DS2 LTS312AR

Check for proper installation of all IC chips. Be especially careful about pins folded under chip bodies, or overhanging the side of a socket.

- () Attach a computer or terminal to the serial port of the DevMtr.
- () Load a communications program and configure it for 9600 bps, no parity, eight (8) data bits, one (1) stop bit.
- () While holding switch S1 closed, apply power to the DevMtr. The following sign-on message will appear from the monitor program in EPROM U9:

BUFFALO 3.4 (ext) - Bit User Fast Friendly Aid to Logical Operation

- () Release S1.
- () Press the <CR> or <ENTER> key of the computer to get the monitor prompt:

>

- () Type

MD DE00 DE80 <CR>

where <CR> means the <ENTER> key of your computer.

- () The following will appear:

```

DE00 7E 80 00 7E 80 84 7E 80 52 7E 80 62 7E 80 F0 7E      R b
DE10 80 85 7E 80 9E 7E 81 4C 7E 80 6A 7E 81 5B 7E 81      L ] [
DE20 78 7E 81 7F 7E 81 A7 7E 81 BD 7E 81 DF 7E 81 FD x
DE30 7E 82 29 7E 82 34 7E 81 0F 7E 82 56 7E 82 62 7E      ) 4 V b
DE40 82 BB 7E 82 A2 7E 82 C3 7E 82 F0 7E 83 31 7E 81      =0 *b ? G
DE50 1E 7E 81 3D 30 00 0C 00 07 D0 2A 62 04 3F 00 47
DE60 83 90 83 FE 84 18 84 2A 84 52 84 30 84 4C 84 57      * R 0 L W
DE70 FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF
DE80 FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF
>

```

- () Now type

MOVE DE00 DE80 B600<CR>

This command will copy the vector table from the EPROM to the EEPROM located within MC68HC11A1 chip U3.

- () The DevMtr will respond with:

>

after several seconds.

- () Next, turn power off of the DevMtr. After a few seconds, turn power on and the following will appear:

```
TAPR Deviation Meter Version 1.0  
Copyright (C) 1993. All rights reserved.
```

```
DevMtr> Calibrating...
```

- () This is the DevMtr sign-on message. The "Calibrating..." message appears as the unit enters its self-calibration mode. At this time, the calibration is meaningless. Once the VCO has been calibrated, however, the self-calibration will set the DevMtr for accurate readings of deviation.

- () After several seconds, the following will appear:

```
DevMtr> Ready  
kHz> 0.0
```

This indicates the DevMtr has completed its self-calibration and should be ready for operation.

- () Carefully examine the tuning slug in coil L1. It has a short, wide slot in the top for tuning purposes. Locate a small screwdriver that will fit in the slot and allow you to turn it.

NOTE: The ferrite core is fragile. When adjusting it in the next steps, use extreme caution. **Do not force the slug or use a tool that is too narrow or the slug may crack.** If it does crack, you may remove the pieces and glue them with an epoxy or quick-setting glue, then try again!

- () Press and hold switch S2. **Continue holding S2 closed throughout the following steps until you are directed to release it.** The following message will appear on the serial port:

```
DevMtr> VCO Calibration  
VCO> X X
```

where "X X" will most likely be "0 0" or "F F". The same numerals or letters will appear on the LED display.

- () Turn the core of L1 counter-clockwise if the display reads "0 0" and clockwise if the display reads "F F" until the reading changes. It will change rather abruptly between "0 0" and "F F".

- () Carefully tune the core until the display shows a reading of "3 8", "3 9", "3 A", "3 B", "3 C", "3 D", "3 E", "3 F", "4 0", "4 1", "4 2", "4 3" or "4 4".
- () Remove the tuning tool and note the new reading. Retune until one of the readings indicated in the previous step is displayed after the tuning tool is removed from the core.
- () Release switch S2.

Congratulations! The DevMtr is now calibrated and ready to be installed into a receiver!

INSTALLATION

The DevMtr may be installed in any number of receivers. General considerations appear later in the section entitled Generic Installations.

Radio Shack PRO-59 Scanner

Mechanical:

The DevMtr may be mounted on the metal baseplate of the scanner. The RS232 connector (J1) will protrude from the rear of the scanner and a hole will have to be cut in the case to accommodate it. The screw receptacle near the speaker will have to be notched to allow the DevMtr board to fit. The DevMtr board should press snugly against the inside rear of the PRO-59 cabinet when it is assembled.

A cutout on the top of the cabinet above the squelch control will need to be made to allow the displays to be read.

The two switches (S1 and S2) may be mounted on the cabinet top above the volume control.

Electrical:

We recommend that you use miniature coaxial cable (like RG-174/U) to make the signal connections inside the PRO-59. This is not a requirement, but if the unit is to be operated in areas of high RF levels, it will help ensure proper performance.

P1: PWR

The square pad (+) may be sired to the point marked "+" in the illustration below. The round pad (-) may be attached to the point labelled "GND" on the scanner PC board, also indicated below.

P2: RSSI

The square pad may be attached to IC5 pin 30. The round pad is ground.

P3: DISC

The square pad may be attached to IC1 pin 9. The round pad is ground.

P4: CAL

Cut both leads of the remaining 10K ohm resistor (brown-black-orange-gold) to a length of about 1/4" (6 mm). Solder one end of this resistor to IC1 pin 18. The square pad may be attached to the free end of this resistor. The round pad is ground.

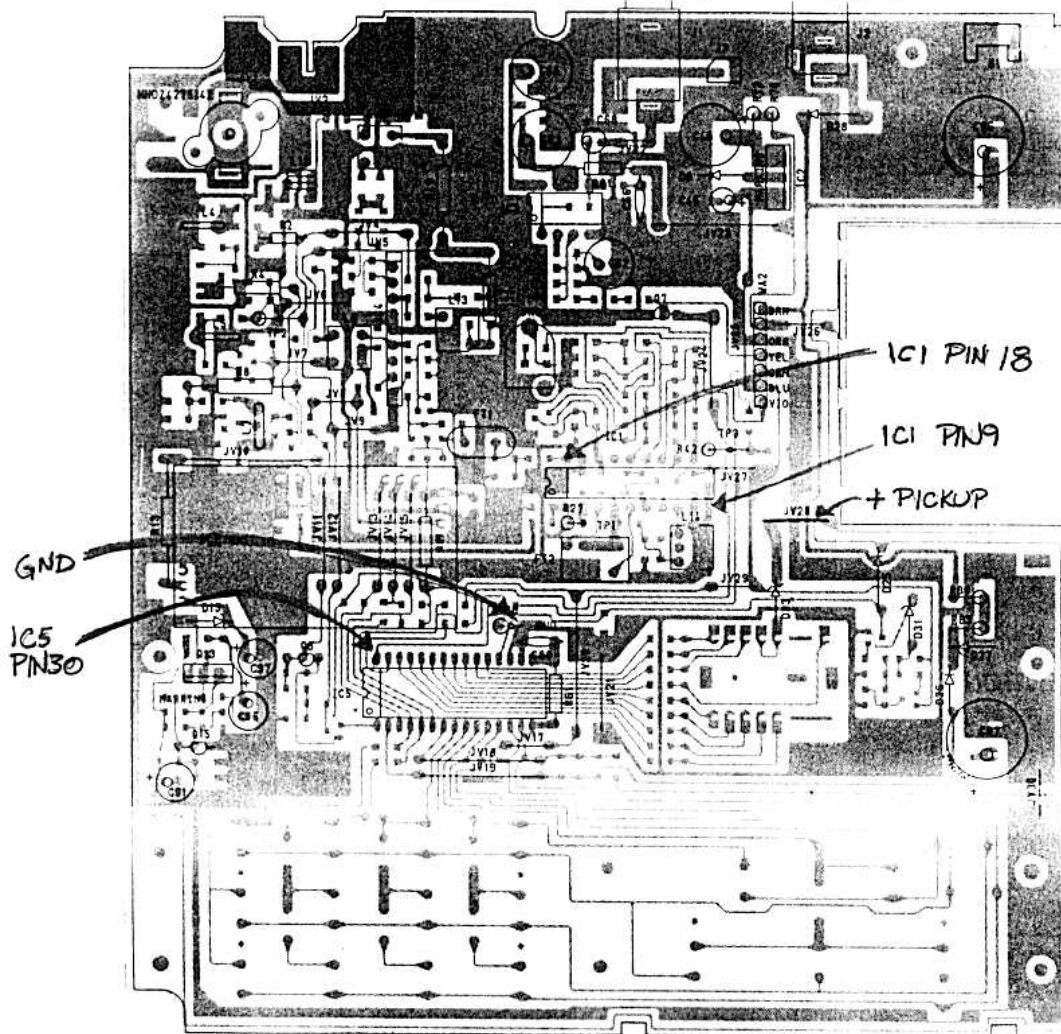


Figure 2 - PRO-59 attachment points.

Generic Installations:

For installations other than the specific one detailed above, refer to the following information.

P1: PWR

The DevMtr requires an unregulated source of +8 to +20 VDC. The current required is under 100 mA and typically only about 55 mA.

Positive input is applied to pin 1 (the square pad). The other pad is common.

P2: RSSI

The DevMtr is defaulted to allow a range of 0 to +10 VDC at the received signal strength indication (RSSI) input. A voltage above about +2.5 VDC indicates a signal is present; a voltage below this level indicates the readings are noise and are to be ignored.

This input has a nominal impedance of 20K ohms to ground.

If the receiver provides a different output than this, it may be accommodated in the following manner:

Different Voltage Range

The DevMtr cannot accept negative voltages. If the positive range exceeds +10 volts, the values of R16 and R17 may be altered to divide the voltage down to a range at the output of U7A not to exceed +5 VDC.

If the maximum voltage is less than about +3 VDC, R3 and R4 may be adjusted to provide gain from U7A.

Different Logic

If your receiver's RSSI is such that a voltage below the threshold means a good signal and a higher voltage means noise, a patch must be made to the EEPROM memory in the DevMtr. This is done as follows:

- () Attach a computer or terminal to the serial port of the DevMtr.
- () Load a communications program and configure it for 9600 bps, no parity, eight (8) data bits, one (1) stop bit.

() While holding switch S1 closed, apply power to the DevMtr. The following sign-on message will appear from the monitor program in EPROM U9:

BUFFALO 3.4 (ext) - Bit User Fast Friendly Aid to Logical Operation

() Release S1.

() Press the <CR> or <ENTER> key of the computer to get the monitor prompt:

>

() Type

MM B626 <CR>

where <CR> means the <ENTER> key of your computer.

() The DevMtr will respond with

B626 A7

() Type

B2<CR>

The DevMtr is now set up to correctly interpret the RSSI logic polarity for your receiver.

Different Threshold Value

The DevMtr uses an 8-bit analog-to-digital converter (A/D) to measure the RSSI voltage. If your receiver provides a simple squelch output (open or closed), the default threshold of +2.5 VDC will probably work just fine. IF not, or if you wish to change the threshold for any reason, use the following procedure.

- 1) Determine the voltage at which you want the DevMtr to take readings. For example, let's assume the voltage is +4.3 volts.
- 2) Determine the DevMtr RSSI input range. This is according to the following formula:

$$5 * ((R16+R17)/R17) * (1+(R3/R4))$$

For the default resistors, this is:

$$5 * ((20,000)/(10,000) * (1+ (0))) = 5 * 2 * 1 = 10 \text{ volts.}$$

- 3) Take the ratio of the desired voltage to the RSSI range as a decimal fraction. For our example, this is

$$4.3/10 = 0.43$$

- 4) The full-scale reading of an 8-bit A/D is 256-1, or 255. SO, the next step is to multiply the result of step 3 by 255. For our example,

$$0.43 * 255 = 109.65$$

Discard any fractional values that might result for your particular value. In this case, we would use 109.

- 5) Now comes the hard part. This value must be converted to an eight-bit hexadecimal number. This can be done using the following method with any simple calculator (or even by hand if you remember how!).

- a) Divide the result from step 4 by 16. Write down the whole number portion.

$$\text{For our example this is } 109/16 = 6.8125$$

We then write down 6.

- b) Subtract the whole number from the result.

$$\text{In our example, this is } 6.8125 - 6 = 0.8125$$

- c) Multiply the remaining value by 16 (even if it is zero).

$$\text{In our example, } 0.8125 * 16 = 13$$

- d) Using the Decimal to Hexadecimal table below, write down the first hex value from step 5a. We'll call this the MSD.

In our example, this is 6.

- e) Next, using the table below, write down the second hex value from step 5c. We'll call this the LSD.

For our example, this is D.

Decimal	Hexadecimal	Decimal	Hexadecimal
0	0	8	8
1	1	9	9
2	2	10	A
3	3	11	B
4	4	12	C
5	5	13	D
6	6	14	E
7	7	15	F

6) Now, this value must be entered into the DevMtr EEPROM as the comparison value for RSSI decisions. To do this:

- () Attach a computer or terminal to the serial port of the DevMtr.
- () Load a communications program and configure it for 9600 bps, no parity, eight (8) data bits, one (1) stop bit.
- () While holding switch S1 closed, apply power to the DevMtr. The following sign-on message will appear from the monitor program in EPROM U9:

BUFFALO 3.4 (ext) - Bit User Fast Friendly Aid to Logical Operation

- () Release S1.
- () Press the <CR> or <ENTER> key of the computer to get the monitor prompt:

>

- () Type

MM B65D <CR>

where <CR> means the <ENTER> key of your computer.

- () The DevMtr will respond with

B65D 3F

- () Type the value that you computed above. For our example this would be

6D<CR>

The DevMtr is now set up to make signal decisions based on your newly entered RSSI threshold value.

P3: DISC

The DevMtr expects the voltage range from your receiver's FM signal detector to fall within the range of 0 to +5 VDC under all conditions. It cannot accept negative voltages, nor can it tolerate voltages in excess of +5 VDC.

If your detector falls outside this limitation, you must construct additional circuitry to scale it within these bounds.

Attach the detector signal to pin 1 (square pad) of P3. Pin 2 is common. This is a high-impedance input, on the order of several hundred thousand ohms.

P4: CAL

The DevMtr outputs a signal here in the I.F. range of your receiver. The available signal is several hundred millivolts. It is coupled through a 10 pF capacitor to minimize loading effects on the receiver. In addition, we recommend installing a 10K ohm series resistor at the attachment point within the receiver. This will help to isolate the effects of the cable attaching to the DevMtr.

This signal is output during VCO calibration as well a self-calibration of the DevMtr, which occurs at every power up.

The default I.F. frequency is 10.850 MHz.

The DevMtr steps from 10 kHz below the I.F to 10 kHz above it in 21 steps of 1 kHz.

Different I.F. Center Frequency

The calibration oscillator may be re-tuned to other I.F. frequencies in the range of 10 to 11 MHz by simply adjusting inductor L1. Other I.F. ranges may be accommodated by further changes in the calibration oscillator component values. Such adjustment is beyond the scope of this manual.

If your receiver I.F. is in the range of 10 to 11 Mhz, you may use the following procedure to alter the DevMtr's calibration constant located in the 68HC11's internal EEPROM:

- 1) Determine the center of the I.F. passband of your receiver. For example, let's assume the frequency is 10.700 MHz.
- 2) Express the frequency in kHz. For our example, this is 10,700.

3) This value must now be converted to a 16-bit hexadecimal number. To do this perform the following steps (you may use any simple calculator or even do it by hand if you remember how!).

- a) Divide the result from step 2 by 4096. Write down the whole number portion.

For our example this is $10700/4096 = 2.612305$

We then write down 2.

- b) Subtract the whole number from the result.

In our example, this is $2.612305 - 2 = 0.612305$

- c) Multiply the remaining value by 4096 (even if it is zero).

In our example, $0.612305 * 4096 = 2508$

- d) Divide the result from step c by 256. Write down the whole number portion.

For our example this is $2508/256 = 9.796875$

We then write down 9.

- e) Subtract the whole number from the result.

In our example, this is $9.796875 - 9 = 0.796875$

- f) Multiply the remaining value by 256 (even if it is zero).

In our example, $0.796875 * 256 = 204$

- g) Divide the result from step f by 16. Write down the whole number portion.

For our example this is $204/16 = 12.75$

We then write down 12.

- h) Subtract the whole number from the result.

In our example, this is $12.75 - 12 = 0.75$

- i) Multiply the remaining value by 16 (even if it is zero).
In our example, $0.75 * 16 = 12$.
Write down the 12.
- j) Using the Decimal to Hexadecimal table below, write down the first hex value from step 3a. We'll call this the MSD.
In our example, this is 2.
- k) Next, using the table write down the second hex value from step 3d. We'll call this the 2SD.
For our example, this is 9.
- l) Similarly, write down the third value (called the 3SD) from step 3g. In our example, this is C.
- m) Finally, write down the fourth value (called the LSD) from step 3j. In our example, this is C.

Decimal	Hexadecimal	Decimal	Hexadecimal
0	0	8	8
1	1	9	9
2	2	10	A
3	3	11	B
4	4	12	C
5	5	13	D
6	6	14	E
7	7	15	F

- 4) Now, this value must be entered into the DevMtr EEPROM as the I.F. center frequency for the VCO synthesizer. To do this, follow these steps:
 - { } Attach a computer or terminal to the serial port of the DevMtr.
 - () Load a communications program and configure it for 9600 bps, no parity, eight (8) data bits, one (1) stop bit.
 - () While holding switch S1 closed, apply power to the DevMtr. The following sign-on message will appear from the monitor program in EPROM U9:

BUFFALO 3.4 (ext) - Bit User Fast Friendly Aid to Logical Operation

- () Release S1.
- () Press the <CR> or <ENTER> key of the computer to get the monitor prompt:
>
- () Type
MM B65A <CR>
where <CR> means the <ENTER> key of your computer.
- () The DevMtr will respond with
B65A 2A
- () Type the value of the MSD:2SD that you computed above. For our example this would be
29<CR>
- () Type
MM B65B <CR>
where <CR> means the <ENTER> key of your computer.
- () The DevMtr will respond with
B65B 62
- () Type the value of the 3SD:LSD that you computed above. For our example this would be
CC<CR>

The DevMtr will now use the I.F. center frequency you have entered for its calibration routines. Be sure to perform the VCO tuning of L1 as described above before you try to use the DevMtr at this new frequency!

Using the Deviation Meter with METCON

The DevMtr has special provisions for use with METCON, TAPR's remote telemetry and control device.

P5: MET

P5 brings the S1 and S2 switch inputs as well as a special pulse output to one convenient location on the DevMtr PC board.

Pin 1

This is part of an optically-isolated pulsed output. It should be tied to a METCON **GND** terminal at one of the digital inputs of a METCON board.

Pin 2

This is the other terminal of the optically-isolated pulsed output. It should tie to any digital input of a METCON device. The input should be configured as a frequency counter.

When pins 1 and 2 are connected as described, the corresponding frequency counter will display a reading of 1/10 the measured deviation.

For example, if the pulsed output were connected to METCON input channel 1, and a signal of 2.8 kHz deviation were being measured, the **AMAP** output from METCON would indicate a value of 280. The following AMAP display from a METCON unit might result:

METCON-1 921031-1.06
 Copyright (c) 1991-1992 T.A.P.R. All Rights Reserved.
 Checksum: 0x72E4

=amap

-A- MEMORY DISPLAY

P6		P5		P4		P2		P0			
0000	0000	0000	0000	0000	0000	0000	0000	0000	0000	OUT	(08 07 06 05 04)
0000	0000	0000	0000	0000	0000	0000	0000	1111	1111	IN	(0D 0C 0B 0A 09)
0000	0000	0000	0000	0000	0000	0000	0000	1111	1111	CHG	(12 11 10 0F 0E)
7	6	5	4	3	2	1	0				
00000	00000	00000	00000	00000	00000	00000	00280	00000		F/P	CTRS (21/22-13/14)
7	6	5	4	3	2	1	0				
255	255	255	255	255	255	255	255	255		ADC	(2A-23)

-A- MEMORY DISPLAY COMPLETE

Pin 3

This pin is wired to S2.

Pin 4

This pin is tied to common on the DevMtr.

Pin 5

This pin is wired to S1.

Pin 6

This pin is tied to common on the DevMtr.

A METCON relay output may be wired across P5 pins 3 and 4, or across P5 pins 5 and 6. This would allow a remote user to activate the functions defined by S1 and S2. S1, for example, is used for self-calibration of the DevMtr. This could then performed by remote command.

Serial Port Information

J1 implements a 9-pin RS-232 compatible port on the DevMtr. It defaults to 9600 bps, no stop bits, eight (8) data bits and one (1) stop bit. It uses the internal UART device located on the 68HC11 chip.

In DevMtr modes, this is an output-only port.

If you desire to use the internal debugging monitor provided by Motorola, simply power up the DevMtr with S1 pressed. Once the debugger signs on, you may release S1 and proceed to use it.

The serial port will connect to a standard 9-pin serial port on a PC with a straight-through connection. The pins used are:

Pin	Name	Function	Direction
2	RXD	Serial Data	From DevMtr to Computer
3	TXD	Serial Data	From Computer to DevMtr
5	GND	Common	Signal Common

If you wish to change the characteristics of the serial port, refer to the Motorola 68HC11 documentation.

HELP!

Please let us know how you install the DevMtr in other receivers so we may expand the manual and share this information with others.

USING THE DEVMTR

The DevMtr may be used to set your transmitter's deviation and to check the deviation of other stations.

It is imperative that any signal to be checked be "full quieting." Any noise on the received signal will be detected and give a false reading of deviation. Further, use of the DevMtr in a strong RF field may result in erroneous readings.

For a normal voice FM transmitter, follow the manufacturer's directions in setting deviation and deviation limiting. In general, deviation should not exceed about 4.5 kHz.

For 1200 bps AFSK/FM< packet (the most common type), use the following general procedure:

- 1) Tune the DevMtr to an unused channel and set the packet transmitter to the same frequency.
- 2) Key the transmitter with the TNC in **CAL** mode. Select the higher modulating tone (usually 2100 Hz or 2200 Hz).
- 3) Adjust the TNC's output control for a deviation reading of 2.8 kHz. More deviation will not help and may make your signal harder for other stations to copy (even though it might sound louder to your ear).
- 4) Unkey the transmitter and exit the TNC's **CAL** mode.

For 9600 bps packet, using direct FSK (the most common type), set things up as for 1200bps packet and then adjust the 9600 bps modem for a reading of 3.0 kHz.

It is always advisable to enable the audio channel of the receiver you are using to measure deviation with! Your ear is a valuable piece of test equipment! As you listen, you may hear a signal that has a lot of 60 Hz hum and low deviation of the actual packet modulation. And you will likely hear stations with excessive deviation needing more retries to get their signals through the network than those which are properly adjusted.

Enjoy your new DevMtr and please let us know of any novel uses you put it to!

HARDWARE

This section includes a detailed circuit theory explanation.

Detailed Circuit Description

The TAPR DevMtr is a microprocessor-based instrument designed to measure the deviation of an applied signal in an I.F. range of 10 to 11 MHz. It is intended to help packet operators properly adjust their transmitters for optimum performance.

Analog Processing Section

Incoming audio from the radio FM detector (usually a quadrature detector within an IC such as a Motorola MC3357, 3359 or 3362) is applied to peak detectors U7C and U7D via R13. U7C is a high gain amplifier which attempts to drive the voltage on pin 9 to match the input voltage at pin 10. D3 acts to pass the positive-going output from U7C back to pin 9 and charges C18 in the process. Thus, C18 is charged to the positive peak value of the voltage applied at P3. R19 serves to discharge C18 so that it will track varying modulation peaks.

U7D similarly tracks the lowest-value input voltage at P3, charging C17. The positive and negative peak values are passed via R18 and R14 to the analog-to-digital converter (A/D) located in U3.

Received signal strength indication (RSSI) voltage, or squelch state, is passed from P2 via R16/R17 to U7A. The output of U7A is passed via R2 to the A/D.

Digital Processing Section

Microcontroller U3, a 68HC11A1, contains a CPU, random-access memory (RAM), electrically alterable read-only memory (EEPROM), clock oscillator, timers, a UART for implementing a serial port and a multi-channel A/D converter in a single chip.

The address/data bus is demultiplexed by latch U8 and interfaced to external EPROM chip U9 (27C256). U9 contains the program for the DevMtr as well as Motorola's BUFFALO monitor. The EPROM is mostly empty, allowing other routines to be programmed into it without replacing it.

Programmable logic chip U5 (16V8 or 18CV8) is used to map the external memory to U3 and to provide special startup signals during reset.

All DevMtr routines are linked through U3's internal EEPROM, and most constants are stored there as well. Such information as RSSI

levels and states and I.F. center frequencies may thus be altered by the user without resorting to re-programming the EPROM. In addition, the user may re-write any routines in the DevMtr code, or add other routines, and store the changes in the EEPROM.

An 8 MHz clock oscillator is formed by U3, Y1, R35, C37 and C38. The resulting bus frequency of 2 MHz is output by U3 at pin 27 as E.

U4 provides a reliable reset circuit for U3. Whenever the +5 volt line falls below about +4.7 volts, U4 asserts reset. When the voltage rises to a safe level, U4 releases reset. This reliable reset is required to help prevent accidentally altering the contents of the EEPROM within the 68HC11 chip.

LED Displays

LED displays DS1 and DS2 provide a local output to the user. Bit patterns for the display (kHz of deviation of raw hex voltage measurements of the VCO tuning voltage) are encoded by U3. Every 10 milliseconds, Q4 and Q5 are turned off and the bit pattern shifted into register U2. Once the pattern is loaded into U2, either Q4 or Q5 is turned on (via R33 or R34) and the appropriate display is illuminated.

Resistors R25-R32 provide current limiting. The refresh rate of 100 Hz provides a display that appears to be steadily illuminated.

METCON Interface

U3 provides a gated pulse output at pin 4. Every second, a burst of pulses starts at a 1 kHz rate. After a number of pulses corresponding to 1/10 the measured deviation (e.g., 280 pulses for 2.8 kHz of deviation) has passed, the pulses are inhibited for the remainder of the one second timeout.

This provides a rate of 0 to 990 Hz, well within the capability of METCON.

These pulses are applied to Q6 via R38. The output of Q5 drives opto-isolator U12 via R39. The output of U12 is passed to P5, with protection provided by D5 and leakage suppressed by R40.

Note that many frequency counters cannot accurately read this burst method of frequency generation. It is especially suited to simple counters that open their count gate for one second and totalize the pulses in that time frame, as does METCON's frequency measuring system.

Also note that you cannot obtain increased accuracy by using this output. The DevMtr measures deviation to the nearest 100 Hz, and the METCON pulse output is in steps of 10 Hz.

Serial Port

Serial information for U3 is passed through level shifter U11 (MAX232 or equal). U11 translates 5 volt logic levels to +/- 9 volts for RS-232 compatibility. Low pass networks C31-C34 along with R36 and R37 serve to remove any RFI and EMI between the DevMtr and any attached cabling or equipment.

Capacitors C29, C30, C38 and C39 provide energy storage for the charge pump within U11 that generates the required + and - 9 volts.

Calibration Oscillator (VCO)

The calibration oscillator is the secret of the DevMtr's ability to accurately measure deviation without any other equipment to calibrate it.

Q2 is a colpitts oscillator, tuned by L1 and various capacitors. The output from Q2 is buffered by Q3 and applied to the receiver via C19 as well as to synthesizer U6 (MC145170) via C20.

U6 is programmed by U3 to the I.F frequency of the receiver. If Q2 is oscillating at the wrong frequency, a correction voltage is derived by error signals from U6. U7B acts as the filter, along with extensive R/C networks R5-R10 and C9-C12. U7B's output is then applied via R11/C14/R12 to varactor diode D4 (MV104). D4 is part of the tuned circuit along with L1. Thus, applying a voltage to D4 will tune the oscillator over a limited range.

A sample of the tuning voltage from U7B is applied to U3 via R1. This voltage is monitored during VCO calibration so that L1 may be properly set.

Q1 is a switch used to turn Q2 on and off. It is normally off, disabling the calibration oscillator.

During calibration, U6 tunes the VCO 10 kHz below the nominal center frequency of the I.F. The resulting detector output voltage is then sampled by the positive and negative peak detectors. The average value of these two readings is obtained (to remove any residual modulation effects from the calibration signal) and stored in a table within U3's RAM. The oscillator is then stepped up 1 kHz, and the process repeated. This continues until the VCO has been stepped from 10 kHz below to 10 kHz above the nominal center frequency of the I.F.

This 10 kHz range is beyond the useful range of most receivers and serves to compensate for the fact that the 8 MHz oscillator of U3 may not be exactly on frequency.

Power Supply

Incoming DC is applied to 5 volt regulator U1 (7805). Diode D1 provides protection from reversed polarity. Capacitors C1-C4 provide charge storage and help suppress oscillations by U1. Numerous bypass capacitors along with a four-layer PC board provide low-impedance power distribution for the various ICs in the DevMtr.

U11 (see Serial Port) provides + and - 9 volts for U7, allowing an inexpensive op-amp to be used with an assured positive voltage swing to +5 volts.

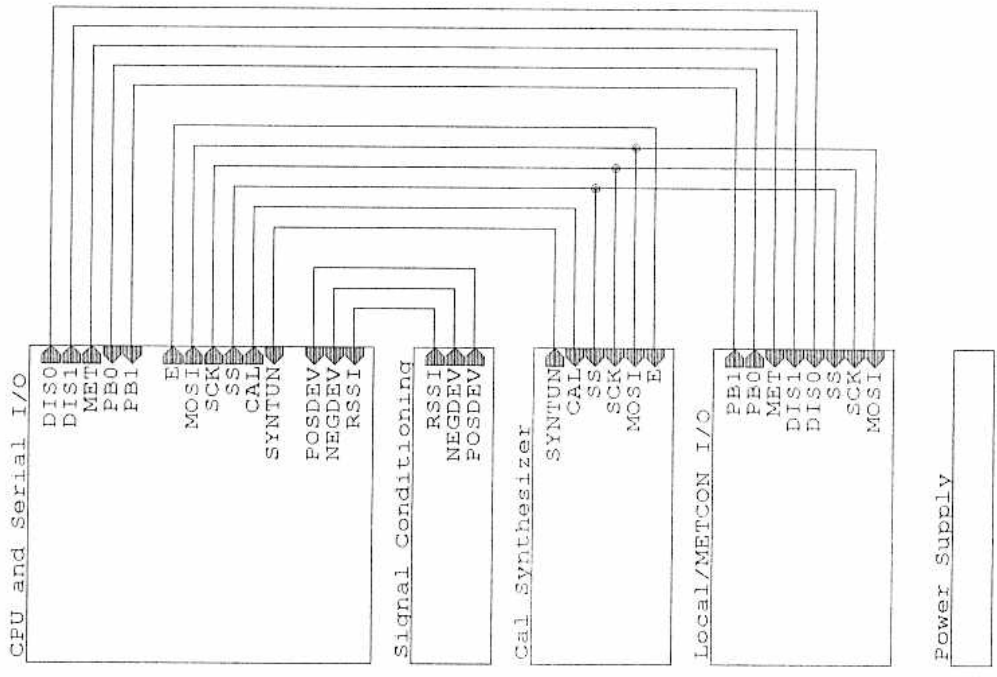
Jumper Functions

There are two (2) jumpers on the DevMtr, JP1 and JP2. They are connected to inputs to the programmable logic chip U5 (18CV8). They are presently **reserved** and should not be shunted. They may be used at a later date for special functions.

Notes

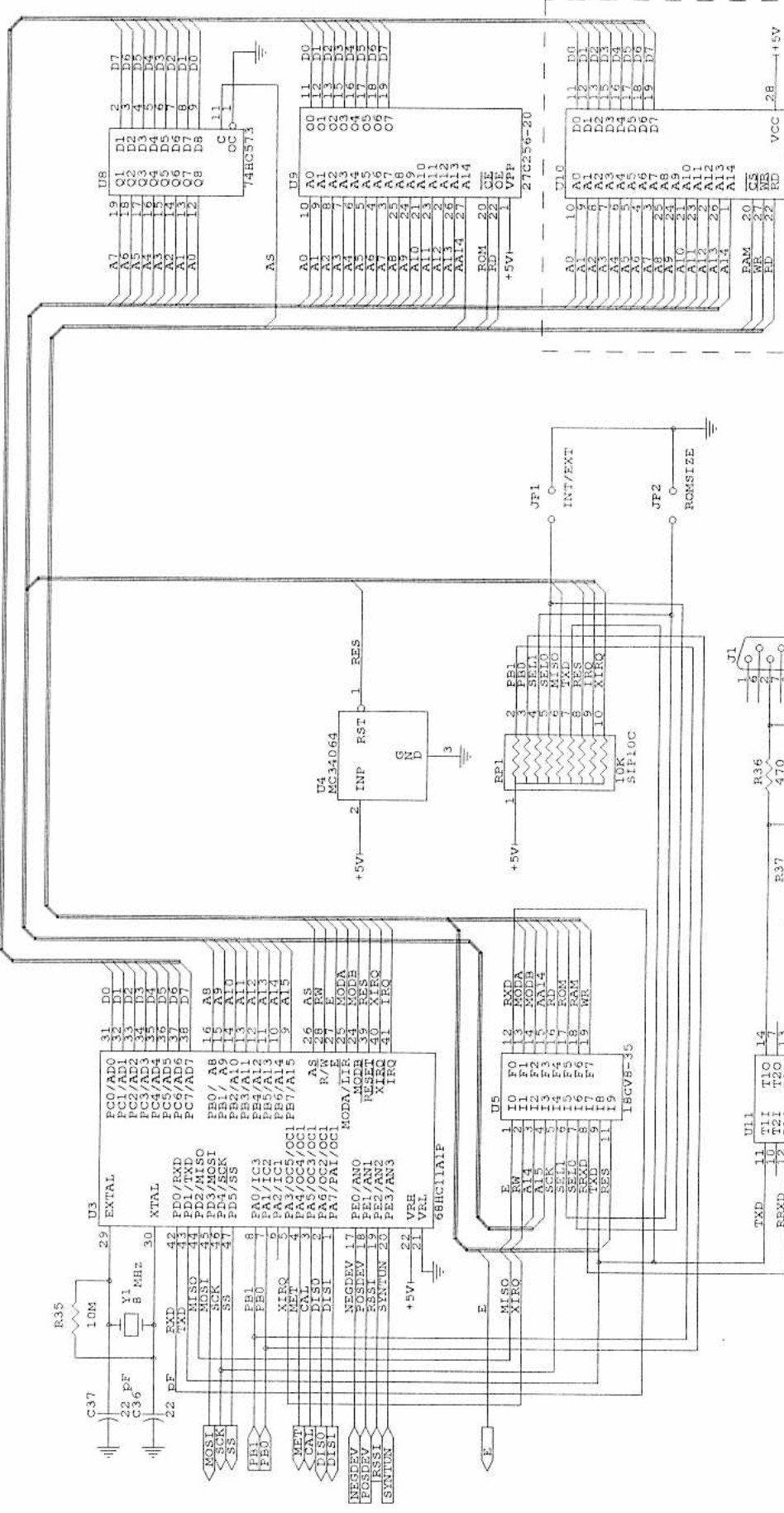
The TAPR DevMtr is an original design by Lyle Johnson, WA7GXD.

This manual was written by Lyle Johnson, WA7GXD.



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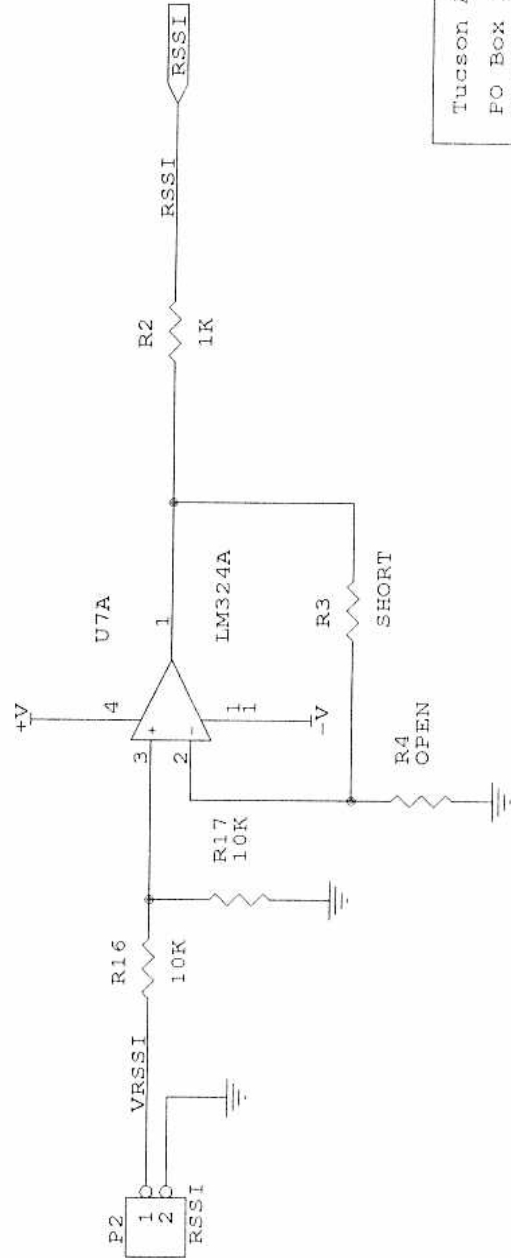
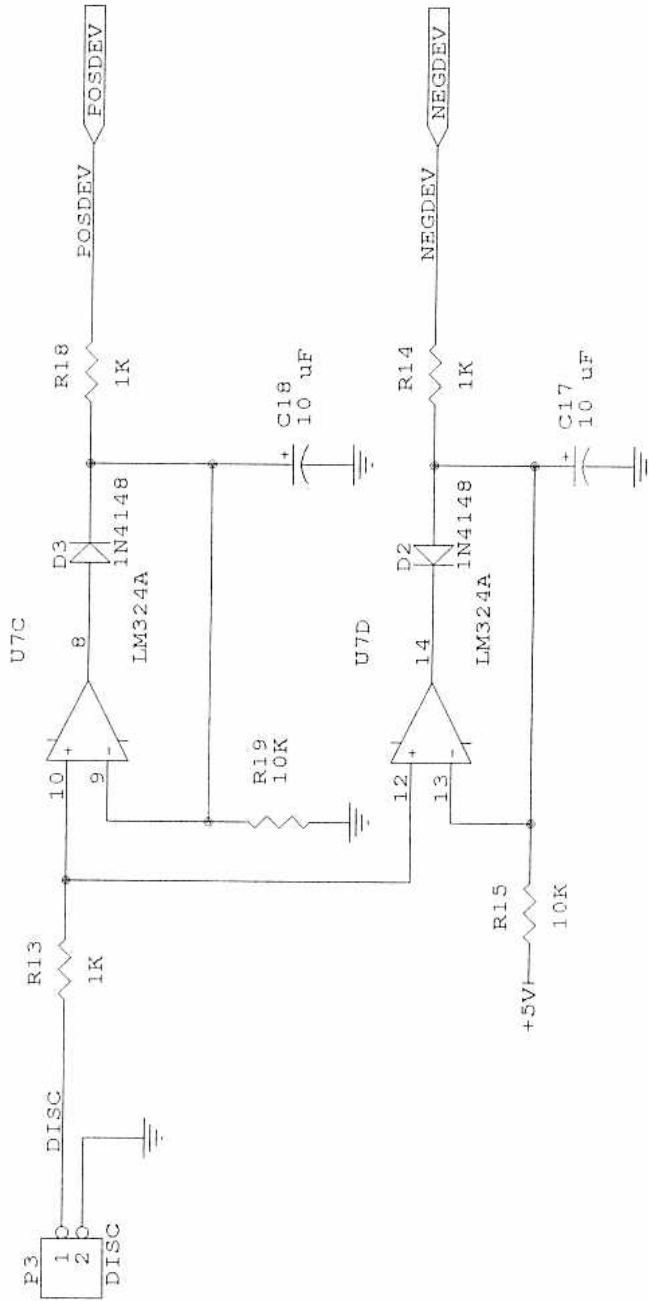
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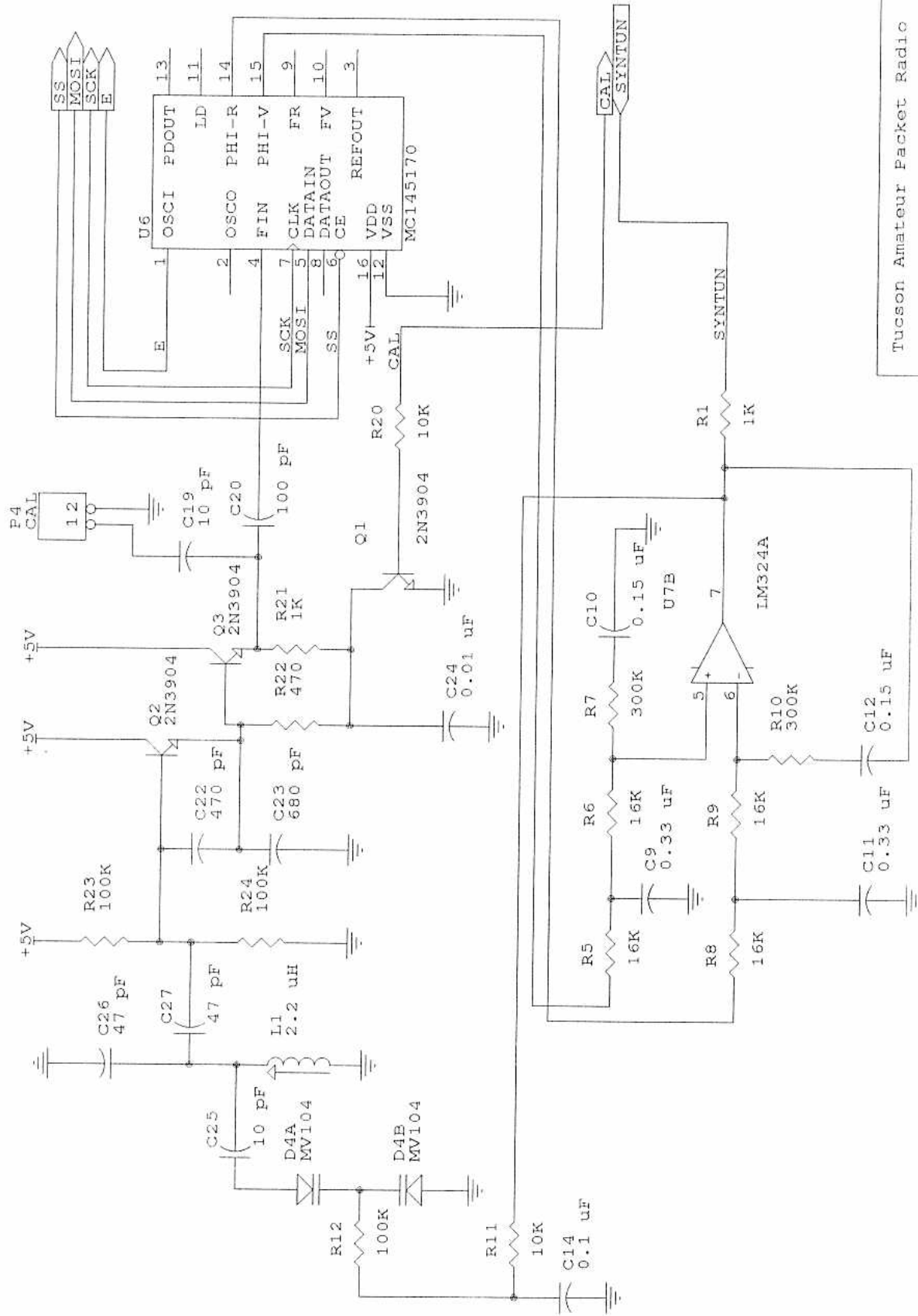
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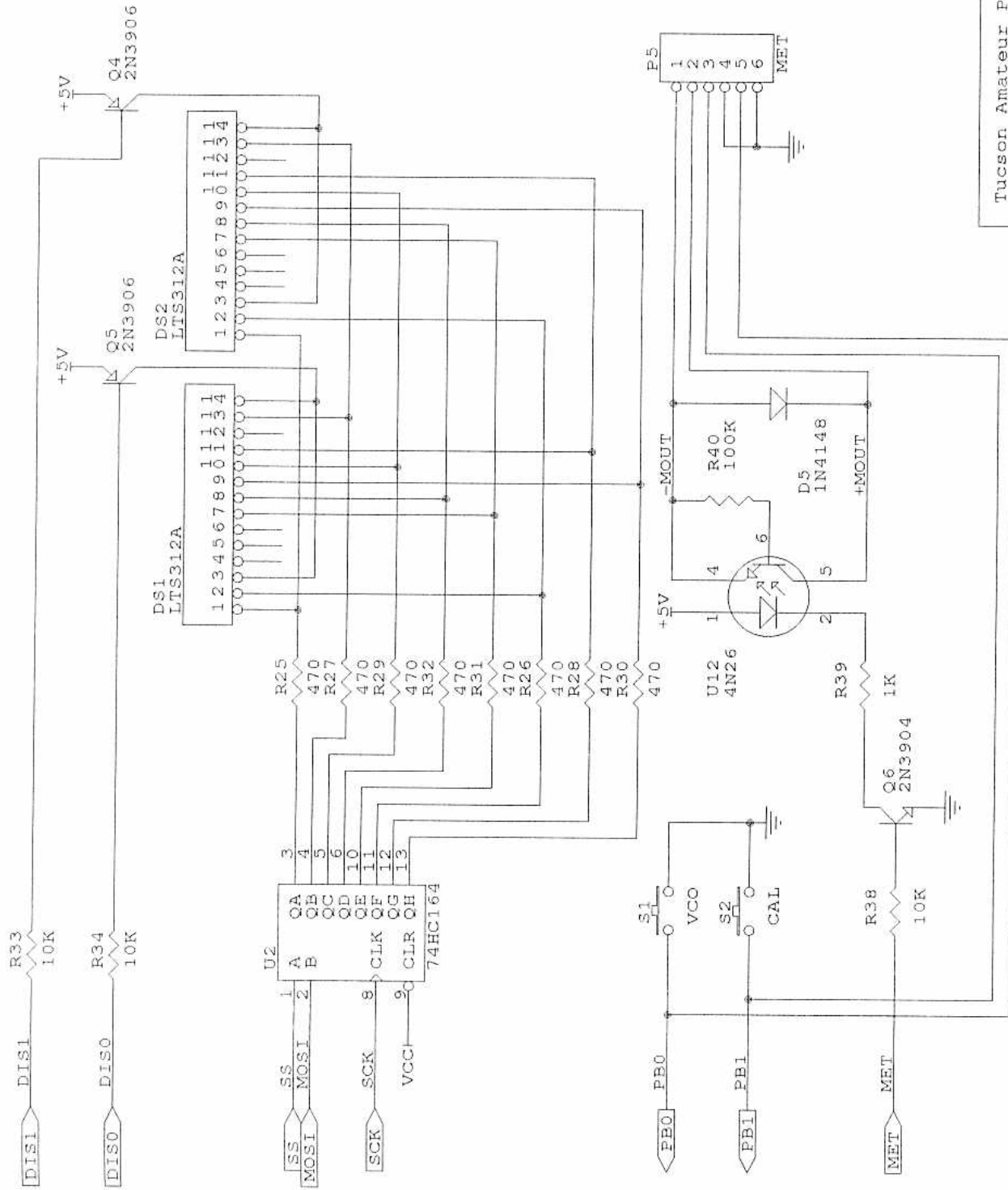
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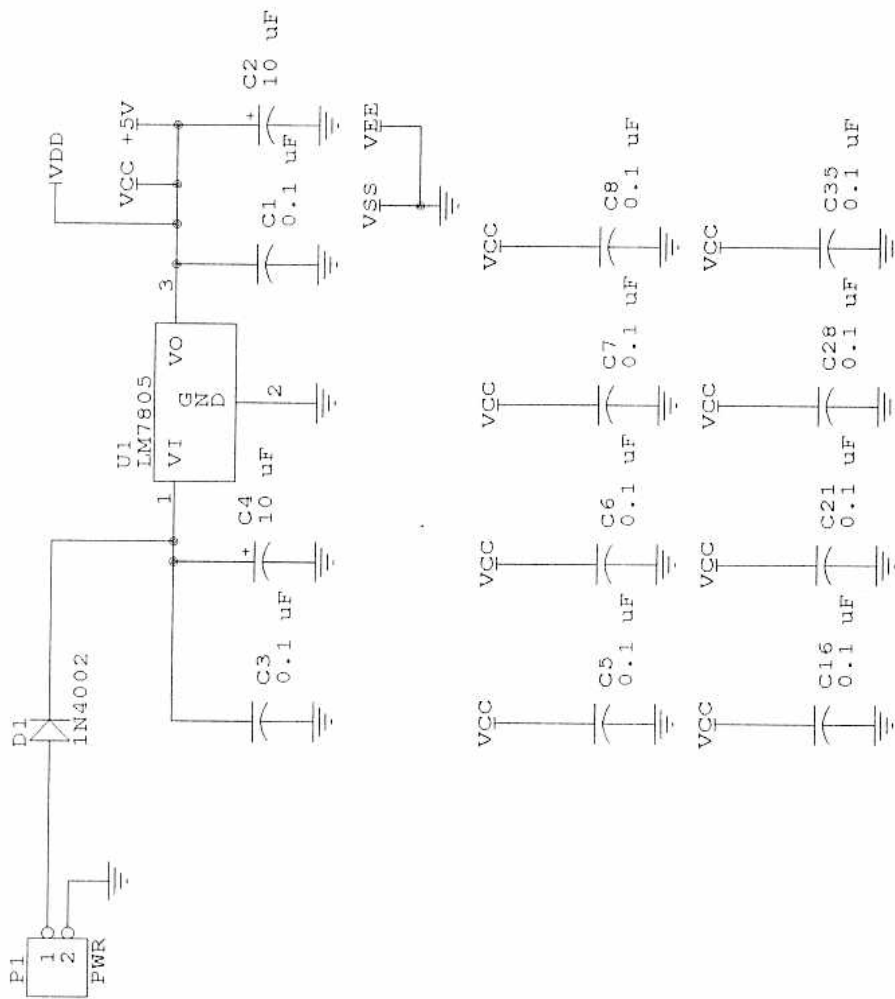
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DevMtr - Power Supply

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