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Non-Profit Research and Development
Corporation

T-238+
Modem

T-238+ Modem Assembly Manual

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Introduction

The T238+ modem board provides the hardware necessary for the T238 or T238+ to transmit APRS packets directly to a radio instead of requiring an external TNC. The board and the software on the T238 do not provide a full-featured TNC, just the basic functions needed to get your APRS packets on the air. While wired up to support data reception as well, no reception functions exist at this time.

Support for this board requires software revision 1.15 or later.

The modem board plugs into the 16-pin header on either T238. All power and control signals come from the main board. Connection to the radio is by means of a DE-9 connector.

The modem board has two LEDs to indicate the radio status, a red LED to indicate an active transmission, and a yellow LED to indicate incoming signal.

The modem assumes an active low transmit enable that can be a separate signal or combined with the transmit audio in the DE-9 connector. Audio level control is possible using a potentiometer.

While mechanically designed to mate with the T238+ as well as T238, this board can be used for any project wanting to add an MX-614 based modem to a project.

Acknowledgments

The Tucson Amateur Packet Radio T238+ Modem Kit was made possible by the efforts of (in alphabetical order):

William Beals, N0XGA - Conceptual Designer
Russ Chadwick, KB0TVJ - Conceptual Designer
John Koster, W9DDD – Project Manager

If you got this board as part of the T238+ kit, assemble the main board and button board and complete the checkout process for those boards first. Once verified, then build and verify this board.

T238+ MODEM BOARD

NOTE: Build and debug the T238+ main board before starting this board

PARTS LIST

The parts list is organized by quantity and part type. Verify that all parts are present by checking in the [ ] as you locate the part in the list. You may wish to take this opportunity to sort the parts into a compartmented container such as an egg carton or muffin tin as you inventory them. This will aid you in kit building.

Resistors ¼W, 5% Carbon Film:
[ ] {1} 100 ? (brown-black-brown-gold)   R110
[ ] {4} 1.2K ? (brown-red-red-gold)   R106,109,114,115
[ ] {2} 10K ? (brown-black-orange-gold)   R100,111
[ ] (3) 100K ? (brown-black-yellow-gold) R101,102,105

Resistors, ¼W 1% Carbon Film:
[ ] {1} 1.24K W (brown-red-yellow-brown)   R103
[ ] {1} 1.43K W (brown-yellow-orange-brown)   R112
[ ] {1} 3.48K W (orange-yellow-gray-brown)   R113
[ ] {2} 24.9K W (red-yellow-white-red)   R107,R108
[ ] {1} 511K W (green-brown-brown-orange)   R104

Resistor, Trimpot
[ ] {1} 10K ? Trimpot (103)   V100

Capacitors
Capacitors may be marked in various ways. The typical markings are listed but may vary. Find all that match and the remaining ones, if any, should become apparent by elimination.

Mylar or Monolithic
[ ] {2} 100pf (101)   C100,C111
[ ] {9} 0.1uf (106)   C101-107,109-110

Electrolytic or Tantalum
[ ] {1} 10uF   C108

Transistors
[ ] {1} 2N3904   Q100

Light Emitting Diodes
[ ] {1} Amber LED   D100
[ ] {1} Red LED   D101

Integrated Circuits
NOTE: Do not handle the ICs at this time! Carefully remove the black foam carrier with ICs from the bag and verify the ICs against this list. Do not touch the ICs! Leave them in the protective foam.

[ ] {1} MX-614   U100
[ ] {1} LM358   U101

Crystals
[ ] {1} 3.58MHz   X100

IC Sockets
[ ] {1} 16-pin DIP Socket   U100
[ ] {1} 8-pin DIP Socket   U101

Connectors
[ ] (1) 2x8-pin female header   P101
[ ] (1) DE9 Male PCB right angle mount   J4

Miscellaneous
[ ] (1) Printed Circuit Board (Rev A)
[ ] (1) Assembly Manual (this document)

Construction Notes

You are now ready to begin construction of the T238+ Modem. Follow these standard construction practices when building the unit.

Use a temperature-controlled, fine-tipped soldering iron of relatively low wattage (25 watts maximum, 15 watts is ideal) and a good quality 60/40 or 63/37 rosin-core solder for construction. Keep the tip of your soldering iron bright and clean, wiping it frequently on a wet rag or sponge. Make solder joints carefully, but swiftly. Prolonged heat on a PC board pad can be as disastrous as it can ruin the PC board. Two to three seconds should be enough time to apply heat to any joint. Due to the proximity of some of the traces on the PC board, solder bridges are a very distinct possibility. Following the important points above could eliminate several hours of troubleshooting (or worse). This is good practice when working on any kit.

You will need small flush or semi-flush cutting pliers and small-tipped long nosed pliers. A magnifying glass may prove helpful to identify the values of the small components.

Pay careful attention to the directions that follow:

1) Read this entire document prior to starting construction of your kit.

2) Identifying the pins on headers and ICs - Pin 1 is identified by the square pad on silk-screen.

Electrostatic Protection
The Integrated Circuits are susceptible to static discharge. Observe anti-static precautions when assembling the T-238+ Modem. Never handle the ICs without grounding yourself, the protective foam, and the PCB first. Always touch and hold the foam first before touching the IC. Always touch and hold the printed circuit board before inserting the IC into its socket. Never leave the ICs on anything but the foam or the PCB.

Construction

Refer to the layout diagram for clarification of parts placement. All references to up, down, left, and right assume that you are looking at the PCB with the text right side up. The DE-9 connector is at the bottom right. Sample construction pictures are also available on the T238 website.

Resistors

Resistors have a lead spacing of 0.4" and should lie flat on the PC board. You may wish to use a lead former to pre-form the resistor leads for neatest appearance. The 1% resistor have an extra band.

Install the following 5 resistors:
[ ] R100 10K ? (brown-black-orange-gold)
[ ] R101 100K ? (brown-black-yellow-gold)
[ ] R102 100K ? (brown-black-yellow-gold)
[ ] R103 1.24K ? 1% (brown-red-yellow-brown)
[ ] R104 511K ? 1% (green-brown-brown-orange)

WARNING! – Be careful when clipping leads, as they have a tendency to fly towards your eyes! Take appropriate precautions (grasp leads and wear eye protection).

[ ] Solder and clip the leads (10 leads total)

[ ] R105 100K ? (brown-black-yellow-gold)
[ ] R106 1.2K ? (brown-red-red-gold)
[ ] R107 24.9K ? 1% (red-yellow-white-red)
[ ] R108 24.9K ? 1% (red-yellow-white-red)
[ ] R109 1.2K ? (brown-red-red-gold)

[ ] Solder and clip the leads (10 leads total)

[ ] R110 100 ? (brown-black-brown-gold)
[ ] R111 10K ? (brown-black-orange-gold)
[ ] R112 1.43K ? 1% (brown-yellow-orange-brown)
[ ] R113 3.48K ? 1% (orange-yellow-gray-brown)
[ ] R114 1.2K ? (brown-red-red-gold)

[ ] Solder and clip the leads (10 leads total)

[ ] R115 1.2K ? (brown-red-red-gold)

[ ] Solder and clip the leads (2 leads total)

Now check your work. All leads should be soldered. There should be no solder bridges or cold solder connections.

[ ] OK so far.

This completes the resistor installation. You should have no remaining resistors.

[ ] No resistors remaining.

IC Sockets

NOTE: If any socket pins are bent, carefully straighten them with a pair of long-nose pliers before assembly. Some types of IC sockets have crimps in the pins to hold them in place when automatic wave soldering is performed. These sockets may be tricky to install if you are not familiar with them. If your kit contains these sockets, you may want to straighten the pins before attempting to insert them into the PC board.

When installing IC sockets double check to ensure that the socket is seated properly against the board with the notch matching the silk-screen. Pin 1 (nearest the socket notch) has a square solder pad. Be sure that all IC socket pins are showing on the solder side of the board. Next, tack-solder two diagonally opposite corners first (such as pins 1 and 8 on a 14-pin socket).

Then solder the remaining pins of that socket before proceeding to the next one. If you find a socket is difficult to install, remove it and double-check for a bent pin.

CAUTION! – Take care to avoid solder bridges!

Install the following IC sockets. Align the notch in the socket to the notch in the silkscreen outline:
[ ] U100 16-pin
[ ] U101 8-pin

Now check your work. All leads should be soldered. There should be no solder bridges (a blob of solder that shorts two adjacent soldered connections) or cold (gray and/or grainy looking) solder connections.

[ ] OK so far.

This completes the IC socket installation.

Ceramic Capacitors

All capacitors should be mounted as nearly flush to the board surface as practical without stressing the leads. Install the following capacitors:

[ ] C100 100pf (101)
[ ] C101 0.1 uF (104)
[ ] C102 0.1 uF (104)
[ ] C103 0.1 uF (104)
[ ] C104 0.1 uF (104)

[ ] Solder and clip the leads (10 leads total)

[ ] C105 0.1 uF (104)
[ ] C106 0.1 uF (104)
[ ] C107 0.1 uF (104)
[ ] C109 0.1 uF (104) (no C108!)
[ ] C110 0.1 uF (104)

[ ] Solder and clip the leads (10 leads total)

[ ] C111 100pF (101)

[ ] Solder and clip the leads (2 leads total)

Electrolytic and Tantalum capacitors
Electrolytic and Tantalum capacitors are polarized. The positive lead goes in the hole on the board marked with a "+". Be careful! Typically the negative lead is marked but sometimes the positive lead is marked.

NOTE: The orientation of the positive "+" leads are not all the same.

[ ] C108 10 uF (106 or 10uF)

[ ] Solder and clip the leads (2 leads total)

Now check your work. All leads should be soldered. There should be no solder bridges or cold solder connections.

[ ] OK so far.

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

[ ] No capacitors remaining.

Trimpot
Align the trimpot according to the three solder leads.
Note: the silkscreen is incorrect! It shows the small plastic tabs on the wrong side.

Install the trimpot:
[ ] V100 10K ohm

[ ] Solder and clip the leads (3 leads total)

Light Emitting Diode (LED)
LEDs are polarized components. The flat side on the base and the shorter lead identifies the cathode lead. Insert the LED according to the silk-screen outline, the flat side or short lead to the flat side of the silkscreen

NOTE – Mounting the LEDs on this board assumes you do not want to see the LEDs once the project is put in a chassis. If you want to see them after the project is in a chassis, save the LEDs and mount them to the chassis instead.

[ ] D100 Amber LED
[ ] D101 Red LED

[ ] Solder and clip the leads (4 leads total)

Transistor
Transistors have a flat side on the package. Insert the transistor in the board such that the flat side matches the silkscreen.

[ ] Q100 2N3904 Transistor

[ ] Solder and clip the leads (3 leads total)

Crystal

This crystal is a three-terminal device. Fortunately, orientation does not matter. Calling it a crystal is not quite correct, it is a ceramic resonator. It has most of the properties of a crystal except it is less accurate (but accurate enough), cheaper, and easier to use.

[ ] X100 3.58MHz Crystal

[ ] Solder and clip the leads (3 leads total)

Female Header

NOTE! The female header will be installed on the bottom side of the board! This is the header that plugs into the T238+, so it needs to be on the bottom of the modem board. Removing this part (if you put it on the wrong side) will be almost impossible without destroying the connector.

WARNING! – Do not hold these parts with your fingers while soldering. The pins get very hot.

[ ] P102 2x8 female header **ON THE BOTTOM**

NOTE: Only location P102 is stuffed at this time. P101 is in case there may ever be a "granddaughter" board.

Connectors

Install the DE-9 connector. Solder in the tabs that hold the connector in place first, then solder the pins.

[ ] J4 DE-9 female

[ ] Solder the leads

Almost done with the main board
At this point, these should be the only items left in the main board kit:

NOTE: Keep U100 and U101 in the antistatic foam

[ ] U100 MX-614
[ ] U101 LM358

Power Up And Initial Testing:

In this section you will slowly power-up the board and check for assembly errors. It is important that you follow these steps carefully. You will systematically apply power to sections of the board while checking voltages to find and eliminate errors. Errors take two forms, the kind that damage components and the kind that don't. Neither is desirable, but the kinds that damage components will require you to find a replacement part.

NOTE: - Before you power up the modem board, your T238+ main board should be constructed and fully checked out.

Pre-Power Check

Before applying power for the first time, please check the following:

[ ] ICs U100 and U101 are NOT installed.

[ ] Check the polarity of all the electrolytic or tantalum capacitors. The capacitors negative side is usually identified with a white stripe and a big minus sign on it. The positive side is identified on the PCB. Not all the capacitors have the same orientation; double-check them with reference to PCB silkscreen.

[ ] Check the polarity of the transistor, does the flat side on the part match the silkscreen on the board?

[ ] Headers P100 and P101 are not connected.

[ ] Header P102 is installed on the BOTTOM of the board.

[ ] Plug the modem into the T238+. Take care to make sure there are no components from the T238+ touching the bottom of the board. Use the screws and spacers to ensure a good fit for the board.

[ ] Apply power to the T238+. Observe anything unusual such as components heating up, smoke or smell. Remove power immediately if anything unusual appears.

Place the ground lead of your voltmeter on pin 4 of U101. This will be the ground reference for the rest of the measurements.

NOTE – In the sections below, there are frequent references to +5V, which actually means the voltage between 4.90V and 5.10V.

With the ground lead of your voltmeter still on U101 pin 4, confirm all the following test points also measure +5V. Remedies are listed if you do not see +5V.

Check	Pin	Remedy if not +5V
[ ]	U100 pin 16	Check socket.
[ ]	U101 pin 8	Check socket.
[ ]	P100 pin 9	Check connector

[ ]	P100 pin 6	R109, D101, Q100.

[ ] Check the positive pin of C108. It should be between 2.45 and 2.55V. If not, check R114, R115, C108 (polarity), C109, R112, R113.

Using a small wire bent in a U-shape, short between U100 pins 14 and 16. Do this carefully so you don't damage the IC socket. The amber "BUSY" LED should light. If it does not, there is a problem with R106 or more likely, the LED is installed backwards.

[ ] Amber LED works

Using a small wire bent in a U-shape, short between U100 pins 3 and 16. Do this carefully so you don't damage the IC socket. The red "XMIT" LED should light. If it does not, there is a problem with R111, R109, Q100, or the LED is installed backwards.

[ ] Red LED works

[ ] Remove power from the T238+.

Next you will insert U100 and U101. Make sure you match the pin-1 notch of the device to the notch on the silkscreen. It can be difficult to line the pins up with the socket. Your best bet is to place the chip sideways on a flat static-safe surface so that one row of the pins all lie flat on the surface. Carefully rotate the body of the IC while pushing down on the pins. Rotating while pushing down should bend all the pins together and bend them where they protrude from the body. Bend the pins a little at a time, then check to see if they are perpendicular to the body of the IC. Once perpendicular, the pins of the IC will be much easier to insert as they line up with the socket.

Insert U100 and U101 slowly. Observe that all the pins slide into the socket. Watch for pins that bend under the IC or out of the IC socket.

[ ] Insert U100, MX-614.

[ ] Insert U101, LM358.

[ ] The notch on the chip is aligned with the silkscreen notch on the PCB.

[ ] Apply power to the T238+. The red LED on the main board or button board should still flash three times quickly, and after approximately 10 seconds it should start flashing once per second.

If the LED does not flash at all, remove the modem board to confirm the LED works OK without the modem board installed. If it does, check the modem board for short circuits, especially between the connector and MX-614.

[ ] LED flashing approximately once per second

With a the ground lead of your voltmeter on pin 4 of U101, check the following voltages:

Check	Pin	Voltage	Remedy
[ ]	U101 Pin 8	+5V	Check IC socket
[ ]	U100 Pin 16	+5V	Check IC socket
[ ]	C8, + pin	2.5V	R114, R115, C108, C109, R112, R113.

[ ] Remove power from the T238+.

CREATING YOUR RADIO INTERFACE CABLE

Four signals are provided on the DE-9 connector, a digital active-low PTT signal, Receive Audio, an AC-coupled Transmit audio, and finally a "just in case" +5V. Five pins (#1-5) are all ground.

Refer to your radio's manual to determine the signaling required to control it from the T238+. While fairly consistent, there are two major ways radios expect control signals for enabling PTT (Push To Talk). One class has separate wires for audio and a "digital" PTT signal. The PTT is invariably active low. The second class combine these two signals onto one wire by having the audio AC-coupled and combined with a DC offset to signal if PTT is active or not.

If your radio is the type that has separate signals, both are provided on separate pins of the DE-9 connector. If your radio requires combined signals, you will need to tie the PTT and TX_AUDIO together with a resistor. The value should be recommended by your radios operator manual and is not provided with this kit. The signals can be combined inside the header or on the main board, whichever is more convenient. The audio is AC-coupled which works with both types of radios.

When building your interface cable, remember that this will be carrying very low level audio signals and will likely be in a high RFI environment. Keep the cable as short as possible, use shielded cable if at all possible and make sure ground connections are solid.

Testing of the modem functions requires the T238+ be fully programmed for modem use and is covered in the T238+ operations Manual.

Congratulations!

You have completed the power-up and initial testing phase! To learn how to setup and operate your T238+ APRS™ 1-Wire™ Weather Station, please refer to the T238+ Operations Manual. It is available on the T-238 web site at

http://www.beals5.com/wx
or
http://www.tapr.org/taprf/html/Ft238.html