HOW THE SOLID STATE MORSE TERMINAL UNIT OPERATES

By Ed Trump

It may be of help to study the exact operation of the various parts of the solid state terminal circuit. This information will be valuable for trouble shooting a terminal unit that is not working properly.

The following discourse assumes that a call is already connected and that a dial-up session is in progress, with the modems at each end of the telephone circuit properly passing the AFSK (Audio Frequency Shift Keying) signals between them.

Refer to the schematic diagram of the solid state Morse terminal unit shown at the end of this document.

The received Morse signal from the distant dialup office is converted by the modem to a "polar" dc voltage that appears on pin 3 of the EIA 25 pin modem connector. This voltage is about 10 volts negative with respect to common (pin 7) when the far end key is closed, and about 10 volts positive with respect to common when the far end key is open. You can measure this at pin 3 with a voltmeter.

This polar voltage change is applied to pin 2 of U1A, which is part of the dual solid state operational-amplifier chip. In this case the U1A section is used simply as an inverter and the output at U1A pin 1 is opposite in polarity to that of the input applied to U1A pin 2.

That is, when the voltage at pin 2 of U1A from the modem is "positive", the output at pin 1 of U1A is "negative" with respect to circuit common, and vice versa, when the input at U1A pin 2 goes "negative", U1A pin 1 goes "positive.

The polar voltage output of U1A pin 1 is applied via a 2.2k ohm resistance to the base of the loop keyer transistor Q1. Notice there is a 1N914 diode connected from the base of the keyer transistor to common. This serves to prevent the voltage presented at the base of Q1 from going very far in the negative direction. If it were allowed to, it would destroy the keyer transistor. The 2.2 K resistor acts as a load for the output of the op-amp U1A, and when the voltage at pin 1 goes "negative" the diode across Q1's base shunts it to common. When the voltage at U1A pin 1 is "positive" it causes Q1 to saturate, and closes the loop circuit from collector to emitter, the emitter being tied to common. Q1 is then just acting as a switch in the loop circuit that is controlled by the incoming signal applied to its base after being processed to the proper polarity by U1A.

Although not shown in the diagram, there should be a diode connected "in reverse" (that is, diode cathode to collector, diode anode to emitter) across the collector-emitter pins of Q1. The purpose of this reverse-connected diode is to shunt to ground (when Q1 opens the loop) the reverse current produced by the collapsing magnetic field in the telegraph instrument windings. The high resistance mainline telegraph instruments most of us use with these converters has a large reverse current kick when the circuit they are in is opened, so we need to protect Q1 from being damaged by it. That is what this diode is for. The circuit will work without it, but Q1 may be destroyed at any time by a reverse current surge, and it is best to include this protection diode to prevent any possibility of it.

Look at the circuit from the collector of Q1, and you will see there is another diode in series with the telegraph loop circuit. This diode plays a critical role in the prevention of "reflections" or "kickbacks" from the terminal back over the circuit to the distant office. In the loop circuit, as long as the telegraph key is closed, "positive" loop voltage supply is connected via the key, sounder coil windings and loop resistors thru this series diode to the collector of Q1. When Q1 is conducting and holding the loop closed, there is about 0.7 volts drop across the collector/emitter junction of Q1, and also there is about 0.7 volts drop across the series diode in the loop circuit. With loop closed and current flowing, then, there is about 1.4 volts "positive" at the junction of the series diode anode and the loop resistor in the telegraph loop. When Q1 opens the loop circuit, current flow ceases, but the voltage potential at this junction of the loop resistor and the series diode anode rises to the value of the loop supply voltage. As long as the key in the telegraph loop remains closed, the voltage at the junction of the series diode and the loop resistor ALWAYS remains at some "positive" value. It fluctuates between about 1.4 volts "positive" when the loop is closed to about 25+ volts "positive" when the loop is opened by the keyer transistor Q1, but always remains "positive" in potential with respect to common. You can measure this voltage fluctuation with a voltmeter.

We use this constant "positive" voltage to "clamp" the transmit portion of the terminal set in the "mark" or "closed circuit" state back towards the distant office by sampling the voltage via a 10k ohm resistor that is connected to pin 6 of U1B. Notice there is a 1N914 diode also connected between pin 6 of U1B and circuit common. This diode clamps the positive voltage sampled from the loop via the 10 K resistor to no more than about 0.7 volts "positive" regardless of whether the local telegraph loop is opened or closed by Q1. As long as the telegraph key in the local circuit is closed, the voltage at pin 6 of U1B will never vary from about 0.7 volts "positive". You can measure this with a voltmeter. Pin 6 of U1B is the "inverting input" of the "B" op-amp section of U1. Pin 5 of U1B is hard wired to common and remains at "zero" volts all the time. The voltage at pin 6 of U1B then controls the output of U1B at pin 7. When the voltage at pin 6 is at "positive" 0.7 volts, the output of U1B at pin 7 is about 10 volts "negative" with respect to common. This "negative" voltage is passed to the modem via pin 2 of the EIA 25 pin connector, and results in a "closed circuit" or "marking" tone frequency being sent to the distant office. This should ALWAYS be so unless the local telegraph key is opened. The voltage at U1B pin 7 should NEVER vary from about "negative" 10 volts or so when the set is receiving from the distant office, and the local telegraph key is closed.

When the local telegraph key is opened, the "positive" telegraph loop supply voltage is removed from the loop circuit. There is a 22k ohm resistor connected from $-V_S$ (about -12 volts, Integrated circuit supply) to the junction of the loop resistor and the series diode discussed above. This serves to drive the voltage at pin 6 of U1B hard in the "negative" direction when the local telegraph key is opened. With a "negative" potential at pin 6 of U1B, it's output at pin 7 goes to about 10 volts "positive" . This transition from "negative" 10 volts to "positive" 10 volts is the "polar" EIA signal that is passed via pin 2 of the modem 25 pin EIA connector and is what causes the AFSK signal being sent towards the distant office to change from "marking" to "spacing" and so on back and forth between the "closed circuit" and the "open circuit" state.

So, as the local telegraph key is opened and closed, the output at pin 7 of U1B towards the modem is controlled in response to the Morse being sent by swinging from minus 10 volts to plus 10 volts.

Some other information about the operation of this circuit...

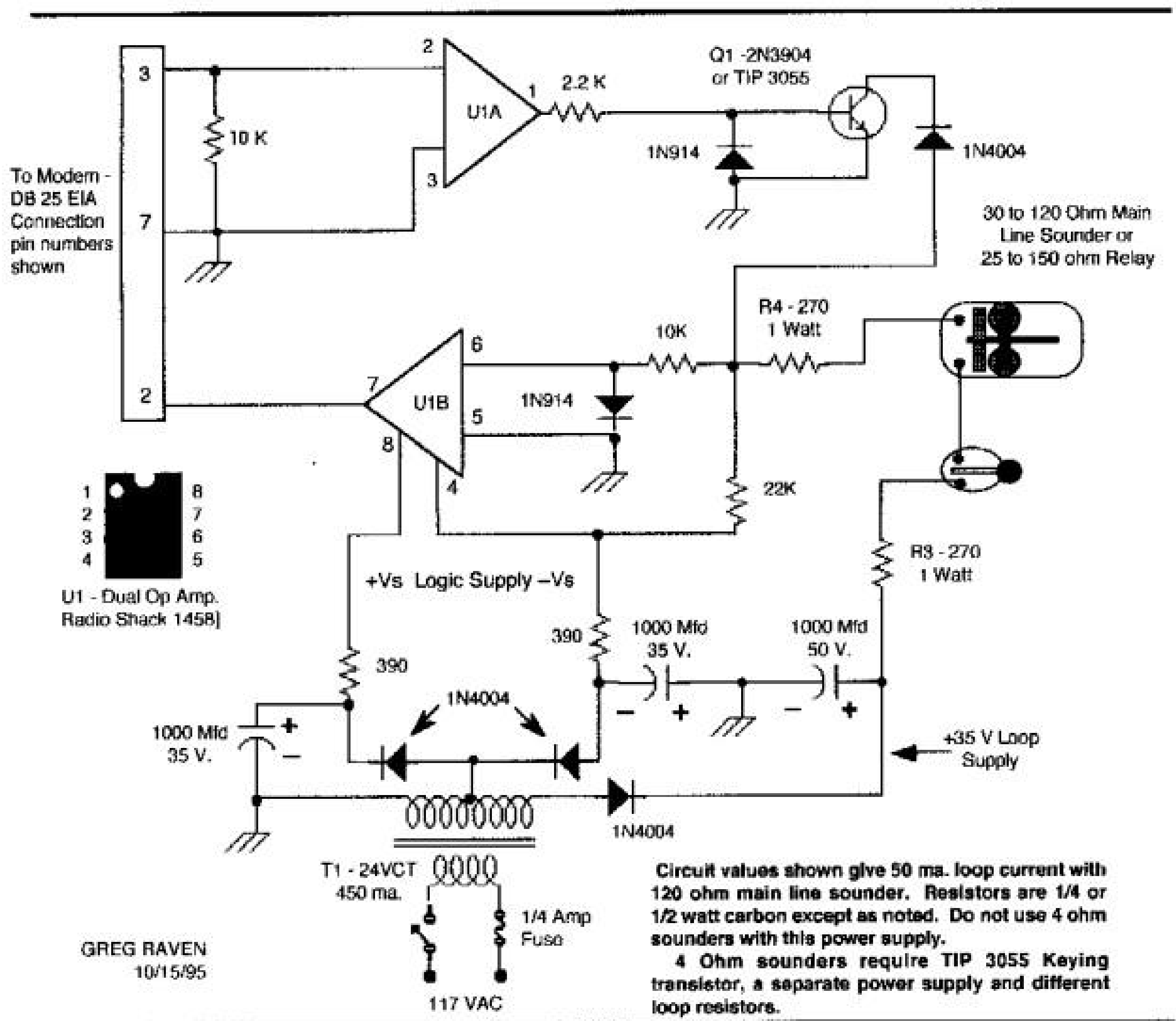
Notice that the telegraph key controls the transmit portion of the circuit regardless of the state of Q1. This provides a means of "break-in" to alert the distant office that you have opened the circuit. When you hold your key open, the distant operator's sounder should stop responding cleanly to his own sending and after a bit of practice he will be able to recognize that you "broke" him.

These sets do not really "break" cleanly. When receiving an "open" circuit state from the far end, the near end sounder will try to pull in but then falls open and does not follow the key correctly. Therefore, a little vigilance is necessary to detect the "break" from the far end.

If you are working into a hub dialup repeater, some hubs will return a "reverse" to the sending operator when someone on one of the legs on the opposite side of the hub "breaks". Again, a little vigilance will be required to recognize this and close your key to allow the breaking operator to send. The sounder will keep clattering while you send but will not follow cleanly, so you need to watch for this and learn how to recognize it.

Morse Telegraph Club, Inc.

Trump-Raven 2-Wire Solid State Dial-up Morse Terminal



Circuit values shown give 50 ma. loop current with 120 ohm main line sounder. Resistors are 1/4 or 1/2 watt carbon except as noted. Do not use 4 ohm sounders with this power supply.

4 Ohm sounders require TIP 3055 Keying transistor, a separate power supply and different loop resistors.