HAMTRONICS® TD-4 SELECTIVE CALLING UNIT AND ECONOMY DTMF CONTROLLER ASSEMBLY, INSTALLATION, OPERATION, AND MAINTENANCE

TABLE OF CONTENTS

GENERAL DESCRIPTION.

The TD-4 Selective Calling Module is an economy touch-tone decoder with one latching output. This versatile module is primarily designed to mute the speaker of a receiver or transceiver until someone calls by sending a 4-digit dtmf signal, thus making it unnecessary to listen to all the activity on a channel just so someone can call you once in awhile. When the proper dtmf digits are received, the speaker is unmuted and an LED is illuminated to let you know a call was received. When you are done listening, a pushbutton switch (not supplied) is pressed to reset the latch and mute the speaker until another call is received. The latch may also be reset by another dtmf command.

The TD-4 also may be used as a simple dtmf decoder/controller to turn on an autopatch or any other single device which requires a simple ground to activate it. It may be used with the AP-3 Autopatch module, for instance, but it would not provide toll call restriction and tone muting as the more elaborate TD-2 DTMF Decoder/Controller Module does.

The 4-digit dtmf address is easily set in the field with wire jumpers. The 2¾ inch square pc board is easily packaged for custom installations, and it operates on 7-14Vdc at only 10-15mA. Low power consumption is made possible by the exclusive use of CMOS ic's.

The TD-4 uses a central-office quality dtmf decoder ic with built-in anti-falsing circuits. It automatically accepts any audio source from 100mV to 2Vp-p. No alignment is required.

The latch output is an open collector npn transistor, which can ground any dc circuit up to 15Vdc and sink up to 50 mA. This can be used, in the case of a selective calling application, to ground an audio line to mute it or operate a small relay in series with an external speaker on a receiver. In the case of controlling another module, like an autopatch, usually you can use the output transistor directly to ground a control circuit on the target module.

PC BOARD HANDLING PRECAUTION.

Be careful whenever you handle the module or any of the ic's. Even though static damage occurs most easily before ic's are installed in their sockets, damage can still occur to the ic's in a completed module if a static discharge occurs at any part of the board during handling. Although wrist straps are not absolutely necessary just to handle the completed board, you should make it a habit of discharging your hand to a grounded object before touching a CMOS module.

CONSTRUCTION.

The pc board is double-sided with plated-through holes. Because it is more difficult to unsolder from this type of board, be sure parts are oriented properly and of the correct value before soldering. Pc traces are close together, so use a fine soldering iron tip.

During construction, orient the board right side up as shown in the component location diagram. The top side as shown has the pin number

markings. Also refer to the parts list and schematic diagram during construction.

☹ *The CMOS ic's used in this kit are all static sensitive; so handle them with care. A grounded wrist strap should be worn whenever you pick up an ic. Do not open the packages containing the ic's until you are ready to install them, and then handle them only with suitable static control measures.*

a. Install ic sockets oriented with notches as shown, and solder.

b. Install led's DS1 and DS2 on the board, observing polarity. The anode (positive) lead is longer.

☹ *Small LED's are heat sensitive. Keep the LED's up off the board about 1/4 inch and solder quickly, applying minimum heat to avoid damage.*

c. Install electrolytic capacitors, observing polarity. Longer lead is positive.

d. Install Q1 and U5, observing orientation.

e. Install diodes CR1-CR3, observing polarity. Vertically mounted parts are illustrated with a circle indicating the body of the part, and the diode symbol next to CR2 on the diagram indicates the polarity. End of diode body with band is cathode and should be toward board when oriented as shown.

f. Install resistors.

g. Install the remaining parts other than the dip ic's, according to the parts list.

h. Check over construction to be sure all parts are installed in proper places and with proper polarity and that solder connections are good. Look for things like cold solder joints and solder splashes. Programming wires will be installed later.

i. Using static protection described earlier, carefully unpack the dip ic's and install them in the sockets. Be sure to orient them as shown, according to notch on the end of each ic. Be careful to engage all the pins in the socket; don't let any leads bend over.

j. Refer to the PROGRAMMING section below to determine jumper wires which must be installed. Wired and tested units are factory-wired with jumpers as shown in the detail drawing above the component location diagram.

INITIAL TESTING.

Although it is not necessary, you may wish to test the tone decoder portion of the board before you proceed with programming. To do so, connect a power supply ground to the ground trace at one of the four corners of the board, and connect +10 to +15 Vdc to the power input at pad E3. Connect a source of touch tones to audio input pad E1, with a level between 100 mV and 2V p-p. The outputs at the three rows of programming pads noted as "decoder outputs" in the component location diagram should have a CMOS logic level (lo close to 0 or hi close to +5V) with the hi corresponding to reception of a valid touch tone digit. You can test all 16 decoder outputs to verify that they respond to corresponding dtmf digit commands.

PROGRAMMING.

How To Program.

Regardless of what the TD-4 is to be used for, it must be programmed to respond to a particular set of dtmf commands. Normally, this will be a four digit command to turn on the output (set the latch) and a similar four digit command to turn off the output (reset). The first three digits are the same for both commands and the fourth digit determines whether it turns on or off.

There is an option to use fewer than four digit commands. This is covered in the next section in order to keep the following discussion simple.

Programming is done by soldering short jumper wires between the desired "decoder outputs" and the "latch inputs". This is easy to visualize if you compare the schematic diagram with the component location diagram. Take a minute now, and do that before reading further.

Now, look at the three rows of decoder outputs surrounding the U2 "16-line decoder" chip in the component location diagram. Those 16 output pads provide connections to the outputs corresponding to the 16 possible digits on a full dtmf pad. The five "latch input" pads, in the second row below U2, are the five inputs which need to be programmed. A jumper wire from each of these five pads is required to be connected to one of the "decoder outputs" above.

Following is an example of the codes established to set and reset the latch, as used in the example illustration shown above the component location diagram. In this example, we used the code "123✻ " to turn on (set) the latch and "123#" to turn off (reset) the latch. As you see, the same first three digits are used to turn it on and off. Only the fourth digit is different.

Example Programming Codes

DIGIT	1	2	3	4S	4R
SET CODE	2	1	3	✻	
RESET CODE	2	1	3		#

Although you can use any digits you want, there are a few guidelines to make it easier.

First, you should consider the first three digits as your personal code, unique to your application. These digits should prevent the circuit from responding to anyone else's codes or random dtmf tones the receiver might hear on the air. These are the same three digits in both the on and off commands.

Second, the same digit should not be used for two consecutive latch inputs because both would be triggered at once. Use a different digit for each latch input.

The last digit of each command should be something logical to indicate on or off, something easy to remember. One common practice in many dtmf operated devices is to use ✻" for "on" and "#" for "off". This is why we chose the example codes as we did. They are also digits which are not used in telephone numbers; so it prevents your unit from responding to a series of dtmf digits used as part of a phone number someone is dialing for an autopatch.

Finally, remember that the "set" and "reset" functions are named relative to the active state of the output transistor, i.e., "set" makes the output transistor turn on and "reset" makes it turn off. When planning your programming, take into account how the output transistor is to be used. In a selective calling application, for instance, setting the latch will normally mute the receiver and resetting it will allow you to hear the receiver. In a case such as this, you will want to program the "reset" function (not "set") to allow the receiver to be unmuted with a dtmf command; so don't let that confuse you.

Following is a blank table you can fill in with the codes you choose. The dashes prevent entering a digit where

inappropriate for each command, the fourth set digit being different from the fourth reset digit. The X's on the reset line indicate that the same digit is used for reset as was already programmed for the set function; so it is not necessary to enter anything for the first three digits of the reset command.

My Programming Codes					
DIGIT	1	2	3	4S	4R
SET CODE					—
RESET CODE	X	X	X	—	

Once you have planned the codes to be used, you can solder jumper wires on the board. Depending on the location of the decoder output pads needed for any given jumper, the length of the jumper can be determined. A convenient length for jumpers that must span the width of ic U2 is 2 inches. For jumpers which don't need to cross the ic, shorter jumpers may be used, about 1 inch long. The ends of the jumper wires should be stripped 1/8 inch, inserted into the pads, and soldered under the board. Check the location of each jumper before it is soldered.

Programming Options.

Normally, four digits are used in each command; however, modifications can be done to allow operation with fewer digits. Here are the options.

To use three digits instead of four for the set and reset commands, connect latch inputs 1 and 2 both to the same decoder output pin. For example, if you want to use the codes "13*" and "13#", connect latch inputs 1 and 2 to the decoder output for the digit "1". That way, the first digit will trigger the first two latch inputs simultaneously. Latch input 3 will be jumpered to decoder output "3", latch input 4S will be jumpered to decoder output "*", and latch input 4R will be jumpered to decoder output "#".

To use only 2 digits instead of 3, a similar trick is used. The first three latch inputs are all connected together to the decoder output for the first digit. The 4S and 4R latch inputs are each connected to their corresponding decoder output digits.

To use a dtmf command to set the latch and use only a local pushbutton switch to reset the latch, as might be done in a selective calling application, jumper latch input 4R to ground. This must be done because it is not a good practice to leave cmos gate inputs unterminated. Because of their high input impedance, the voltage at the input gate would float up and down, causing erratic operation.

To use only one digit commands, unplug U3 so it is out of the circuit. Jumper the decoder output digits that you will use for set and reset directly to E6 and E5 at the left edge of the board.

INSTALLATION.

☹ *Be careful whenever you handle the module. Even though static damage occurs most easily before ic's are installed in their sockets, damage can still occur to the ic's in a completed module if a static discharge occurs at any part of the board during handling. Although wrist straps are not absolutely necessary just to handle the completed board, you should make it a habit of discharging your hand to a grounded object before touching a cmos module.*

Mounting.

The board should be mounted to chassis with 4-40 standoffs about 3/8 in. long in the four corners of the board.

Placement of the board is not critical, but the board should not be mounted in a strong rf field. In a repeater, the transmitter already is shielded; so usually, you don't need to do anything special.

Power.

The unit is designed to operate on +7 to +14Vdc at about 10-15 mA. The low power consumption is due to the CMOS circuitry. A voltage regulator on the board takes care of voltage variations within the range specified, but be sure you use filtered dc power and don't allow any spikes or reverse polarity to be applied. The positive power supply connection should be made to pad E3 on the TD-4 board.

Be sure to get a good dc and signal ground through the mounting hardware. (If you cannot get ground connection through the hardware, connect a ground wire from your power supply to pad E2 on the board.)

Tone Inputs.

The range of audio tone levels which the tone decoder ic will accept is 100 mV to 2V peak-peak. Audio can be applied from any source, including radio receivers, and telephone lines (with some sort of interface such as an autopatch board). The audio source must be referenced to ground.

Check to be sure that your source is compatible. If not, some adjustment will have to be made. If you cannot alter the level from your source to within this range, you may be able to change the sensitivity of the tone decoder to some extent. See the CUSTOMIZING section later in the manual.

If you interface with our AP-3 Autopatch Board, you don't need to be concerned about compatibility. The tones for the TD-4 should come from E8 on the Autopatch Board.

If you are using the TD-4 as a selective calling unit, see the section on Selective Calling Applications later in this manual.

Local Switches.

If you want to use a pushbutton switch to allow manually setting or resetting the latch, wire it as shown in Figure 1. For example, in a selective calling application, it makes sense to use a dtmf command to trigger the "reset" input to open the squelch so you can hear the message the person calling you transmits. However, you probably will want to close the squelch by setting the latch in the TD-4 manually with a little pushbutton switch installed on the case you mount the TD-4 in. You might also want to be able to open the squelch manually to monitor; so it also makes

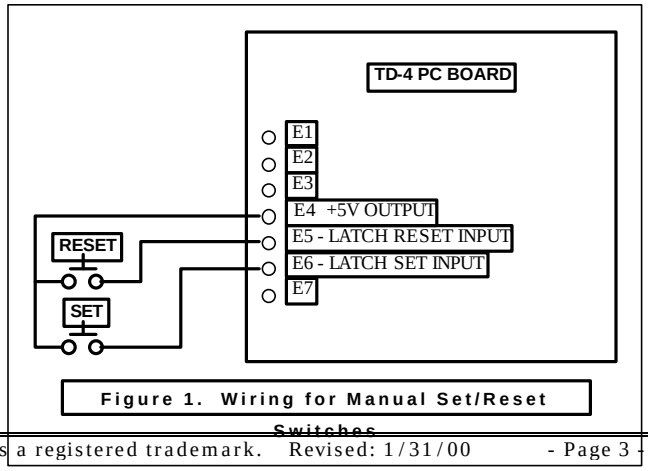


Figure 1. Wiring for Manual Set/Reset Switches

sense to have a second pushbutton switch for the "set" function, even though that function would be done by dtmf command most of the time.

Latching Output Transistor Circuit.

The output transistor Q1 can be used to drive solid state circuits directly, and it can drive small relays to switch power loads. The output transistor can sink loads up to +15V and 50 mA. An example of using the TD-4 to turn on a dc circuit directly would be using the output transistor to ground a control terminal on our AP-3 Autopatch module to activate the patch.

☹ *If you drive an inductive load, like a relay coil, be sure to connect a diode with reverse polarity across the load to absorb any inductive spikes which could damage the transistor.*

If you are making a selective calling device, refer to Selective Calling Applications, which follows.

Momentary Outputs.

In some applications, you may need just a momentary logic output and not a latching output. Outputs at various points in the logic circuits can be used externally, providing not too much load current is drawn. These are cmos ic's; so the available output current is only about 500µA. This is sufficient to turn on a small signal transistor if you put a resistor in series with the output voltage going to the base of the transistor. The resistor should be 47K or greater.

One option available is to use the decoder outputs for individual dtmf digits directly from the output of 16-line decoder U2. These are accessible on pads surrounding U2, as shown in the component location diagram.

Another option is to use the logic result of the four-digit logic circuits, which are provided by U3 (see schematic). In this case, the "set" and "reset" outputs of U3A and U3B are available on pads E6 and E5 at the left edge of the board.

LED Indicators.

There are two led's on the board, which indicate the status of the various circuits. DS1 is illuminated whenever a valid dtmf signal is received. DS2 indicates when the output circuit is turned on, i.e., output transistor Q1 is conducting. Although these were included primarily for use in testing, it is possible to remove them from the board and carefully extend them to a front panel with hookup wire.

Selective Calling Applications.

Since many TD-4 owners will want to use it for selective calling (paging) operation, we cover all the details here in one place. Many of these items have been discussed earlier, but we want to review them so you have a good idea of everything that is needed in one comprehensive discussion.

The first thing to do in setting up a selective calling adapter for your receiver is to decide how the receiver audio will be muted so you know if the muted situation corresponds to transistor Q1 conducting (turned on) or non-conducting. This establishes the sense of the set and reset functions. Normally, it is easiest to use the output transistor to short some point in the audio path to ground when you want to mute the receiver. Another way to mute the speaker is to use a small relay to interrupt one of the speaker wires, but this should be a last resort.

Figure 2 shows a typical installation. The output transistor is used to ground the wiper of the volume control in the receiver to mute it until the dtmf code is received to unmute the audio. (We are not referring here to your receiver's mute circuit but just our added muting circuitry, which effectively does the same thing.)

In order to mute the audio, it is necessary to find a point in the audio path which has some resistance in series with it so the ground can work, in effect, as the bottom half of a voltage divider; the top half is the resistance in the audio path, and the bottom half is the almost-zero resistance of the turned on transistor.

In this case, we were able to make the assumption that we would never run

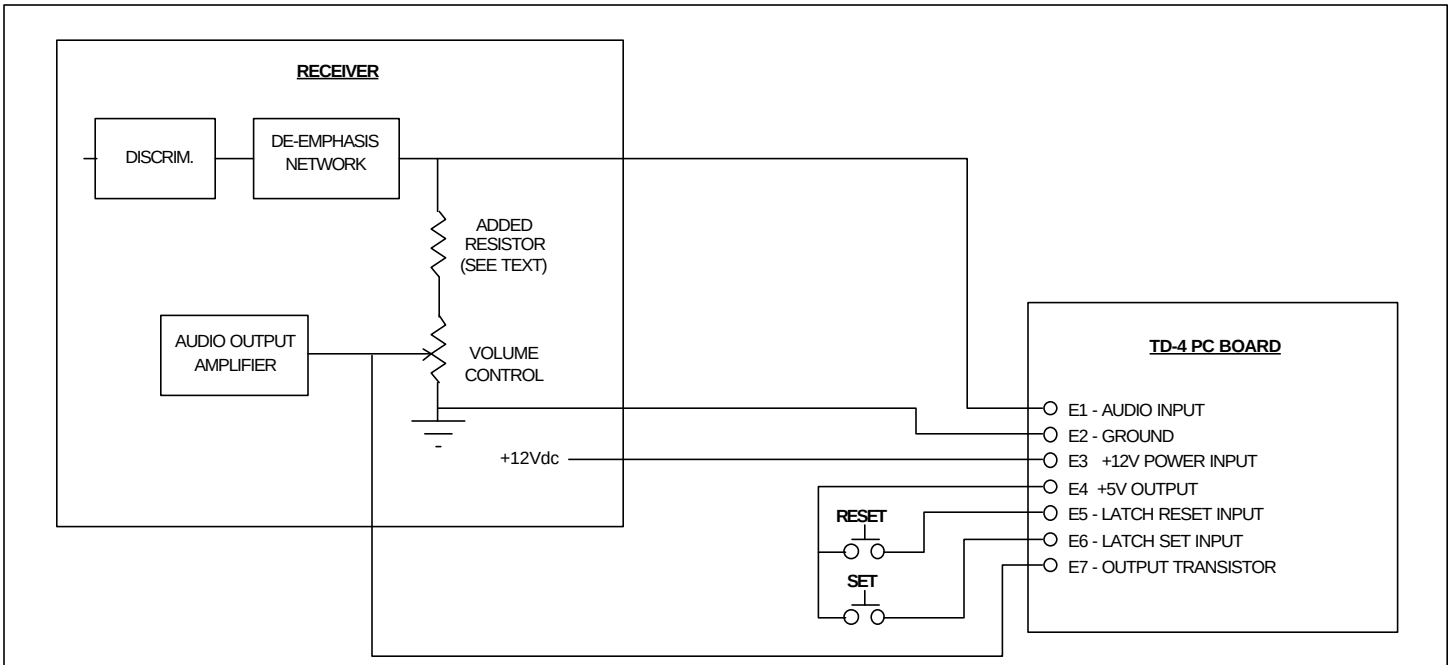


Figure 2. Wiring for Selective Calling Applications

the volume control over about ¾ throttle; so there will always be some resistance in the top half of the volume control to work against. This is important because if you short the point you use to feed the dtmf tones to the input of the TD-4 board, once you mute the receiver, there will never be any audio (dtmf tones) applied to the TD-4 to allow the appropriate code to unmute the receiver again.

If you want to be able to run the volume control wide open sometimes, or you cannot short the wiper of the volume control to do the muting, then it may be necessary to add some fixed resistance in series with the audio to the volume control to work against, as shown if Figure 2. The resistor value should be at least half the value of the volume control.

It may also be possible to mute the audio by using the output transistor of the TD-4 to ground some dc control point in your squelch circuit. To do so, however, requires that you have a good knowledge of how the squelch circuit works, and it requires that this method does not squelch the audio needed to provide dtmf tones to the TD-4 input circuit.

The audio source for E1 of the TD-4 board must be at a level of at least 100 mV p-p with dtmf tones present. This can be taken from any point in the receiver after the detector. In the case of an fm receiver, it must also be after the de-emphasis circuit so that the high and low tones will be at about equal levels and with minimum distortion. Do not take audio from a "discriminator" output of the receiver if it is unfiltered or not de-emphasized audio.

☹ *Note that the dtmf decoder ic in the TD-4 has anti-falsing features which prevent any response if the audio tones are distorted or have excessive twist (large difference in level between high and low tone of a pair.)*

It is important to have a good ground connection between the receiver and the TD-4 to minimize hum and noise and provide good quieting when the receiver is muted. Connect a ground wire between E2 on the TD-4 and the ground plane on the receiver board near the audio circuits.

It is also important to keep the audio and ground leads between the receiver and TD-4 relatively short to avoid noise and hum. Normally, 12 inches should be OK. Remember, you are connecting directly into the low level audio stages of the receiver.

DC power for the TD-4 can be any regulated and filtered dc power source of at least 7Vdc but not over 14Vdc. The TD-4 has an on-board 5V regulator. You should be able to steal the power from the receiver, since only 10-15mA is needed.

The manual "set" and "reset" switches were described earlier. You probably want to install both on the panel of your enclosure, one to mute the audio until the required dtmf digits are received and one to unmute it when you want to listen.

If you want to do the extra work, it would be nice to extend the led's to the panel of the enclosure as described earlier.

Emergency Alert Decoder Application.

Recently, some amateurs have established an unofficial standard for alerting listeners to emergency traffic. A number of clubs have endorsed this standard, which calls for a dtmf 0 (zero digit) to be sent for six seconds to open monitors. This is referred to as a "LiTZ" system, or "long tone zero" system, as it is referred to in a Dec 1992 *73-Magazine* article.

It is easy to modify the latch input circuits on the TD-4 to perform this function, ie, mute the receiver until a dtmf zero has been received for six continuous seconds. Refer to the schematic diagram. To make the TD-4 respond this way, first remove diodes CR1-CR3, which makes each "and" gate respond slowly, in about 2 seconds, instead of instantly, as happens with the diodes in place. Then, tie all four inputs to the "0" decoder output pad; these being latch inputs 1, 2, 3, and either 4S or 4R, depending on which is used to unmute the receiver. If the other fourth latch input (4S or 4R) is not used, be sure to tie it to ground to prevent erratic operation.

The way the circuit works, when wired this way, is in a bucket brigade fashion. When a zero is received, first C5 charges slowly, then U3-D turns on, charging C6 slowly, and finally U3-C turns on, charging C7 slowly. After all three capacitors are charged in sequence that way, U3-A or U3-B turns on to unmute the receiver.

OPERATION.

General.

Operation is fairly simple. A control sequence normally consists of four digits, with the first three being a common "key" used with both commands, and the fourth digit being a function identifier: "set" or "reset". As soon as the fourth digit is received, the selected function is performed. Normally, these dtmf commands are sent over the air with a touch tone microphone on a transceiver.

For security, the entire four-digit command must be sent with no more than a few seconds between digits. Each digit remains active in memory in the TD-4 logic circuits for only a few seconds and then it is cleared.

Operation as DTMF Controller.

The output transistor in the latch circuit can sink up to 50 mA to ground in any dc control circuit up to 15V. This could, for instance, ground the control terminal to turn on an autopatch module.

Any small relay with a coil resistance over 250 ohms also can be used. Reed relays are ideal. Be sure to connect a reverse diode across the relay coil to protect the transistor from inductive spikes.

Operation as Selective Calling Adapter.

When used as a paging device to mute a receiver until someone wants to talk to you, the TD-4 normally is latched into the "set" state with a pushbutton switch on the enclosure. Then, if someone wants to call you, he/she sends the appropriate four-digit command to "reset" the latch in the TD-4, which unmutes the receiver audio. You could also use a manual "reset" pushbutton switch on the enclosure to turn on the audio locally so you can monitor or use the transceiver in a normal manner.

You can extend the led's and mount them on the enclosure so you can see when any valid digits are received for testing and also see what state the latch is in. This is very handy. If you come into the shack and find the led indicates someone called you when you were

away, you can give a call to inquire if someone was looking for you.

CUSTOMIZING.

There are several parameters which are preset to what is considered normal, but you may wish to change them if settings don't do what you want.

The first is the duration of tone presence necessary to be recognized as a valid digit. This is set, along with minimum time required between digits, by R3/C2. The present setting is what is considered normal in the telephone industry, namely 40-50 mSec. The only reason you might wish to change it so you can dial faster (but with possible falsing) or slower (for more protection). However, we recommend you simply use it as is.

Another parameter you can play with is the amount of time each digit is stored in memory, which affects how long a user has to complete the full four-digit sequence. This is controlled by the r/c time constant in input gate circuit of each "and" gate in U3. For instance, when the first digit is received at latch input pad "1", the voltage charges C5 quickly through CR1. C5 is slowly discharged through R4 when the sender release the first digit on his/her dtmf pad. When the voltage falls far enough that U3-D no longer responds, it is too late to enter the second digit, which is applied to the other input of the "and" gate. To lengthen the time constant, increase the value of R4, and vice versa.

The gain of the input op-amp in U1 can be changed within reason to allow various ranges of audio levels to be accepted. The gain is set by the ratio of R2/R1.

THEORY OF OPERATION.

Refer to schematic diagram. The input to tone decoder chip U1 is processed through a dial tone filter and a band split filter using switched capacitor technology. The signal is then analyzed by two zero-crossing detectors and a digital detection algorithm to determine if and which tones are present. Then, the resulting logic signals are processed in a code converter and latch circuit to provide four binary outputs (called Q1-Q4) with encoded information about dtmf digits which may have been received.

A valid digit strobe (StD) signal indicates when any valid digit tones are received. This valid digit signal is used to gate U2 and to illuminate DS1 through U4 inverters when tones are received. The whole circuit is run on a clock controlled by color burst crystal Y1. The ratio of R2/R1 sets the gain of the op-amp input circuit. R3/C2 sets the length of time necessary for presence of valid tones and the interval between tones to prevent erratic operation.

U2 decodes the hexadecimal information from U1 to provide 16 CMOS output lines corresponding to the digits on a DTMF pad. Programming is done by soldering jumper wires from decoder output pads at the output of U2 to adjacent latch input pads at the input of U3.

The output of the TD-4 is a small-signal npn transistor, which can ground an external circuit when turned on by latching flip-flop U4-C/U4-B. When the latch is set, U4-B applies a positive voltage through R8 to the base of Q1 and U4-C grounds DS2 through current limiter R7.

The latch can be set and reset in two ways. First, an external pushbutton switch can be used to complete a circuit from +5Vdc (at E4) to apply a logic hi directly to the set or reset input of the latch. The latch can also be set or reset by the four-digit dtmf decoder logic of U3.

To set the latch, U-4A must be activated; and to reset the latch, U3-B must be activated. To be activated, these two "and" gates must have both their input gates hi (positive). One input of each "and" gate is activated by the fourth digit of the dtmf command on lines "4S" and "4R". The other input of each "and" gate is activated by U3-C, which turns on only if the first three dtmf digits are received correctly. After the first digit is received, C5 is charged positive through CR1, and the charge slowly discharges through R4 after the first digit is released. If the second digit is received at U3-12 before C5 discharges completely, then U3-D turns on and charges C6 in the same fashion. C6 then holds the charge for a length of time, even if C5 has fully discharged. If the third digit is received at U3-9 before C6 discharges completely, then U3-C charges C7. If the fourth digit is then applied to U3-1 or U3-5 before C7 discharges completely, the set or reset signal is applied to the latch to complete the command.

TROUBLESHOOTING.

General.

Tracking down trouble is fairly straightforward. The Theory of Operation section describes the signal path and what each circuit does. A table at the left side of the schematic diagram near U1 gives typical dc voltages for those pins which are analog functions. All other voltages represent digital circuits, which have either a CMOS hi (near +5V) or lo (near ground) as marked on the schematic by the little pulse symbols indicating the active state. The only circuit with a different voltage is the latch output transistor, which has about +0.7V at the base when turned on. The collector is at ground when conducting and open circuited when off.

Power Supply Problems.

The operating voltage of the unit is +7 to +14Vdc. Current drain normally is about 10-15mA, depending on whether led's are lit, since they draw more current than the other circuits. If your TD-4 is drawing excessive current, look for shorts on the B+ line and perhaps ic's plugged in backwards.

Voltage regulator U5 normally limits current drain to 100 mA, even if the output line is shorted to ground. If your TD-4 draws about 100 mA of current and U5 is hot, check for a short on the +5V line somewhere. You may even want to unplug the ic's, one at a time, to see if one of them is the cause.

If you find an ic has been damaged during operation or testing, check the power supply which operates the TD-4 to see if there are any transients. These could be generated by a relay or some other inductive device operating on the same supply line. Any such inductive devices must have a diode connected across their coil with polarity reversed so it absorbs any inductive kickback the coil generates when the operating voltage is turned off.

☹ *Remember that the ic's are static sensitive. You don't want to further damage the board while troubleshooting. A ground wrist strap should be worn when handling the ic's.*

Check the latch flip-flop to see if it is responding and supplying the required

current to turn on the output transistor and "ON" led. The latch can be set and reset manually by jumpering +5Vdc from pad E4 to pads E6 and E5.

Erroneous Logic Operation.

If an ic isn't responding properly, also check to see that all of its pins are plugged into the socket properly and that one or two pins are not bent under or outside the socket.

Leaving an input of one of the cmos ic's unterminated can cause erratic and unpredictable operation. Be sure any unused latch inputs are grounded.

Tone Level.

A logical troubleshooting procedure would be to start by checking the audio source to be sure valid tones of proper level are being fed into the TD-4. The range of acceptable levels is 100 mV to 2V peak-peak.

The input circuit of dtmf decoder chip U1 is an op amp, between input pins 1 & 2 and output pin 3. The level of audio at pin 3, which is what is applied to the detector circuits, must be at least 90 mV p-p (both tones at once). You can check this level with a scope (not a voltmeter) to be sure your installation provides at least this level. If not, you may change the place you derive the dtmf audio for the TD-4 in your receiver or decrease the value of R1 to get more gain in the op amp circuit.

Tone Quality.

The anti-falsing circuits in U1 prevent valid digit recognition if there are certain things wrong with the audio.

There may not be any strong tones present other than the two required for the dtmf digit. Having too strong a subaudible tone, if used, can be a problem, although normal deviation levels of about 300 Hz are acceptable for subaudible tones.

There may not be excessive distortion of the tones. This may be caused by over deviation in the transmitter or being off frequency, either of which causes distortion by having modulation sidebands splash over the edge of the filter in the receiver.

DTMF Frequencies Vs Digits

Freq (Hz)	1209	1336	1477	1633
697	1	2	3	A
770	4	5	6	B
852	7	8	9	C
941	*	0	#	D

Tone Frequency.

The tones must be on-frequency within 1% to 2% or they will not be recognized. The following table gives frequencies of touch tones. You should check your tone pad if some of the digits don't respond, to see if the pad is sending tones on frequency. This usually may be done by pressing two adjacent buttons at once on the dtmf pad, which allows only one tone of the pair to be sent.

If the U1 chip is not decoding touch tones, also check to see if its oscillator is running and at the proper frequency. You may need to use a 10:1 scope probe for the frequency counter input to keep from loading the oscillator circuit. The next step would be to check the hexidecimal signals from U1 to U2 and check for a valid digit signal from pin 15 of U1. (The valid digit led should light).

The next thing to check is the inputs to the U3 logic circuits. Is each time delay circuit operating properly when the digit is applied? Does the capacitor charge quickly and discharge slowly when the appropriate dtmf digit is sent. Check to see that each "and" gate output goes hi when the required inputs are applied.

Tone Level Twist.

If falsing occurs with some commands or the unit fails to respond, you should check the twist of the incoming tones in addition to their frequencies. Twist is the relationship between the level of tones in the high group to the level of tones in the low group. There should be no more than 10 dB difference between the two tone levels in any digit. That is about a 3:1 difference in voltage.

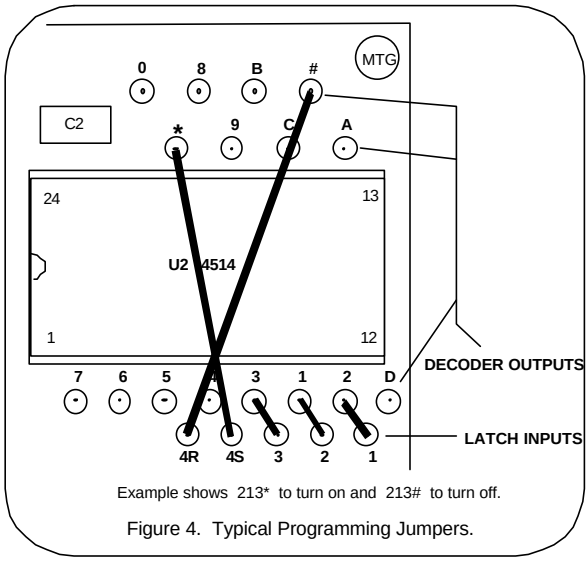
Various factors influence the twist of the tones, including the tone pad at the transmitter, coupling capacitor values in your system, receiver de-emphasis, transmitter pre-emphasis, and how hard you drive the tones at the transmitter.

One problem with some transmitter setups is that a ham will set his tone level too high, trying to get full 5 kHz deviation. The level is actually set so high that it goes into limiting. This may cause the high and low tones to be transmitted at the same level instead of having the desired pre-emphasis. It may also add distortion to the tones. Then the receiver de-emphasis at the other end causes the low tone to be at a higher level than the high tone because the pre-emphasis at the transmitter was wrong. You should encourage system users to be conservative in setting tone levels at their transmitters.

Another cause of bad twist on touch tones can inadvertently occur if a sub-audible tone decoder is used in the receiving system. The high-pass filters supplied on sub-audible tone decoder boards, usually connected in series with the audio in the receiver to get rid of buzz from sub-audible tones, can severely degrade the levels of lower frequency touch tones as well. If you have such a board installed in your receiver audio path, you might want to check its effect on touch tone twist. If a problem, you may want to take your touch tones from a point in the receiver unaffected by the high-pass filter or even just not use the filter in your receiver. Generally, the required level of deviation to make a sub-audible tone system work is very low, about 0.3 kHz or less, and some people run the level much higher than needed, which causes the buzz. Running the proper level may allow the filter to be removed with no great problem.

PARTS LIST.

Ref Desig	Description (marking)
C1	.01 µf disc (103)
C2	0.15µf mylar (red)
C3	1 µf electrolytic
C4	47 µf electrolytic
C5-C7	1 µf electrolytic
CR1-CR3	1N4148 switching diode
DS1-DS2	T1 red LED
Q1	2N3904
R1-R2	100K
R3	510K
R4-R6	1 meg
R7	1.2K
R8	10K
U1	G8870 dtmf decoder
U2	4514 hex to 16-line decoder
U3	4081 quad and gate
U4	4001 quad nor gate
U5	78L05 5V regulator
Y1	3.5795 MHz color burst xtal



Example shows 213* to turn on and 213# to turn off.

Figure 4. Typical Programming Jumpers.

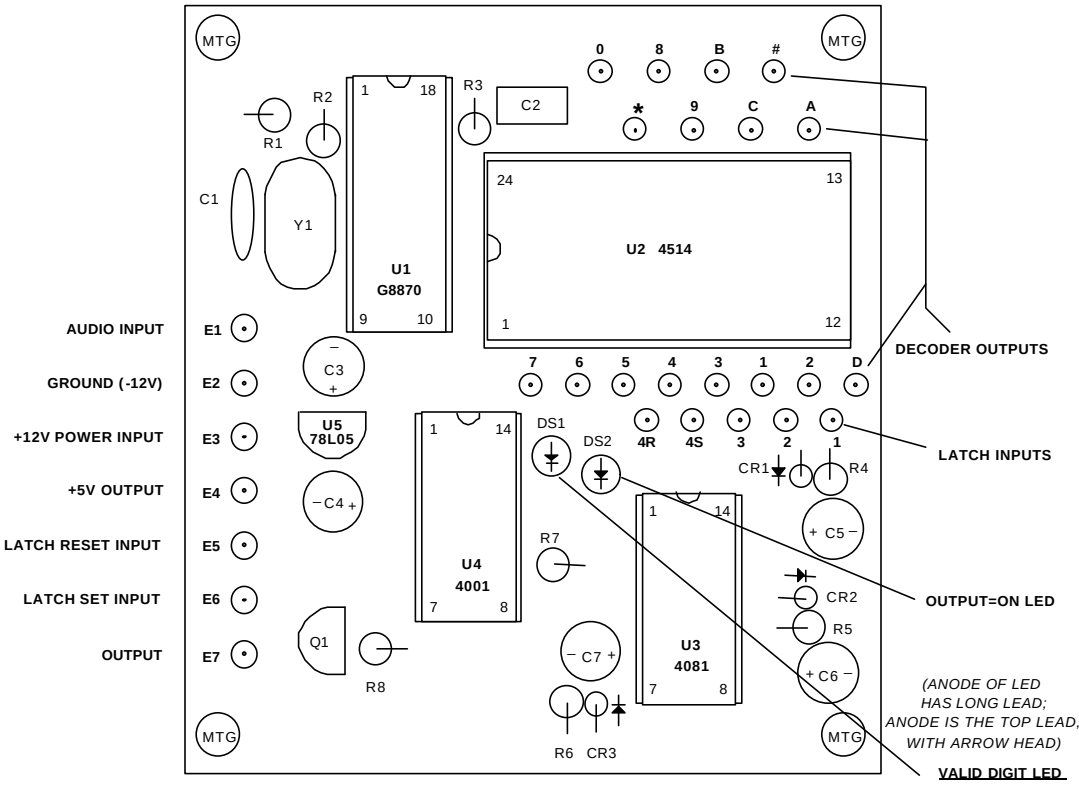


Figure 5. TD-4 Component Location

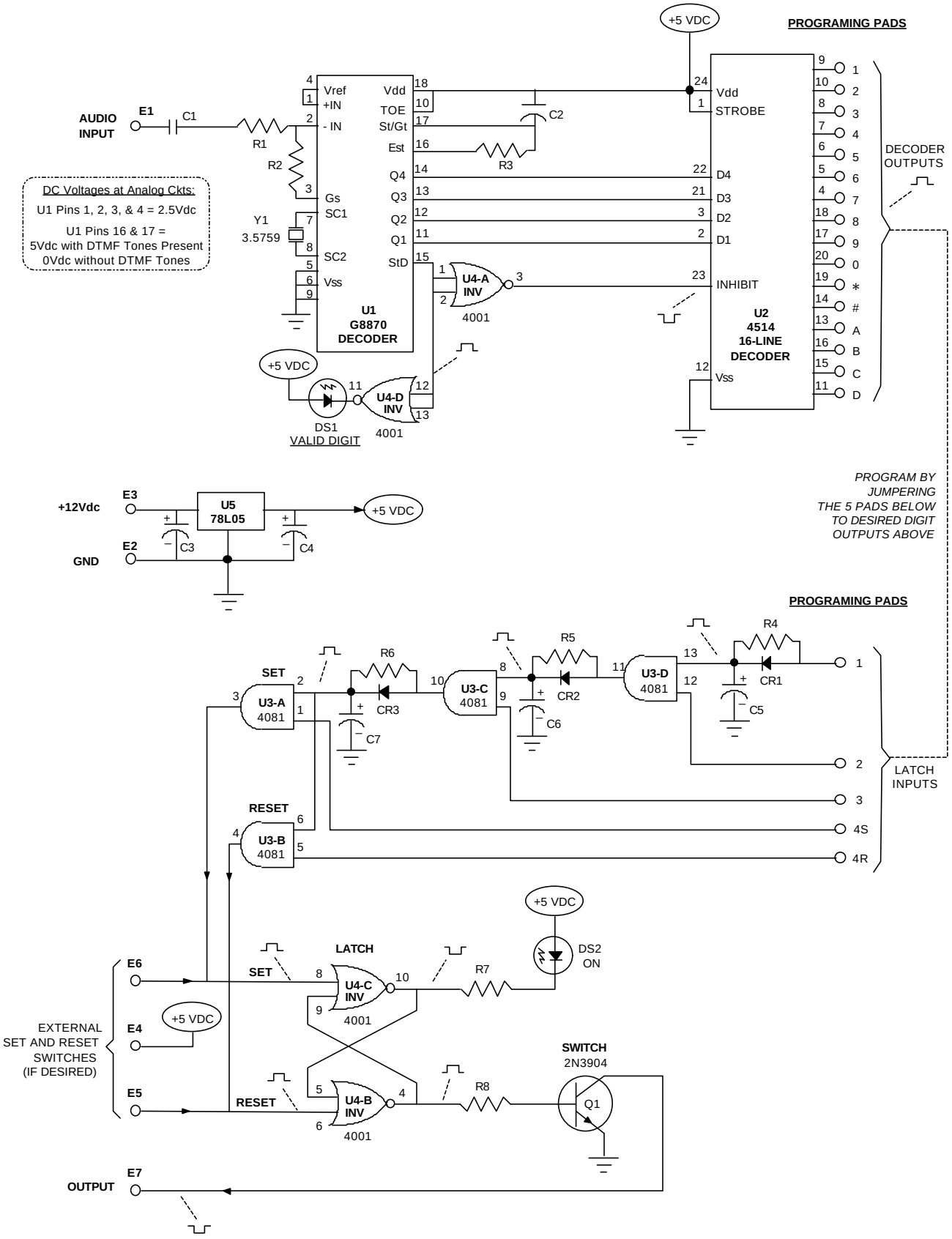


Figure 6. TD-4 Schematic Diagram.

