HAMTRONICS® TD-2 DTMF DECODER/CONTROLLER

GENERAL DESCRIPTION.

The TD-2 is an advanced DTMF tone decoder and multichannel controller providing 5 latching outputs and up to 12 momentary outputs. Latching outputs are handy to control autopatches, repeaters, sub-audible tone decoders, and various other on/off functions. A toll call restrictor is included in the autopatch control circuitry at no extra cost. The heart of the TD-2 is a central office grade, 16-digit, crystal controlled DTMF decoder chip with built-in filters to prevent falsing on noise or voice signals. Reliable operation is maintained for any audio input level from 100mV to 2V p-p. Low power consumption is made possible by the exclusive use of CMOS ic's. The unit can operate on 10-15Vdc at only 15mA. Control codes are easily programmable and allow flexibility in code types. See our catalog for a full list of features.

THEORY OF OPERATION.

Refer to schematic diagram. The input to tone decoder chip U1 is processed through a dial tone filter and a bandsplit 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 provide a muting signal to the autopatch board when tones are received. It also operates the toll call restrictor, which is discussed later. The whole circuit is run on a clock controlled by color burst crystal Y1. The audio input signal is filtered by L1/C1 to remove any rf which may be picked up on the wiring. The ratio of R2-R3 sets the gain of the op-amp input circuit. C3-R4 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 for the various functions is done by soldering jumper wires from program pads at the output of U2 to adjacent function program pads.

The 4013 latches may be operated synchronously or directly. The Q output will assume a hi whenever the set input is triggered by a hi or a lo whenever the reset input is triggered by a hi. The not-Q output is just the inverse. The latch also may be operated synchronously, with its Q output assuming the whatever state the data input has applied when the clock input receives a hi. If the clock input is lo, the latch ignores the data input. But if the clock goes hi at any time, the latch will follow the data input when the clock is hi.

U5A/B and U6B are D-type flip-flops operating as a "key" latch in conjunction with program inputs K1-K3. The output of U6B is high only upon proper receipt of a three digit code, which provides a security "key" to unlock the rest of the logic gates. R8/C11/CR2 in the reset circuit of U5A provides a five-second time delay. When the first digit of the key is received, the not-Q output of U5A releases the reset inputs of the other two flip-flops for about five seconds. If the full three digit code is not completed within that time period, all three flip-flops are reset.

There are 12 momentary functions, each using a 4081 ANDgate. Normally, one input of each AND-gate is tied to the so-called "key" bus coming from U6B and the other input is tied to a programming pad bearing the name of the output line from the AND-gate. To actuate a function, it is necessary to send the three-digit key plus a fourth digit indicating the desired function. During the interval when the key is active (about five seconds), if any other function is selected, it may be activated with just its one digit function code. If the key period expires, then the key must be re-sent to start another command. It is also possible to eliminate the key altogether, if the security is not needed, allowing one digit commands at any time. This is done by disconnecting the input of the AND-gate normally connected to the key bus and reconnecting it to the +5V bus instead. You can even use the key for some functions and not others; using only a "#", for instance, to turn off the autopatch, but requiring the full four digits to turn it on.

When a particular AND-gate receives both a key input and a function input, it applies a hi signal to its output line. In the case of five pairs of AND-gates, the outputs also are tied to the "set" and "reset" inputs of latches. The latches, in turn, drive output transistors and led's. The open-collector transistor switches may be used to drive external circuits. Thus, the momentary outputs, which are CMOS hi's in the active state, may be used or the latch outputs may be used or any combination of latch and momentary outputs may be used as desired.

The names of the lines were selected based on two parameters. First, the letter indicates the function usually associated with the line. The "R" function normally is used to enable or disable a repeater. The "A" function normally controls an autopatch in a repeater. Of course, the circuits can be used for any other function, but it was thought best to select names based on uses most owners will have for them. The other functions are not dedicated to any particular function; so they were named B, C, D, and E. (E is the pair of momentary functions which has no latch. We loaded the pc board with all the functions we could fit on the board, and we had two AND-gates left to provide the extra momentary functions. There is no other significance. If you need a momentary function or two, you can use the E functions without feeling you are wasting an associated latch.) The number, 1 or 0, indicates which line turns the latched output on or off.

It is a little confusing looking at the latch circuits until you realize that the repeater latch circuit is different from the others, which turn on a circuit by the collector of the transistor conducting to ground. The R latch mutes a repeater by grounding the COS line from the receiver or autopatch to the COR board input. Thus, the repeater is off when the transistor is active instead of being on when the transistor conducts like the other circuits. The autopatch latch is different, too, because of extra toll call restriction circuits. There also is a difference in the way that the latches are preset at power up. The repeater wants to be enabled after a power failure, not disabled. So its latch is wired to default with the repeater enabled. The other latches default in the off condition. Default status is set by the C/R networks on the clock or reset inputs of the latches. When power is first applied, a positive pulse is applied by the capacitor to reset the latches.

The autopatch latch has some extra circuitry with it to provide toll call restriction. U4 is a counter which keeps track of which digit is received after the autopatch latch is turned on. When the autopatch is off, the not-Q output of U6A is hi, keeping U4A/B reset. However, when the four digit code is sent to bring up the patch, U6A turns on, and the reset signal is removed from U4, allowing it to count digits. The Q output of U4B remains lo until the second digit after the autopatch turns on. If a 0 or 1 is received during the first digit after the patch is brought up, U3B, which is used as an AND- gate, is satisfied that it has two lo's, and it provides a clock input to autopatch latch U6A. Since the data input is wired lo, that causes the output of the latch to assume the data input (lo) condition, thereby killing the autopatch. If any other digit is received as the first digit of a phone number, U3B is not satisfied, and the autopatch remains on. On subsequent digits, digit counter U4 removes its lo from U3B, so the patch will not be turned off by any received digit, even a 0 or 1.

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 parts location diagram. The top side as shown has the pin number markings. Also refer to the parts list and schematic diagram during construction.

Before assembly, it is important to decide whether or not you will use the three digit key for controlling all of the functions. If you will want to control some or all of the functions with only a single digit code, it is necessary to break some pc paths on the top of the board which will be concealed later by ic sockets. If you want to modify the pc board in this way, refer to the section on Programming prior to assembly.

CAUTION. *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 the led's on the board, observing polarity. The positive lead is longer on some led's. On others, there is a flat on one side as shown on the parts location diagram.

CAUTION: *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 the remaining parts other than the dip ic's, according to the parts list. Be sure to observe polarity on the diodes, transistors, U12, and the electrolytic capacitors. 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.

d. 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. Note that one hole above U5 is a "via" used only to make a connection between the top and bottom of the board. Nothing is installed in this hole. Note also that programming wires will be installed later.

e. 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 either dot or notch on the end of each ic. If any conflict between notches and dots on an ic, the notch (which only appears on one end) takes precedence. Sometimes, RCA cmos ic's have a test dot of some color (eg. blue) on one end, and such dots can be confusing because they can appear on either end. Ignore such dots if the ic also has a notch or white bar on one end, which would indicate the pin 1 end. Be careful to engage all the pins in the socket; don't let any leads bend over.

PC BOARD HANDLING PRECAUTION.

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.

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 dc input at pad 2. Connect a source of touch tones to audio input pad 1, with a level between 100 mV and 2V p-p. The outputs at the left two rows of programming pads should have a CMOS logic level (close to 0 and +5V) with the hi corresponding to reception of a valid touch tone digit. The "mute" signal should also appear at mute pad 3 at the edge of the board whenever any valid digit is received.

PROGRAMMING.

The following discussion is an attempt to simplify the steps required to plan how to use the various functions on the TD-2 module. There are many variables involved, but breaking it down like this should make it easier to consider everything.

Read through the paragraphs which follow, and take actions where appropriate. Table 1 is a sample of the type of plan you should make. This is a typical setup in an amateur radio repeater installation, and it is the programming we use for wired units at the factory unless something else is requested. The chart shows the correspondence of the decoder output pads with the function-input programming pads for each function. It also shows the complete command sequence desired for each function, based on having to send the three "key" digits plus the function-indicator digit for each command. You should make a plan like this for your installation, noting what each function will be used for.

There are 12 momentary functions available. 10 of them may be used either for a simple momentary function or as the input to control a latching function. The E0 and E1 functions may be used only as momentary functions. *(Refer to theory of operation for more information on these circuits.)*

The five latching functions are similar except that the R function, being normally used for control of a repeater, has reversed nomenclature, ie., the "R0" function causes a short to ground at the latch transistor output pin, and the "R1" function causes an open circuit. The other latching functions are just the opposite. *(See Theory of Operation for reason why.)* The A latch normally is used for autopatch operation. It has toll call restriction circuitry connected to it. If used for some other function, the toll call restrictor can be eliminated by simply breaking the pc traces to pins 8 and 9 of U3, and reconnecting those inputs to ground instead.

Any of the functions not required to turn a latch on and off may be used for some momentary purpose. Because the E functions are momentary only, they should be considered first for momentary applications.

The latching outputs can be used to drive solid state circuits directly and can drive small relays to switch power loads. The output transistors can sink loads up to +15V and 50 mA. 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.

The momentary outputs are essentially the outputs of CMOS gates. They provide about +5V in the active state and close to ground in the passive state. Output current is no more than 3 mA.

When you select programming codes, you can use any touch tone digit for any function you want. You can reuse digits as many times as you want; there is no need to use each digit only once. The fan-out capabilities of U2 allow it to drive any number of AND-gate inputs from any digit output pad. The mechanics of making connections are more of a limitation. The board uses wire jumpers for programming. This allows easy field programming without prom burners, etc., but it does require a little planning and workmanship. If you analyze the sample programming in Table 1, you will see that it provides for maximum use of all the digits with nearby function pads to make wiring neat. Any codes can be programmed, though, and if neatness and ease of programming are not important to you, then you have more freedom in selecting codes.

Programming is done by soldering 2-1/2 inch lengths of hookup wire stripped about 1/4 inch on each end. That length allows a little slack so wires can be moved around to allow access to solder other wires.

Be sure to terminate the inputs to all the AND-gates by connecting any unused function programming pads (not the digit output pads, but the AND-gate input pads) to ground. If the gate inputs are left floating, the operation of the ic's can be erratic and can affect other functions that are used. Noise input can also cause unterminated ic's to draw more current.

Normally, the three digit "key" is used as the first part of any command, and the fourth digit indicates the function. However, if the security is not needed and you don't mind having someone accidently perform a control function by hitting one digit, the pc board can be modified to provide single-digit operation of one or more functions. An example of this is that some repeater owners want to be able to turn off the autopatch with a single digit, such as "#", even though the full four digits are required to turn it on. Also, in an industrial control operation, you might want to have quick commands to perform repeated operations without having to dial up a "key" sequence each time. Bear in mind that the "key" provides useful functions; so consider what you are giving up before you make a decision to opt for a single digit command.

Unfortunately, the only way the pc board could be laid out was to put the "key" bus trace on the top of the board. This means, you may need to modify the traces under the ic sockets for U7, U9, or U11 to change to single digit operation, depending on whether you only want to change an individual function, a group of functions, or all the functions to single-digit operation. If you compare the schematic diagram with the pc board, you will note the "key" bus pc trace running on the top of the board from U6 at its lower-left extreme to U11 at its upper-right extreme and making a right-angle turn just below the lower-right programming pad.

The AND-gate pad(s) you wish to reprogram for single digit operation must be disconnected from the "key" bus by cutting the pc trace, and such pad(s) must be reconnected by a bus wire jumper to +5V instead, which you can access on pin 14 of each 4081 ic. The jumpers, of course, can be soldered under the board, but you must have access to break the "key" bus on the top of the board. If you have a unit which is already wired, you may need to carefully unsolder the ic socket for necessary access. If you are reprogramming more that one function, you may be able to break and reconnect a whole section of the "key" bus instead of individual ic pins.

You may reduce the number of digits in the "key" by reconnecting U5 and U6 latch inputs. For a 2-digit key, disconnect 3rd digit key latch, U6B, "D" input from U5B and connect U6 pin 9 to +5V instead. Then, use the K1 and K3 programming pads as your "key" inputs. U5B essentially is out of the circuit.

If you want a 1-digit "key", then disconnect the "key" bus line from U6B pin 13 and connect it to U5A pin 1 instead. Use K1 as your "key" input for programming.

Here is a trick suggested by a customer on how to convert to a one-digit key after the board has been assembled using the 4 digit method. Remove U6, bend pin 13 out, and reinstall U6 making sure pin 13 does not connect with pin 13 on the IC socket. Now jumper pin 13 and pin 14 of U6 by soldering the pins together on the bottom of the board.

TESTING PROGRAMMED BOARD.

After the board has been programmed, all of the functions may be tested. Power up the board as done for *Initial Testing* on page 2; apply touch tones of proper level; and check for proper responses at the momentary and latching outputs with a voltmeter. You can also monitor the "key" bus line on the board with a voltmeter to see that it goes hi for about five seconds after the 3-digit key is sent and then returns to lo. The "mute" output can be checked at pad 3 at the left side of the board to see that it goes hi whenever any valid digit is received.

You can also check the toll call restrictor circuit by attempting to dial various numbers after the autopatch latch is turned on. If you dial a 0 or 1 as the first digit after the patch is brought up, the patch latch should

Table 1. Typical Programming Plan.

ProgramPads	Function	Full Sequence
*---K1	"Key" 1st digit	
1---K2	"Key" 2nd digit	
2---K3	"Key" 3rd digit	
0---R0	Repeater Off	* 1 2 0
9---R1	Repeater On	* 1 2 9
#---A0	Autopatch Off	* 1 2 #
3---A1	Autopatch On	* 1 2 3
8---B0	Aux B Off	* 1 2 8
7---B1	Aux B On	* 1 2 7
5---C0	Aux C Off	* 1 2 5
6---C1	Aux C On	* 1 2 6
B---D0	Aux D Off	* 1 2 B
A---D1	Aux D On	* 1 2 A
D---E0	Aux E0 Momentary Only	* 1 2 D
C---E1	Aux E1 Momentary Only	* 1 2 C

Table 2. DTMF Frequencies

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

dump. It should not dump if any other digit is sent first or if a 0 or 1 is sent after the first digit in the phone number.

INSTALLATION.

Caution. *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 your chassis with 4-40 standoffs about 3/8 inch long in the four corners of the board. Be sure to get a good dc and signal ground through the mounting hardware. If you cannot get ground through the hardware or if you need a ground lug to solder to, you can mount a solder lug under the mounting screw in one corner 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. In our REP-100 Repeater, the TD-2 normally is mounted under the left side of the chassis, toward the front.

Power.

The unit is designed to operate on +10 to +15Vdc at about 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.

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. The input circuit of U1 is a typical op-amp, with gain set by the ratio of R3/R2. A reasonable change in resistor values can be made to reset the range of levels the chip will accept.

If you interface with our AP-1 Autopatch Board, you don't need to be concerned about compatibility. The tones for the TD-2 should come from E8 on the Autopatch Board.

Output Circuits.

The latch outputs are open-collector transistor circuits, which can be used to sink current up to 50 mA on circuits up to +15V. The *Theory of Operation* and *Programming* sections tell more about the default condition and control line terminology. If you use the outputs to operate small relays, be sure to put a reverse diode across the relay coil to soak up transients.

The "R" latch output should be used if you want to enable and disable a repeater by remote control. The "R" output is normally used in our REP-100 Repeater to ground the COS line coming from the receiver or autopatch to the COR board. This prevents the transmitter from being keyed after the "R0" command is given.

The "A" latch output should be used to turn an autopatch on and off. In our REP-100 Repeater, the "A" output grounds E13 of the AP-1 Autopatch Board to turn on the autopatch.

The "Mute" output from pad 3 normally is connected to E10 on our AP-1 Autopatch Board to mute the transmitter audio whenever a valid digit is received so that it cannot be heard on the air.

Momentary outputs are direct CMOS outputs from 4081 and-gates. They provide close to +5V in the active state and close to ground in the passive state. CMOS outputs will provide only low current levels, up to about 3 mA.

Switching Large Loads.

In applications where the TD-2 is used to turn equipment on and off, the output transistor in the TD-2 can be used to turn a relay on and off. Two types of relays can be used.

Figure 3a shows a solid state relay, such as the A95 relay we sell as an accessory. The positive input of the relay goes to +12Vdc and the negative input goes to the TD-2 output. Note that solid state relays generate heat; so the metal base of the relay must be coated with heatsink compound and mounted to a metal box or other metal object to dissipate the heat. The A95 relay is rated to switch ac current up to 10A, at voltages of 24 to 220Vac.

The other type of setup is to use a small relay, drawing less than 50mA, to switch ac to operate a large power contactor, as shown in figure 3b, or used to switch a small load directly. In this case, make sure you have a diode connected as shown to prevent damage from transients generated when the relay coil is turned off.

LED Indicators.

There are led's on the board to indicate the status of the various functions: one for each latch and one to indicate when a valid digit is received. 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.

OPERATION.

Operation is fairly simple. A control sequence normally consists of four digits, with the first three being a

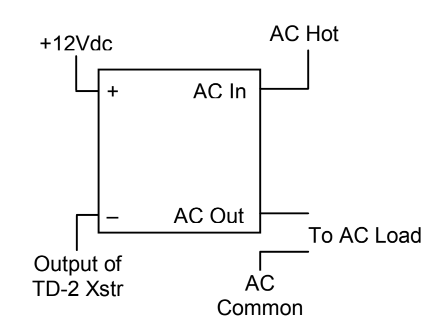


Figure 3A. Solid State Relay Wiring.

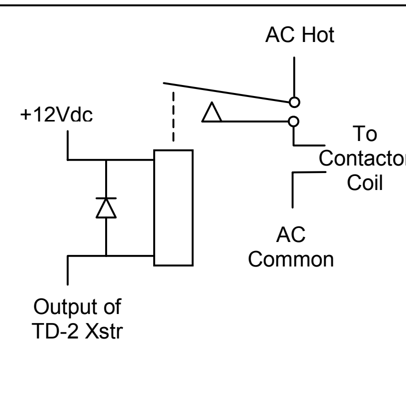


Figure 3B. Small Relay Switching Power Contactor.

common "key" used with all commands, and the fourth digit being a function identifier. As soon as the fourth digit is received, the selected function is performed.

If some or all of the functions have been modified for operation with a smaller "key" or no "key" at all, then operation will be different for those functions. For security, the entire command sequence must be sent within about five seconds or a timer will reset and the sequence must be started from scratch.

Note that the "key" timer will keep the key circuit enabled for about five seconds once it is tripped. Therefore, if more than one command is to be sent in a short period of time, only the final digit of the second and following commands need be sent. If you resend the "key" digits during the five second period, they will be taken as function identifier digits and not "key" digits and may cause erroneous operation.

For example, using the commands in our example, Table 1, if we want to turn the autopatch on and then off again within the five seconds, we would send "* 1 2 3" to turn it on and just "#" to turn it off, since the "* 1 2" is still "in memory", so to speak because the "key" timer is still on.

TROUBLESHOOTING.

Tracking down trouble is fairly straightforward. The *Theory of Operation* section describes the signal path and what each circuit does. The only significant voltages are CMOS hi's (near +5V) and lo's (near ground) as marked on the schematic by thelittle pulse symbols. The only exception is the latch output transistors, which have about +0.7V at the base when turned on. The collector is at ground when conducting and open circuited when off.

The operating voltage of the unit is +10 to +15Vdc. Current drain normally is about 15mA, depending on how many led's are lit, since they draw more current than the other circuits.

Note that led brightness may vary from one led to the next. To save power and space on the board, the led's are driven directly by the CMOS ic's. In this mode, the ic's put out just as much current as they can into what looks like almost a short circuit load. The amount of short-circuit current varies from one chip to the next, and so the brightness of the led's vary. This should cause no concern, since the function of the led is simply to indicate whether the circuit is on or off.

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-2. The range of acceptable levels is 100 mV to 2V peak-peak. Table 2 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. If the U1 chip is not decoding touch tones, check to see if its oscillator is running and at the proper frequency.

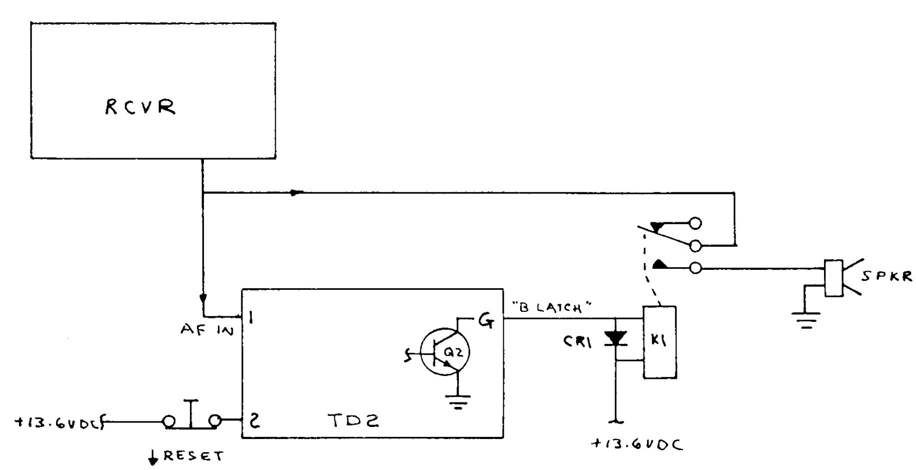
You may need to use a 10:1 scope probe for the frequency counter input to keep from loading the oscillator circuit. The next step would be to check the hexidecimal signals from U1 to U2 and check for a valid digit signal from pin 15 of U1 (the valid digit led should light).

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.

The next thing to check is the "key" bus. Check to see if the output of U6B at pin 13 goes hi when the "key" digits are received. Next, check the momentary outputs: R0, R1, A0, A1, etc. Finally, check the 4013 latches to see if they are responding and supplying the required current to turn on the output transistors. The led's can be used as an indicator of latch status.

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 as to go 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 your6 receiver. Generally, the required level of deviation to make a sub-audible tone system work is very low, about 0.2 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.



Suggested Selective Calling Unit Circuitry

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 R4/C3. The present setting is what is considered normal in the telephone industry, namely 40-50 mSec. You may wish to change it so you can dial faster (but with possible falsing) or slower (for more protection).

Another parameter you can play with is the five second timer setting for the window after reception of the "key" digits during which other tones will be accepted as function indicators. This is set by the R8/C11 time constant. You could shorten the time experimentally to find a time which requires someone to really send the four digits quickly and allow no additional time to do other commands. Or you could slow it down so that it would allow a series of commands to be sent with one digit each after the initial "key" digits are sent.

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 R3/R2.

SOME ADDITIONAL TRICKS YOU MAY BE INTERESTED IN FOR USE WITH THE TD-2.

SELECTIVE CALLING UNIT.

The following diagram illustrates how you can use a TD-2 module as a selective calling unit with the addition of only a few parts. This allows you to monitor an fm radio channel for calls directed only to you and mute the speaker the rest of the time.

The receiver audio is routed to the TD-2 input and also via relay K1 contacts, which mute the relay unless the "B latch" function is activated at the TD-2. The TD-2 requires an audio input level of 100 mV to 2 V p-p for proper operation. If you run the receiver audio at a low to moderate level (less than 1/10th watt), you can connect the TD-2 input at pad 1 directly to the speaker output of the receiver. If you plan to crank the speaker level up fairly high, you may exceed the allowable level into the TD-2 and cause blocking of tones. In such a case, either build a simple L-attenuator with about 1000 ohms in series and 100 ohms in shunt from pad 1 to ground or connect the TD-2 to the discriminator in the receiver after the deemphasis network.

Since the default condition of the "B latch" in the TD-2 at power up is "off", the speaker relay will operate only after the required tone sequence is received for the "B" function. The speaker may be turned off again either by momentarily breaking the B+ to the TD-2, as shown in the diagram with the push-button normally-closed switch, or by sending the proper tone sequence to turn off the "B latch" in the TD-2, which of course can be done by the sending station remotely.

The output transistor in the latch circuit can switch up to 50 mA. Any small relay with a coil resistance over 250 ohms can be used. Reed relays are ideal. Although 13.6 Vdc is shown in the diagram for relay power, any voltage up to 15 Vdc can be used if compatible with your relay. Be sure to connect a reverse diode across the relay coil to protect the transistor from inductive spikes. If you like, an LED can be connected across the relay coil too and located on your front panel to indicate when the audio circuit is open.

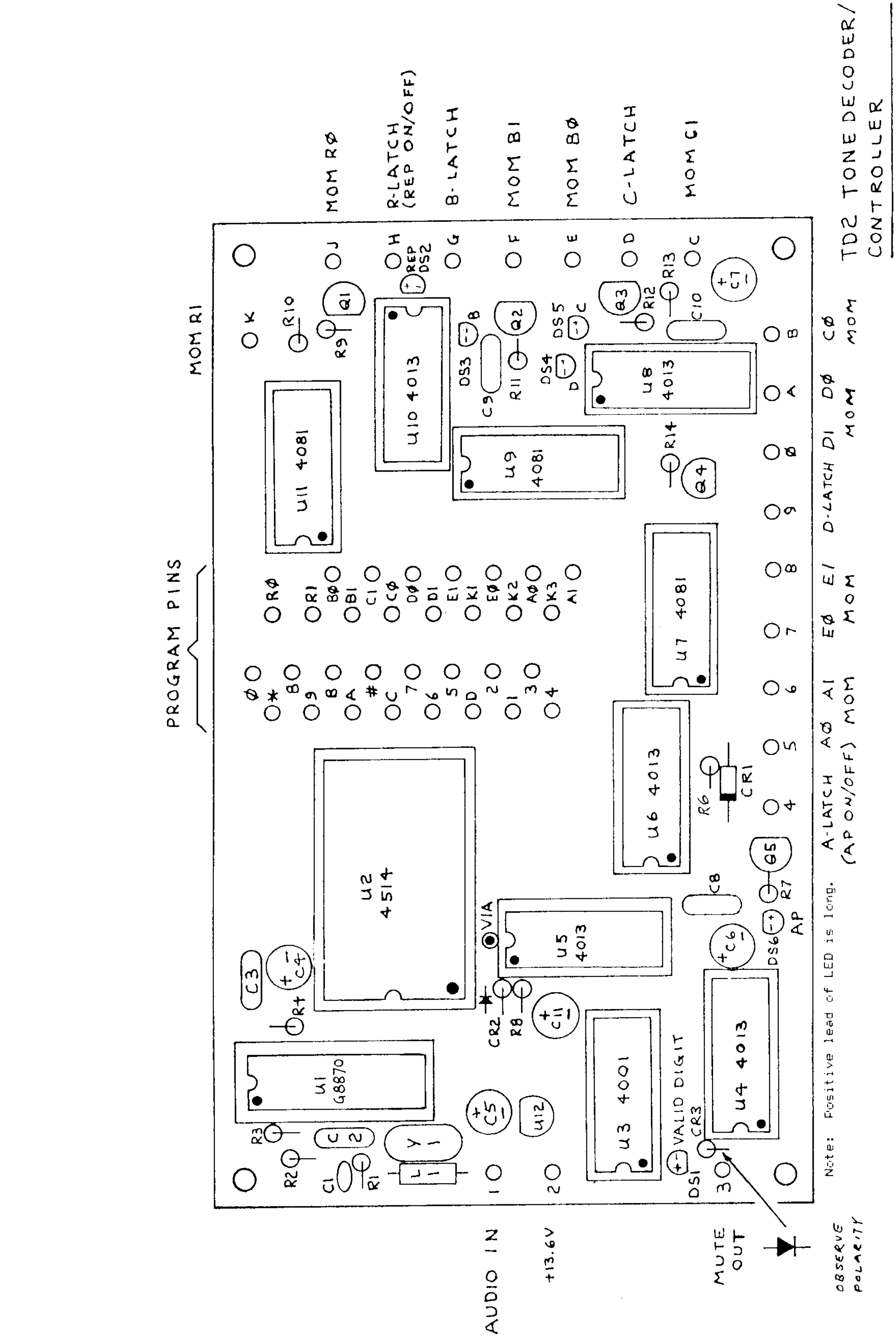
DEFEATING THE TOLL CALL RESTRICTOR.

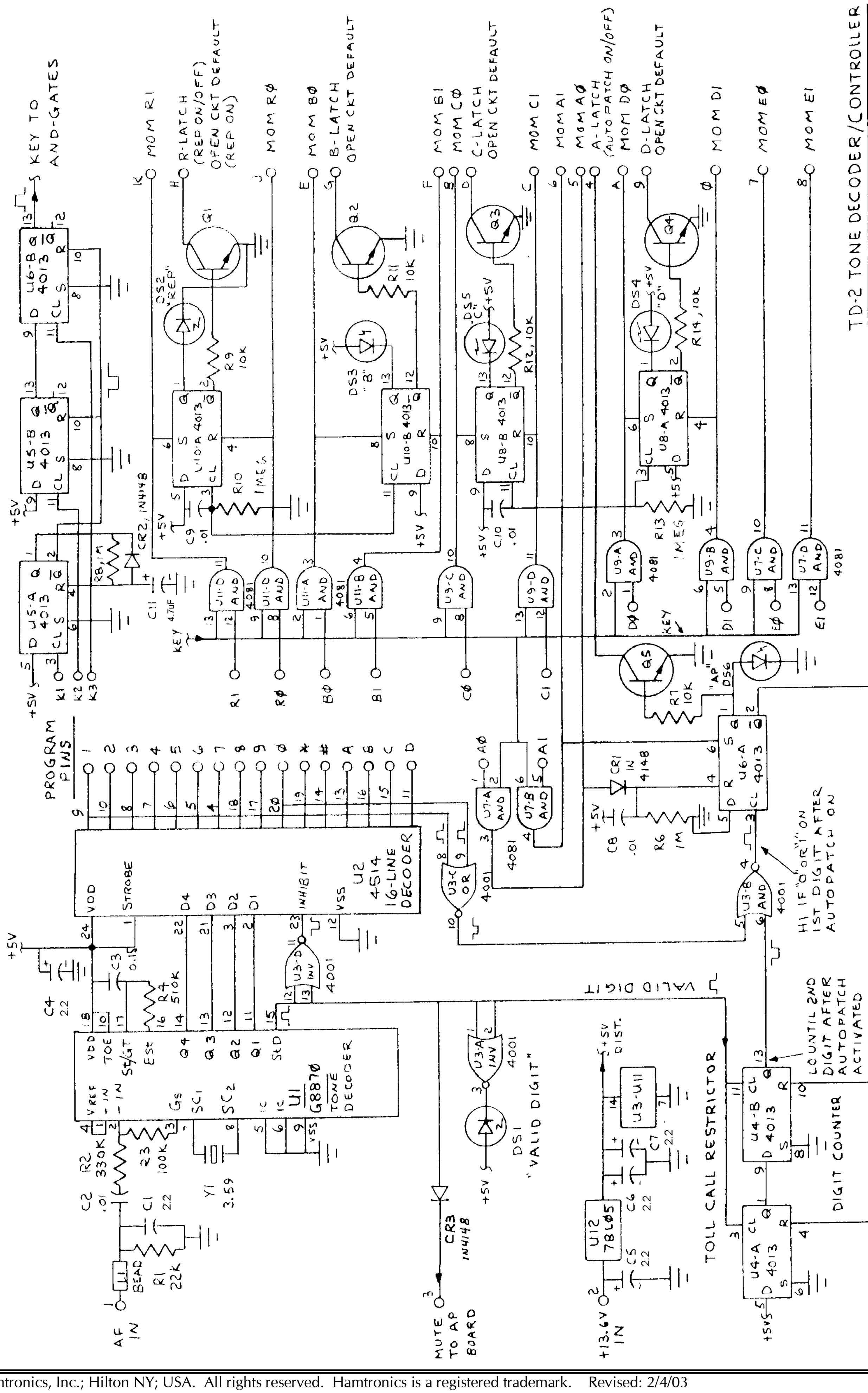
If you plan not to use the toll call restrictor, the easiest thing to do is break the traces from the "0" and "1" lines to pins 8 and 9 of U3-C. Since it is never good practice to leave a CMOS gate input floating, pins 8 and 9 should be connected to ground.

If you want to be able to turn the toll call restrictor on and off with one of the latching functions of the TD-2, break the ground trace between pins 7 and 8 of U4 and connect a 1K resistor from pin 8 to the +5 V bus at U4 pin 5. You can turn the toll call restrictor on by grounding pin 8 of U4 with any of the extra latch outputs you may have available. U4 pin 8, the "set" input of second stage of the digit counter in the toll call restrict circuit, will block operation of the toll call restrictor when pin 8 is ungrounded because the resistor applies a hi unless the controlling latch grounds pin 8. With the "set" input constantly high, the counter output remains high and U3-B thinks you have already passed the first digit in the phone number.

PARTS LIST.

Ref #	Value (marking)
C1	.001 uf (102, 1nM, or 1nK)
C2	.01 uf disc (103)
C3	0.15 uf mylar (red)
C4-C7	2.2 uF electrolytic
C8-C10	.01 uf disc (103)
C11	4.7 uF electrolytic
CR1-CR3	1N4148 diode
DS1-DS6	Miniature red led
L1	Ferrite bead
Q1-Q5	2N3904 or 2N4124
R1	22K
R2	330K
R3	100K
R4	510K
R5	Not used
R6	1 meg
R7	10K
R8	1 meg
R9	10K
R10	1 meg
R11-R12	10K
R13	1 meg
R14	10K
U1	GTE/Mitel G8870 Tone Decoder
U2	4514B Hex - 16 Line Decoder
U3	4001B Quad Nor Gate
U4-U6	4013B Dual D Flip-Flop
U7	4081B Quad And Gate
U8	4013B Dual D Flip-Flop
U9	4081B Quad And Gate
U10	4013B Dual D Flip-Flop
U11	4081B Quad And Gate
U12	78L05 Regulator
Y1	3.59 MHz Color Burst Crystal


TD2 TONE DECODER/
CONTROLLER
AUDIO IN
+13.6V
MUTE OUT
OBSERVE POLARITY
PROGRAM PINS
MOM R1
MOM RØ
R-LATCH (REP ON/OFF)
B-LATCH
MOM B1
MOM BØ
C-LATCH
MOM C1
A-LATCH (AP ON/OFF)
AØ A1 MOM
EØ E1 MOM
D-LATCH D1 DØ MOM
CØ MOM
VALID DIGIT
Note: Positive lead of LED is long.
U1 G8870
U2 4514
U3 4001
U4 4013
U5 4013
U6 4013
U7 4081
U8 4013
U9 4081
U10 4013
U11 4081
U12
VIA
AP
REP


TD-2 TONE DECODER/CONTROLLER

