INTRODUCTION
The TERIDIAN Semiconductor Corporation Transceivers are complete Touch-Tone™ detection and generation systems. Each can operate in a stand-alone mode for the majority of telecommunications applications, thereby providing the most economical implementation of DTMF signaling systems possible. Each combines precision active filters and analog circuits with digital control logic on a monolithic CMOS integrated circuit. TERIDIAN DTMF device use is straightforward and the external component requirements are minimal. This application guide describes operation, performance, system requirements and typical application circuits for the TERIDIAN DTMF products.

HOW THE TERIDIAN DTMF CIRCUITS WORK
The task of a DTMF Receiver is to detect the presence of a valid DTMF signal on a telephone line or other transmission medium. The presence of a valid DTMF signal indicates a single dialed digit; to generate a valid digit sequence, each DTMF signal must be separated by a valid pause.

Table 1 gives the established Bellcore standards for a valid DTMF signal and valid pause. The TERIDIAN DTMF Receivers meet or exceed these standards.

Similar device architecture is used in all TERIDIAN DTMF Receivers. Figure 1 shows the TERIDIAN 75T202 Block Diagram. This architecture is implemented in all TERIDIAN Semiconductor Corp. DTMF receivers. In general terms, the detection scheme is as follows: The input signal is pre-filtered and then split into two bands, each of which contains only one DTMF tone group. The output of each band-split filter is amplified and limited by a zero-crossing detector. The limited signals, in the form of square waves, are passed through tone frequency bandpass filters. Digital logic is then used to provide detector sampling and determine detection validity, to present the digital output data in the correct format, and to provide device timing control.

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>One Low-Group Tone, and</td>
<td>697, 770, 852 or 941 Hz</td>
</tr>
<tr>
<td>One High-Group Tone</td>
<td>1209, 1336, 1477 or 1633 Hz</td>
</tr>
<tr>
<td>Frequency Tolerance</td>
<td>$f_0 \pm (1.5% + 2 \text{ Hz})$</td>
</tr>
<tr>
<td>Amplitude Range</td>
<td>$-24 \text{ dB } \leq A \leq 6 \text{ dBm} @ 600\Omega$ (Dynamic Range 30 dB)</td>
</tr>
<tr>
<td>Relative Amplitude (Twist)</td>
<td>$-8 \text{ dB } \leq \frac{\text{High Group Tone}}{\text{Low Group Tone}} \leq +4 \text{ dB}$</td>
</tr>
<tr>
<td>Duration</td>
<td>40 ms or longer</td>
</tr>
<tr>
<td>Inter-tone Pauses</td>
<td>40 ms or longer</td>
</tr>
</tbody>
</table>

TABLE 1: Bell System Standards
PERFORMANCE CONSTRAINTS

SPEECH IMMUNITY AND NOISE TOLERANCE

The two largest problems confronting a DTMF Receiver are:

1- Distinguishing between a valid DTMF tone pair and other speech or stray signals that contain DTMF tone pair frequencies. This is referred to as Speech Immunity or “talk-off”.

2- Detecting valid tone pairs in the presence of noise, which is typically found in the telephone (or other transmission medium) environment. This is referred to as Noise Tolerance.

The TERIDIAN DTMF Receivers use several techniques to distinguish between valid tone pairs and other stray signals. These techniques are explained in later sections. Briefly, the techniques are:

1- Pre-filtering of audio signals. Removes supply noise and dial tone from input audio signal and emphasizes the voice frequency domain.

2- Zero-crossing detection. Limits the acceptable level of noise during detection of a tone pair. This is important for speech rejection.

3- Valid tone pair/pause sampling. Samples the detection filters and checks for consistency before a valid tone is declared.

DETAILED DESCRIPTION OF OPERATION

AUDIO PREPROCESSOR

The Audio Preprocessor is an analog filter that band limits the input analog signal between 500 Hz and 6 kHz. In addition, it emphasizes the 2 kHz to 6 kHz voice region.

Band limiting suppresses supply noise, dial tone frequencies and high frequency noise. The emphasized voice region helps to equalize the audio response since many phone lines tend to roll off at about 1 kHz. In addition, preservation of the upper voice frequencies is important in providing speech immunity.

TONE BAND SPLITTING
After the analog signal is preprocessed, it is split into two bands, each of which contains only one DTMF tone group. The band split filters are actually band-stop filters to maintain all frequencies except the other tone group; this is done to maintain all analog information to enhance speech immunity but not allow the other tone group to act as interfering noise for the band being detected. These band stop filters have “floors” that limit the amount of tone pair twist that further enhances speech immunity. See device data sheets for acceptable twist limits.

ZERO-CROSSING DETECTORS
The output of each band-split filter is amplified and limited by a zero-crossing detector (limiter). The function of the zero-crossing detector is to produce a square wave at the prime frequency emanating from the band-split filter. If a pure tone is not present, as in the case of voice or other interfering noise, a rectangular wave with a variable period will result. Proportional to the interference, the limiter output power is spread over a broad frequency range as the zero-crossings “dither”. When a high level of noise or speech occurs, no single bandpass filter pair will contain significant power long enough to result in a tone detection. On the other hand, when a pure DTMF tone exists with acceptable noise levels, the output of the limiter will not have any significant dither and tone detection will occur. The zero-crossing detector also acts as a AGC (Automatic Gain Control) in that the output amplitude is independent of input amplitude; this additionally establishes an acceptable signal-to-noise ratio not dependant on tone amplitude.

BANDPASS FILTERS & AMPLITUDE DETECTORS
The bandpass filters perform tone frequency discrimination. Their responses are tailored so that if the frequency of the limited square wave from the zero-crossing detector is within the tone frequency tolerance, the filter output will exceed the amplitude detector threshold. The amplitude detectors are interrogated periodically by the digital control circuitry to ascertain the presence of only one tone in each band for the required duration. In a similar fashion, valid pauses are measured by the absence of valid tone pairs for the specified time.

TIMING AND LOGIC
During the qualification process, the output decode generates the proper digital code for the received DTMF tone pair. After the fidelity and duration of this signal have been verified, the timing circuitry latches this code into the output register and raises the data valid (DV) flag. The only external precision component needed for the TERIDIAN DTMF Receivers is a 3.58 MHz parallel resonant crystal (color-burst frequency) with a 0.01% tolerance for the onboard oscillator. A $1 \, \Omega$ 10% resistor should be connected in parallel with the crystal. This generates the precise clock for the filters and for the logic timing and control of the chip.

CIRCUIT IMPLEMENTATION
Standard CMOS technology is used for the entire circuit. Logic functions use standard low-power circuitry while the analog circuits use precision switched-capacitor-filter technology.

HOW TO USE THE TERIDIAN DTMF RECEIVERS
PRECAUTIONS
Although static protection devices are provided on the high-impedance inputs, normal handling precautions should be observed for CMOS devices.

All CMOS parts are prone to a destructive latch-up mode. This behavior is inherent to these parts due to their physical structure. The latch-up mode can best be described as a low impedance, high current state existing between the power supply connections on a CMOS chip. This is also referred to as triggering of parasitic SCR behavior.

The most common cause of latch-up mode is operating a CMOS part outside of its rated power supply voltage. Over-voltage at any pin can cause latch-up. For the TERIDIAN DTMF Receivers and Transceivers, the pin voltage should be constrained to the range between $V_N - 0.5V$ and $V_P + 0.5V$ (except the analog input pin whose conditions are discussed below). Clamping diodes should be utilized wherever necessary to ensure that voltage ratings are not exceeded.

Another cause for latch-up is fast $dv/dt$ transients affecting the chip. These transients are encountered in applications that require the connection/disconnection of “live” boards. While these applications are very rare and their implementation is best avoided, it must be mentioned that whenever they are necessary, they present a severe environment for CMOS parts. Care must be taken in such instances to ensure that ground planes and supply rails are connected first and disconnected last. This will go a long way in eliminating voltage transients.
Voltage transients that exist on power lines must also be controlled. High voltage transients caused by switching of high current devices can trigger latch-up. High frequency decoupling is a requirement for the proper operation of TERIDIAN DTMF devices. A 0.01 mF to 0.1 mF ceramic decoupling capacitor should be connected to the power supply pin at the chip.

**POWER SUPPLY**

Excessive power supply noise should be avoided, and to aid the user in this regard, power supply hook-up options are provided on some devices.

Since the digital circuitry of the devices possess a high noise immunity characteristic of CMOS logic, it is the analog section that is affected the most by power supply noise. On those TERIDIAN DTMF Receivers that have separate Analog Negative and Digital Negative supply connections (grounds), namely VNA and VND, an unfiltered supply may be used at VND. It is necessary that VND and VNA vary by no more than 0.5V.

The analog circuitry of the devices require low power supply noise levels as specified on the device data sheet. The effects of excessive power supply noise are decreased tone amplitude sensitivity and less tone detection frequency bandwidth. Power supply noise can be significantly reduced by decoupling the IC with a 0.1 mF ceramic capacitor. Power supply noise effects will be slightly less if the analog input is referenced to VP. This is accomplished by connecting VP to ground and utilizing the negative power supply. Obviously this means the digital logic must also have a negative supply.

**DIGITAL INPUTS**

The digital inputs are directly compatible with standard CMOS logic levels powered by VP and VN (or VND). The input logic levels should swing within 30% of VP or VN to insure detection. Any unused input must be tied to VN or VP.

**ANALOG INPUT**

The analog input is the signal input pin for the devices, and is specially biased to facilitate its connection to external circuitry, as shown in Figure 2. The signal level at the analog input pin must not exceed the positive supply as stated on the device data sheets. If this condition cannot be guaranteed by the external circuitry, the signal must be AC coupled into the chip with a 0.01 mF ± 20% capacitor.

**ANALOG INPUT NOISE**

The TERIDIAN DTMF Receivers will tolerate wide-band input noise of up to 12 dB below the lowest amplitude tone component during detection of a valid tone pair. Any single interference frequency (including tone harmonics) between 1 kHz and 6 kHz should be at least 20 dB below the lowest amplitude tone component. Adherence to these conditions will ensure reliable detection and full tone detection frequency bandwidth. Because of the internal band limiting, noise with frequencies above 8 kHz can remain unfiltered. However, noise near the 56 kHz internal switched-capacitor-filter sampling frequency will be aliased (folded back) into the audio spectrum; noise above 28 kHz therefore should be low-pass filtered with a circuit shown in Figure 3 using a cut-off frequency \( f_c \) of 6.6 kHz.

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**FIGURE 2: Direct and AC Coupled Configurations**

![Diagram showing direct and AC coupled configurations](image)
A 1 kHz frequency cut-off frequency filter can be used on “normal” phone lines for special applications. When a phone line is particularly noisy, tone pair detection may be unreliable. A 1 kHz low pass filter will remove much of the noise energy but maintain the tone groups; however, decreased speech immunity will result. This usage should only be considered for applications where speech immunity is not important, such as control paths that carry no speech.

Some DTMF tone pair generators output distorted tones that the TERIDIAN DTMF Receivers may not detect reliably (inexpensive extension telephones are an example). Most of the interfering harmonics of these may be removed by use of a 3 kHz low-pass filter as in Figure 3. Some speech immunity degradation will result. It should be mentioned that when using low-pass filters, a higher cut-off frequency will preserve more of the speech immunity advantages.

The TERIDIAN DTMF Receivers provide superior speech immunity and noise rejection. The analog signals are subjected to stringent criteria and rigorous qualification in order to assure that only true DTMF tone pairs are detected and decoded properly. Stray signal and noise with sufficient amplitude will cause a DTMF receiver to disqualify a valid DTMF tone pair.

Such a condition can be occasionally encountered when using DTMF “beepers.” Beepers are normally used to transmit DTMF signals from dial-pulse phones. It has been observed that non-linearity in the response of carbon microphones in telephone handsets introduces intermodulation products, which actually produce new frequency components. These components happen to fall directly into the useful bandwidths of some of the basic tones that the receiver must detect. Because of the presence of these components (normally referred to as third-tone) with a valid DTMF tone, detection is disabled. To inhibit the more common higher frequency third tones from arriving at the receiver, the circuit shown in Figure 4 is suggested.

**TELEPHONE LINE INTERFACE**

In applications that use a TERIDIAN DTMF Receiver to decode DTMF signals from a phone line, a DAA (Direct Access Arrangement) must be implemented. Equipment intended for connection to the public telephone network must comply with and be registered in accordance to FCC Part 68. For PBX applications, refer to EIA Standard RS-464. Some of the basic guidelines are:

1. Maximum voltage and current ratings of the TERIDIAN DTMF Receivers must not be exceeded; this calls for protection from ringing voltage, if applicable, which ranges from 80 to 120V RMS over a 20 to 80 Hz range.
2. The interface equipment must not breakdown with high-voltage transient tests (including a 2500V peak surge) as defined in the applicable document.
3. Phone line termination must be less than 200Ω DC and approximately 600Ω AC (200-3200 Hz).
4. Termination must be capable of sustaining phone line loop current (off-hook condition) which is typically 18 to 120 mA DC.
5. The phone line termination must be electrically balanced with respect to ground.
6. Public phone line termination equipment must be registered in accordance to FCC part 68 or connected through registered protection circuitry.

Figure 5 shows a DAA. Features include:

1. 150V surge protector to eliminate high voltage spikes.
2. An optocoupler ring detector, optically isolated from the supervisory circuit.

**FIGURE 3: Filter for Use in Noisy Environments**

<table>
<thead>
<tr>
<th>FC (kHz)</th>
<th>R (kΩ) (5%)</th>
<th>C (µF) (20%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>1.6</td>
<td>0.1</td>
</tr>
<tr>
<td>3.1</td>
<td>5.1</td>
<td>0.01</td>
</tr>
<tr>
<td>6.6</td>
<td>2.4</td>
<td>0.01</td>
</tr>
</tbody>
</table>

**SUGGESTED COMPONENT VALUES**
2. Back-to-back Zener diodes to protect the DTMF (and optional multiplexer Op-Amp) from ringer voltage.
3. Audio multiplexer which allows voice or other audio to be placed on the line (a recorded message, for example) and not interfere with incoming DTMF tone detection.

**OUTPUTS**

The digital outputs of the TERIDIAN DTMF Receivers (except XOUT) swing between VP and VN (or VND) and are fully compatible with standard CMOS logic devices powered from VP and VN. The 5V DTMF devices will also interface directly to LSTTL.

Data Outputs D8, D4, D2 and D1 are three-state enabled to facilitate an interface to a three-state bus. Care must be taken to prevent the substrate diodes from becoming forward biased or damage may result.

**TIMING**

Within 40 ms of a valid tone pair appearing at the DTMF Receiver Analog Input, the Data Outputs D8, D4, D2 and D1 will become valid. Seven microseconds after the data outputs have become valid DV will be raised. DV will remain high and the outputs valid while the valid tone pair remains present. Refer to individual data sheets for the timing of signals.

**SYSTEM INTERFACE**

Provision has been made on the TERIDIAN DTMF receivers and transceivers (with the exception of TERIDIAN 75T204) for handshake interface with an outside monitoring system. In this mode, the DV strobe is polled by the monitoring system at least once every 40 ms to determine whether a new valid tone pair has been detected. If DV is high, the coded data is stored in the monitoring system and the monitoring system pulses CLRDV digit “high.
With some systems operating in the handshake mode, it may be desirable to know when a valid pause has occurred. Ordinarily this would be indicated by the falling edge of DV. However, in the handshake mode, DV is cleared by the monitoring system each time a new valid tone pair is detected and, therefore, cannot be used to determine when a valid pause is detected. The detection of a valid pause in this case may be observed by detecting the clearing of the Data Outputs. Since, in hexadecimal format (the mode usually used with a handshake interface), the all zero state represents a commonly unused tone pair (digit "D"), the detection of a valid pause may be detected by connecting a four input NOR gate to the device outputs and sensing the all zero state.

**TIME BASE**
The TERIDIAN DTMF Receivers contain an on-chip oscillator for a 3.5795 MHz parallel resonant quartz crystal. The crystal is placed between XIN and XOUT in parallel with a 1 MΩ resistor, while XEN is tied high. Since the switched-capacitor-filter time base is derived from the oscillator, the tone detect band frequency tolerance is proportional to the time base tolerance. The TERIDIAN DTMF Receiver frequency response and timing is guaranteed with a time base accuracy of ±0.01%. To obtain this accuracy, use CTS Part No. MP036, Fox Part No. FOX36S or equivalent quartz crystal.

When the oscillator is connected as above, and XEN is tied high, the ATB (Alternate Time Base) pin delivers a square wave output at one-eighth the oscillator frequency (447.443 kHz nominal). The ATB pin can be converted to a time base input by tying XEN low; ATB can then be externally driven from another device such as the ATB output of another DTMF. No crystal is required for the ATB input device; XIN must be tied high if unused. Several TERIDIAN DTMF Receivers can be driven with a single crystal (refer to device data sheet for fan-out limit).

XOUT is designed to drive a resonant circuit only and is not intended to drive additional devices. If a 3.58 MHz clock is needed for more than one device and it is desirable to use only one resonant device, an separate inverter should be used for the oscillator inverter, buffered by a second inverter or buffer. The buffer output would then drive XIN of the TERIDIAN DTMF Receiver as well as the other device(s); XOUT must be left floating and XEN tied high.

**DIAL TONE REJECTION**
The TERIDIAN DTMF Receivers incorporate enough dial tone rejection circuitry to provide dial tone tolerance of up to 0 dB. Dial tone tolerance is defined as the total power of precise dial tone (350 Hz and 440 Hz as equal amplitudes) relative to the lowest amplitude tone in a valid tone pair. The filter of Figure 6 may be used for further dial tone rejection. This filter exhibits an elliptic highpass response that provides a minimum of 18 dB rejection at 350 Hz, and 24 dB rejection at 440 Hz so long as the component tolerances indicated are observed. The DTMF on-chip filter rejects 350 Hz at least 6 dB more than 440 Hz. Therefore, employing the filter of Figure 6 yields a dial tone tolerance of +24 dB.

**PRINTED CIRCUIT BOARD IMPLEMENTATION**
The TERIDIAN DTMF Receivers are analog in nature and should be treated as such; circuit noise should be kept to a minimum.

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**FIGURE 6: Dial Tone Reject Filter**

Note: All resistors 1%, all caps 5%, unless noted, op-amps: 1/2 LM1458 or equivalent
To be certain of this, all input and output lines should be kept away from noise sources (high frequency data or clock lines); this is especially true for the Analog Input. Noise in the ground or power supply lines can be avoided by running separate traces to support logic circuits or by running thicker (lower resistance) busses. Capacitive power supply bypassing should be performed at the device. Refer to the Power Supply section above.

PERFORMANCE DATA
A portion of the final TERIDIAN DTMF Receiver device characterization uses the Mitel CM7290 tone receiver test tape. The evaluation circuit shown in Figure 7 was used to characterize the TERIDIAN 75T202. The speed and output level of the tape deck must be adjusted so that the calibration tone at the beginning of the tape is exactly 1000 Hz at 2V RMS.

The Mitel tape yields similar results on all of the TERIDIAN DTMF Receivers. Test results for the TERIDIAN 75T202 are summarized in Table 2 (performance of other receivers is identical to the 75T202). In short, the measured performance data demonstrates that the TERIDIAN DTMF Receivers are monolithic realizations of a full "central office quality" DTMF receiver.

<table>
<thead>
<tr>
<th>TEST #</th>
<th>RESULTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>2a, b</td>
<td>B.W. = 5.0% of fo</td>
</tr>
<tr>
<td>2c, d</td>
<td>B.W. = 5.0% of fo</td>
</tr>
<tr>
<td>2e, f</td>
<td>B.W. = 5.3% of fo</td>
</tr>
<tr>
<td>2g, h</td>
<td>B.W. = 4.9% of fo</td>
</tr>
<tr>
<td>2i, j</td>
<td>B.W. = 5.0% of fo</td>
</tr>
<tr>
<td>2k, l</td>
<td>B.W. = 5.3% of fo</td>
</tr>
<tr>
<td>2m, n</td>
<td>B.W. = 5.3% of fo</td>
</tr>
<tr>
<td>2o, p</td>
<td>B.W. = 4.8% of fo</td>
</tr>
<tr>
<td>3</td>
<td>160 decibels</td>
</tr>
<tr>
<td>4</td>
<td>Acceptable Amplitude Ratio (Twist) = -19.1 dB to +15.2 dB</td>
</tr>
<tr>
<td>5</td>
<td>Dynamic Range = 32.5 dB</td>
</tr>
<tr>
<td>6</td>
<td>Guard Time = 23.3 ms</td>
</tr>
<tr>
<td>7</td>
<td>100% Successful Decodes at N/S Ratio of –12 dBV</td>
</tr>
<tr>
<td>8</td>
<td>2-3 Hits Typical on Talk-Off Test</td>
</tr>
</tbody>
</table>

TABLE 2: Mitel #CM7290 Test Tape Results for 75T202 (Averaged for 10 parts)
APPLICATIONS
CREATING HEXADECIMAL “0” OUTPUT UPON DIGIT “0” DETECTION
To be consistent with pulse-dialing systems, the TERIDIAN DTMF Receivers provide hexadecimal “10” output upon the detection of a digit “0” tone pair when in the hexadecimal code format. However, some applications may instead require a hexadecimal “0” with a digit “0” detection. The circuit of Figure 8 shows an easy method to recode the hexadecimal outputs to do this using only 4 NOR gates.

FIGURE 8: HEX “0” out with Digit “0” Detect Conversion Circuit

```
<table>
<thead>
<tr>
<th>Digit</th>
<th>D8</th>
<th>D4</th>
<th>D2</th>
<th>D1</th>
<th>Hexadecimal &amp; Figure 8 Circuit</th>
<th>Digit</th>
<th>D8</th>
<th>D4</th>
<th>D2</th>
<th>D1</th>
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<tbody>
<tr>
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<td>1 0 0 0 0 1 1</td>
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<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
```

TABLE 3: Output Code of Figure 8
Monolithic Dual-Tone Multi-Frequency (DTMF) Receivers

Note that the circuit will not give proper code for the "*", "B" or "C" digits and will cause both digits "D" and "0" to output hexadecimal "0". This circuit should therefore be considered for numeric digits only. The output code format is shown in Table 3.

This circuit is useful for applications that require a display of dialed digits; the digit display usually requires a hexadecimal "0" input for "0" to be displayed.

16-CHANNEL REMOTE CONTROL

DTMF signaling provides a simple, reliable means of transmitting low speed information over a 2-wire twisted pair. The complete schematic of a 16-channel remote control is shown in Figure 9. When one of the keypad buttons is depressed, a tone pair is sent over the transmission medium to the TERIDIAN DTMF Receiver.

The 74HC4514 raises one of its 16 outputs in response to the 4-bit output code from the DTMF. The output at the 74HC4514 will remain high until the next button is depressed.

2-OF-8 OUTPUT DECODE

The circuit shown in Figure 10 can be used to convert the binary coded 2-of-8 to the actual 2-of-8 code (or 2-of-7 if detection of the 1633 Hz tone is inhibited). The output data will be valid while DV is high. If it is desired to force the eight outputs to zero when a valid tone is not present, DV should be inverted and connected to both (inputs of the MC14555B.

DTMF TO ROTARY DIAL PULSE CONVERTER

The 2-of-8 output of Figure 10 can be modified to interface with a pulse dialer as shown in Figure 11. Figure 12 shows the interface for adding pulse detection and counting to a TERIDIAN DTMF Receiver.

The loop detector provides a digital output representing the telephone loop circuit "make" and "break" condition associated with rotary pulse dialing. For the circuit of Figure 12, ground represents a "make" and VP a "break". The loop detector feeds dial pulses to IC-1, a binary counter, and to IC-2A, a re-triggerable "one-shot". When a dial pulse appears the 4_output of IC-2A immediately goes low, resetting IC-1. The clock input to IC-1 is delayed by R1-C1 so that reset and count input do not overlap. The binary outputs of IC-1 will reflect the pulse count and 0.2 seconds after the last pulse the 4_output will go high. C3-R3 differentiates this pulse and clocks the output latch, IC-3, holding the output pulse until the next digit.

The 0.2 second timeout of IC-2A indicates the end of dial pulsing since even a slow (8 pps) dial would input another pulse every 0.125 seconds. The binary outputs of IC-1 are paralleled with those of the TERIDIAN DTMF Receiver circuit through diodes to the inputs of IC-3. A pull-down resistor is necessary on each IC-3 input pin. IC-1 must be a binary, not BCD, counter.

With a 74HC175 for IC-3 the output data is latched until the next valid input, whether from a rotary dial or dual tone instrument. A unique situation exists, however, when going on-hook. The loop detector will output a continuous level of VP, which would trigger IC-2A and put a single count into IC-1. A high level from the loop detector also turns on Q1, pulling the clock input of IC-3 to ground. Since the loop detector output will be low at the completion of dialing, all outputs are valid even when the telephone is placed on-hook, an important consideration if output data is recorded.
FIGURE 11: Touch-Tone™ to Rotary Dial Pulse Converter Adding Rotary Dial Pulse Detection Capabilities
FIGURE 12: Adding Pulse Detection and Counting to the TDK DTMF Receiver