CAT PAPER

CAT Paper: P-4

Discussion about DTMF Decoding

All of the CAT controllers use DTMF decoders and is a vital component in operating and controlling any repeater. If the DTMF decoder becomes inoperative or is not working at all, several signals, voltages, etc., can be measured in determining how the DTMF problem can be corrected.

A Look At The DTMF Signal

DTMF generation is a composite audio signals of two tones between the frequency of 697Hz and 1633Hz. The DTMF keypad is arranged such that each row will have it's own unique tone frequency and also each column will have it's own unique tone. Below is a representation of the typical DTMF keypad and the associated row/column frequencies.

High Tone Group

Low Tone Group

	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

By pressing a key, for example 5, will generate a dual tone consisting of 770 Hz for the low group, and 1336 Hz of the high group.

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CAT PAPER

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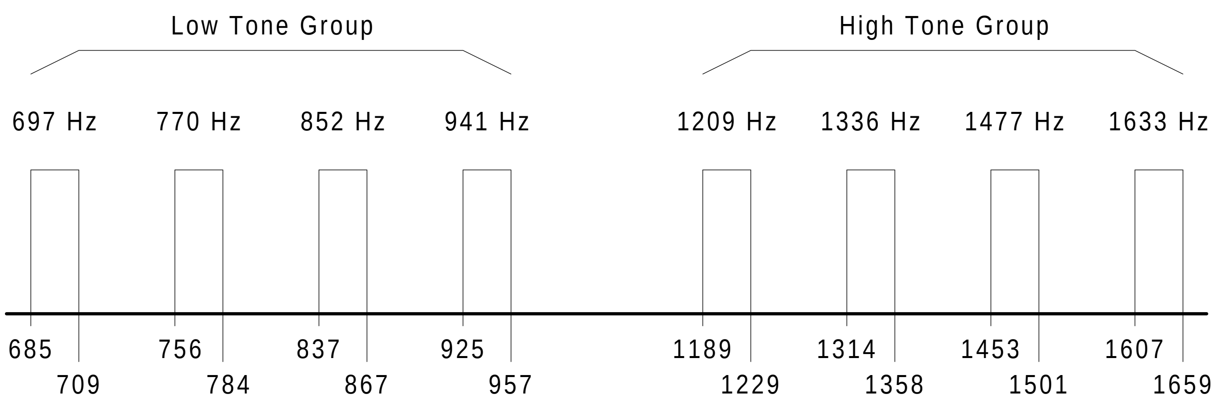
The tone frequencies were selected such that harmonics and intermodulation products will not cause an unreliable signal. The decoders used in the CAT controllers have a digital low/ high tone decoder with frequency passband as follows:



As the above frequency spectrum illustrates, each tone must fall within the proper bandpass before a valid decode will take place. If one, or both tone(s) falls outside the spectrum bandpass, the decoder will operate erratic becoming unreliable or not operate at all.

Signal Input Levels

Another important requirement for reliable decoding is the signal level applied to the decoder audio input. The manufacture rates the dynamic range as from -26 dBm to +2 dBm. However, when the decoder is used across a radio link, the level input needs to be adjusted with care. After careful study and field testing, 220 mVAC at the decoder input proved to provide the best input level. This is why audio level adjustments when installing a CAT controller calls for the decoder level input adjusted first for a solid input to the decoder of 220 mVAC.

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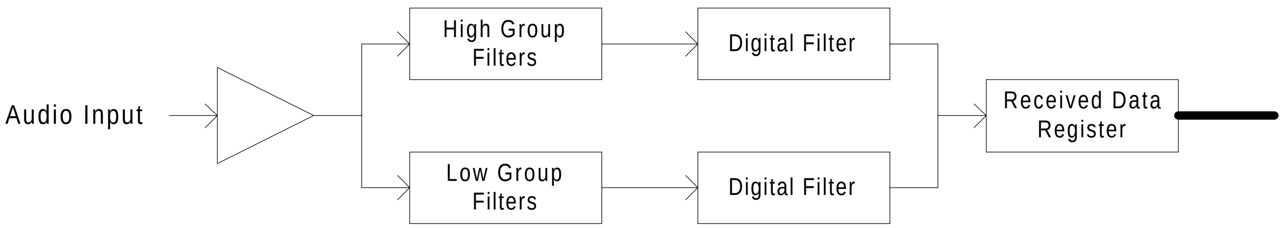
Twist, what is it?

Twist is known as the difference in signal levels between the two tones. If a DTMF tone applied to the decoder IC has equal low and high tone amplitudes, the twist is equal to zero. However in communication links, were the DTMF signal is amplified and possible filtered in the radio receiver, twist can become a concern because the frequency response of that receiver is not flat. Usually the higher frequency tone group will be attenuated resulting in the higher DTMF keys A, B, C, and the D key becoming effected whereas the other keys are working OK. Remember also that the transmitting DTMF signal can also have some twist resulting in some handy talkies working OK while others are not.

If you suspect twist to be a problem, you'll need to first find out if the problem is transmitted twist. That is, make sure your transmitted signal is flat before you proceed to the receiver. If the twist is being generated in the receiver, an oscilloscope will be your best piece of test equipment to trace down were the problem is. Using the receiver's schematic, begin at the FM discriminator and make measurements with each tone group. Once you have your base measurements (and have determined they look OK with no twist), move your scope probe along the receiver signal path and look for any signal degradation. If your taking your receiver signal off of the speaker for example, now would be the time to move your signal pick-off point ahead of the audio output amplifiers. You will notice not only an improvement or removal of twist, but usually the audio quality will be improved.

Microprocessor Interface

Once the DTMF signal has been applied, internal interfacing circuits must first separate the two tones into two discrete tones, one from the low group and the other from the high group.



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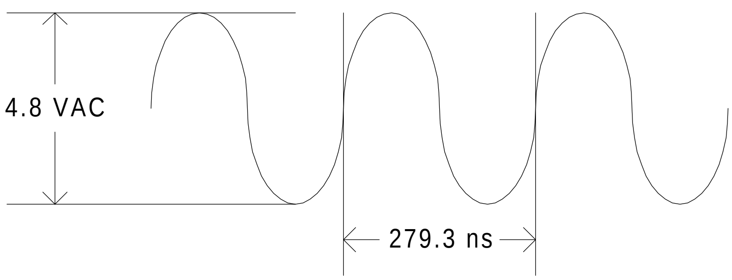
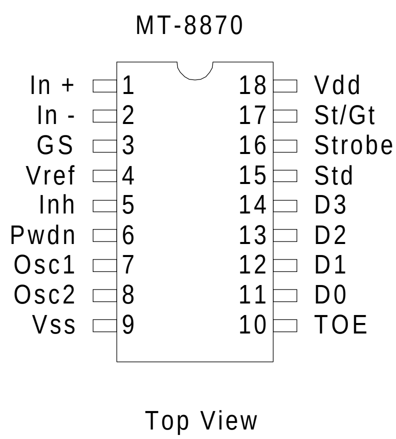
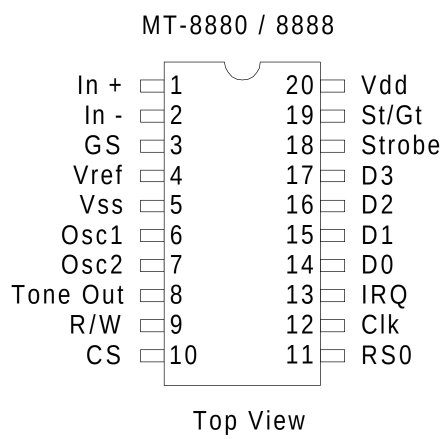
Discussion about DTMF Decoding

Once separated, the signals are applied to two digital filters to decode the exact tone. Since the digital filters operate with internal clock signals, it is necessary to have some sort of clock standard (accurate and stable) to insure consistant filtering and decoding. The clock source for these decoders is an external color burst crystal (3.5795 Mhz) connected between the OSC1 and OSC2 integrated circuit pins. Measurement of the internal clock signal can be made with an oscilloscope connected to the OSC2 pin of the integrated circuit to determine if the clock signal is satisfactory. (Use X10 probe)



MT-8870	Pin 8
MT-8880	Pin 7
MT-8888	Pin 7





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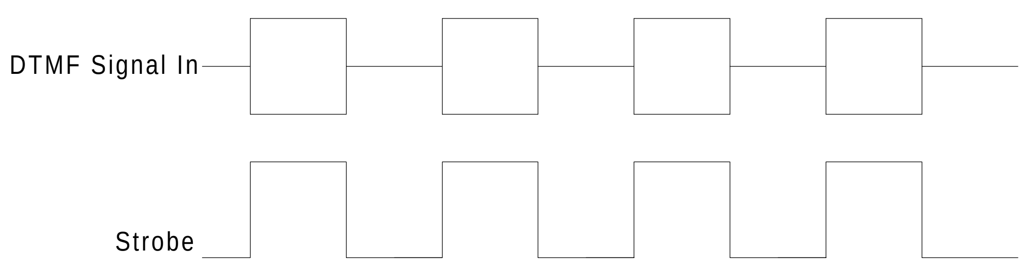
CAT
PAPER

Discussion about DTMF Decoding

Next the microprocessor needs to be signaled that a valid DTMF tone has arrived. The decoder accomplishes this by a signal output from the decoder called STROBE. That signal can be monitored by an oscilloscope to determine if the microprocessor is being told a signal has arrived. For the different decoder devices used in the CAT controllers, the pin numbers for the stobe signal are:

MT-8870	Pin 15
MT-8880	Pin 18
MT-8888	Pin 18

While having your scope probe connected to the strobe pin, apply a signal into the receiver and modulate it with DTMF tones. For each tone you press, the strobe line should increase from near zero volts, to a voltage between 4.5 to 5.0 VDC. Try all of the 16 DTMF tones to insure that all of them are decoding satisfactorily. Remember, if the strobe line does not respone to DTMF inputs, then a problem with the audio input needs to be investigated.



CAT PAPER

Discussion about DTMF Decoding

Digit	Freq Low	Freq High	D3	D2	D1	D0
1	697	1209	0	0	0	1
2	697	1336	0	0	1	0
3	697	1477	0	0	1	1
4	770	1209	0	1	0	0
5	770	1336	0	1	0	1
6	770	1477	0	1	1	0
7	852	1209	0	1	1	1
8	852	1336	1	0	0	0
9	852	1477	1	0	0	1
0	941	1336	1	0	1	0
*	941	1209	1	0	1	1
#	941	1477	1	1	0	0
A	697	1633	1	1	0	1
B	770	1633	1	1	1	0
C	852	1633	1	1	1	1
D	941	1633	0	0	0	0

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