73M2901CE
V.22 *bis* Single Chip Modem

APPLICATION NOTE

AN_2901CE_040 **January 2009**

Using the 73M2901CE DTMF Detector

Introduction

One of the features of the 73M2901CE is the DTMF detection function. The 73M2901CE supports all the modes described in this application note.

Description

The DTMF detector uses Goertzel filters to detect valid DTMF tone pairs. This is a Discrete Fourier Transform (DFT) technique that is commonly used for detecting specific frequencies, such as DTMF. This detector can be used in two ways, either through a test mode (J6 command) while interrogating the DTMF detector register, S65, or by way of a DTMF Caller ID mode (S95=48) that is used in some countries. Caller ID is normally received only when the modem is in an on-hook condition (there are exceptions for some countries). Due to the amount of processing that is required for the DTMF detection algorithm, the 73M2901CE does not detect DTMF during call progress or a data connection; it detects DTMF only while on hook. Call progress is defined as off-hook but not sending or receiving a data carrier, so once the 73M2901CE has gone off hook, DTMF detection is not possible. This may present a problem for some applications, but there are ways to get around this limitation, as discussed later in this application note. Also, some machine generated DTMF tone sequences may be difficult to detect because the 73M2901CE DTMF detector requires a tone to be present for at least 100 ms. Manually entered DTMF will nearly always be present for greater than 100mS and therefore is easily detected.

Methods

The first method of detecting DTMF is a completely user driven method that can be used when the modem is expecting a manually entered DTMF input. To use this method, the modem, in an on-hook condition, is given the “ATJ6<CR><LF>” command to put it in the DTMF receive test mode. As an aid to making the interrogation of the S65 DTMF detect register as fast as possible, it is suggested that the commands be given at 9600bps. Also, bit 5 of S73 should be cleared to remove the 125ms delay between commands. When a DTMF tone is expected, the S65 register is interrogated by sending “ATS65? <CR><LF>”. The 73M2901CE will then return a “1” in the MSB location of along with the lower nibble representing the digit received (see Figure 1).

If the MSB is not a “1”, a valid tone was not detected. Once the “ATS65?<CR><LF>” is given, it is not necessary to send the entire command string again to poll the DTMF detection register. Simply send “A/” (without <CR><LF>”) and the modem will repeat the last command given. This can make polling a bit faster and easier. Do this repeatedly until you receive an indication that a DTMF tone was received. This can be repeated to detect any number of DTMF digits, but when receiving a tone sequence, the user must also detect the silent periods between digits as well since it may be possible that the same digit is consecutively sent.

The second method is called DTMF Caller ID mode. The DTMF Caller ID mode is enabled by the S95 Caller ID register (Figure 2). The exact modes supported by S95 differ slightly for different versions of the 73M2901CE, but the DTMF modes are the same. Caller ID is off by default. When it is enabled and a caller ID message is received, the 73M2901CE will output “CID:xxxxxxxxx” where xxxxxxxxx is the Caller ID message that is received. To obtain only the raw DTMF digit data output without “CID:”, set the S95 register to enable DTMF Caller ID and set bit D7 to 0 (the default is 1) with “ATS95=48<CR><LF>”. In this mode, the digits are detected automatically (along with the separating spaces), so polling is eliminated. The digits are output on RXD (in ASCII) as they are received without “CID:” at the beginning.

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
Det Valid	Reserved	Reserved	Reserved	DTDET3	DTDET2	DTDET1	DTDET0

DTMF Detect bits					Dialed	Tone Pair Detected	
Det Valid	DTDET 3	DTDET 2	DTDET 1	DTDET 0	Digit	Low Tone (Hz)	High Tone (Hz)
1	0	0	0	0	D	941	1633
1	0	0	0	1	1	697	1209
1	0	0	1	0	2	697	1336
1	0	0	1	1	3	697	1477
1	0	1	0	0	4	770	1209
1	0	1	0	1	5	770	1336
1	0	1	1	0	6	770	1477
1	0	1	1	1	7	852	1209
1	1	0	0	0	8	852	1336
1	1	0	0	1	9	852	1477
1	1	0	1	0	0	941	1336
1	1	0	1	1	*	941	1209
1	1	1	0	0	#	941	1477
1	1	1	0	1	A	697	1633
1	1	1	1	0	B	770	1633
1	1	1	1	1	C	892	1633

Figure 1: S65 DTMF Detection Register Table

Normally DTMF signaling is received through the Caller ID path that consists of a series resistor and capacitor that bypass the hook switch. In order to meet telephone network recommendations this path must have an AC impedance of greater than 60KΩ for the U.S. and many other countries. The reason for this it to assure that when a number of Caller ID enabled devices are connected in parallel on a PSTN connection, they will not load the line and unduly attenuate the Caller ID signals. This also significantly attenuates the Caller ID signal to the 73M2901CE. Caller ID is normally received at a fairly high amplitude since it is sent from the local telephone office, but the Caller ID R/C network impedance in series with the 600 Ω transformer presents approximately 40 dB loss from the line to the 73M2901CE. To help compensate for some of this loss the 73M2901CE has an automatic 20dB gain boost that is used when in the Caller ID mode. This still leaves approximately 20dB of attenuation, but the receive dynamic range of the 73M2901CE can deal with this additional loss. DTMF is also sent at a higher level than normal voice and data, so this also works in our favor during DTMF reception. DTMF received from a remote telecom device could have additional network attenuation. All this will add some additional settling time. This can present a problem for detection of DTMF tones, and there may be some benefit from bypassing the hook relay with a low impedance (a parallel switch and possibly a capacitor for example) to minimize signal loss and noise. The CID gain boost should usually be disabled if a low impedance path is used, but if you are always expecting to receive low-level signals, it might be better to leave it in. CID gain boost is controlled by S110 bit 5 and is ON by default during Caller ID reception. To turn it off, use the command “ATS110-32<CR><FL>”. Reliable reception under laboratory conditions was achieved with a short across the hook switch and gain boost off at receive levels of -38 dBm and with tone durations of 70 ms. Remember that for normal Caller ID reception the network must be in an “on hook” state without a DC path enabled. As they say, “your results may vary” depending on conditions such as noise, signal amplitude, distortion, or other external factors.

If for any reason there is a need to receive DTMF while off hook, the off hook condition must be controlled by a signal other than the 73M2901 RELAY pin. It can be done using one of the USR pins to control an additional relay, if they are not being used for some other purpose, or directly from the modem’s host processor. In many cases, it can simply be wire-ORed with the RELAY signal through a current limiting resistor. In this case, the 40 dB attenuation from the CID path is not going to be present, so the CID gain boost is not needed and the CID gain boost should be turned off.

There may be cases where an application jumps from a connected modem state to DTMF sending and receiving or vice versa. In these cases it will be necessary to “fool” the 73M2901CE into thinking it is on-hook during the DTMF periods while still maintaining a connection with the other end. If the modem is hung up, the connection will be broken, so in this case it is necessary to have a second hook switch control besides the RELAY signal output. In this way, the modem can think it hangs up even though the connection is enabled. The modem can then be used for whatever DTMF functions it needs to perform and then reconnected as a modem if needed. When reconnecting as a modem, simply send ATD or ATA (depending on which side of the connection the modem is on), but make sure you do not have dial tone detection enabled when ATD is used since there won’t be a dial tone sent from the network.

Bit 0	Dual Tone – Alert Signal expected.
Bit 2:1	Number (0-3) of Line Reversal and/or Ring Pulse – Alert Signals expected before CID.
Bit 3	CID expected between 1st and 2nd Power Rings. Note: bits 0 through 3 of S95 are ignored if bit 7 = 0.
Bit 4	Enables CID option. This bit applies only to On-Hook/Offline/Type I Caller-ID.
Bit 5	0 = FSK modulation used for CID. 1 = DTMF type CID.
Bit 6	Enables using USER 11output to signal DAA to enter CID state during IDLE mode.
Bit 7	Enables using USER11 output to signal DAA to enter Idle-line signaling state for CID. Bit 7 = 0 sets continuous CID mode where S95 bits 0, 1, 2, and 3 are ignored. Also enables using USER 11 output to signal DAA to enter idle line signaling state for LIU-E detection.

Special modes:

S95 = 0X01 0000B	FSK Continuous Caller ID mode.
S95 = 0X110000B	Send detected DTMF codes to DTE without “CID:” message.
S95 = 10011001B	Detect US Type 1 and Type2 Snoop CID simultaneously. In this mode the modem may automatically modify S72 register bit 5 to look for Dots (Type1) or marks (Type 2 Snoop).

Figure 2: 73M2901CE S95 Register Description

As can be seen, there are many ways the 73M2901CE can be used outside normal modem applications. Some care is needed to make sure the application presents the required signal levels and tone durations for compatibility with the detector characteristics of the 73M2901CE. There are trade-offs between the receive levels, CID gain, and tone durations, so it is difficult to specify exactly what can be expected from the DTMF detector for every situation. The 73M2901CE DTMF detector has proven to work well in a variety of applications and under laboratory conditions. With some attention to detail and within the stated limitations, it is highly likely you can use it for DTMF communications in you application.

Revision History

Revision	Date	Description
1.3	1/15/2009	Converted original version 1.3 to Teridian format and changed doc number from AN-021 to AN_2901CE-040. There is no change to technical content.