CML Microcircuits

COMMUNICATION SEMICONDUCTORS

Application Note

Motorola MC145443 to CMX865A Migration

1 Introduction

Many designs have used the Motorola/Freescale MC145443 Bell 103 modem for low speed data communications, but those designs are now in jeopardy because the MC145443 has been made obsolete. The new CMX865A 1200bps/300bps modem IC can easily be made to replace the MC145443 for customers who wish to support legacy designs with a minimal amount of redesign effort. The purpose of this application note is to describe how the CMX865A can be made to replace the MC145443.

The new CMX865A from CML Microcircuits can perform the same functions as the MC145443. In addition to supporting the Bell 103 communications of the MC145443, the CMX865A also integrates additional features that had to be performed with external circuits in MC145443 designs. The CMX865A consumes much less current than the older Motorola/Freescale device, and as with all CML devices, the CMX865A can be obtained as a RoHS product.

The CMX865A datasheet should be consulted while reviewing this application note

2 CMX865A 1200bps/300bps Modem IC

The CMX865A is an ideal replacement for the MC145443 Bell 103 modem IC. In addition to supporting the Bell 103 standard used by the MC145443, the CMX865A integrates many telecom features that were performed by external components in MC145443 designs. Additionally, the 1200bps capability of the CMX865A allows for faster in-the-field firmware updates, if needed.

The rich feature set of the CMX865A includes the following:

- Bell 103 and V.21 (300bps)
- Bell 202 and V.23 (1200bps)
- DTMF Tx/Rx
- Low voice-falsing DTMF detector
- Call progress tone detection
- User-programmed tone Tx/Rx

3 Functional Differences between MC145443 and CMX865A

The CMX865A can be considered as a superset of the MC145443's functions, but with a serial microcontroller interface. The following table lists the major functional differences between the MC145443 and the CMX865A:

Function	**MC145443**	**CMX865A**
Power supply voltage?	4.5V – 5.5V	3.0V to 3.6V
Packages?	20-PDIP, 20-SOG	16-SOIC, 16-TSSOP
Crystal frequency?	3.2MHz – 5.0MHz	6.144MHz
Operating current consumption?	7mA	4mA (V_{DD}=3.3V)
Powersave current consumption?	200uA	6.5uA
Tx data loading?	Asynchronously from host via 'bit-banging'	Loaded byte-wise, over C-BUS interface, into Tx Data register
Rx data reception?	Asynchronously, via 'bit-banging', from RxD pin	Read byte-wise, over C-BUS interface, from Rx Data register
Supported standards?	Bell 103	Bell 103, V.21 (300bps) Bell 202, V.23 (1200bps)
How is standard chosen?	Fixed	Selected by software
How to select Originate vs Answer mode?	Chosen by logic level on MODE & SQT pins	Selected by software
DTMF Tx?	Not provided	Yes
DTMF Rx?	Not provided	Yes
Call progress tone detection?	Not provided	Yes
User-programmed tone Tx/Rx?	Not provided	Yes
Echo cancellation tone (2225Hz) Tx?	Generated with logic levels on /LB and SQT pins	Generated under software control
Maximum Tx output power?	-8dBm (referenced to 600ohms)	-2.2dBm (referenced to 600ohms)
How to adjust Tx output power?	External component change	Software change
Receiver dynamic range?	-48dBm to -12dBm (36dB total)	-45dBm to -9dBm (36dB total)
How to adjust Rx input gain?	External component change	Software change

Table 1: Functional Differences between MC145443 and CMX865A

The following table illustrates the pins of the MC145443 and their counterparts on the CMX865A:

MC145443		CMX865A		
Pin Number	Pin Name	Pin Number	Pin Name	Comments
1	DSI (Driver Summing Input)	N/A	N/A	CMX865A includes DTMF Tx function so "driver summing input" is not required for DTMF. If audio is desired to be transmitted, the audio must be injected into the signal path downstream of the CMX865A.
2	/LB (Analog Loopback)	N/A	N/A	CMX865A uses software configuration (General Control register, $E0, b11) to enable analog loopback mode.
3	/CD (Carrier Detect Output)	N/A	N/A	CMX865A issues IRQ and sets a bit (Status register, $E6, b10) when carrier is detected.
4	CDT (Carrier Detect Timing)	N/A	N/A	Carrier detect timing cannot be adjusted with CMX865A.
5	RxD (Receive Data)	N/A	N/A	CMX865A issues IRQ and sets a bit (Status register, $E6, b6) when a new byte of receive data is available for reading from the Receive Data ($E5) register.
6	V_{DD}	12	V_{DD}	
7	CDA (Carrier Detect Adjust)	N/A	N/A	Carrier threshold adjustment cannot be adjusted with CMX865A.
8	Xout (Crystal oscillator output)	2	XTALN	CMX865A crystal oscillator circuit requires external load capacitors. XTALN pin can be left floating if external clock signal drives the XTAL/CLOCK pin.
9	Xin (Crystal oscillator input)	3	XTAL/CLOCK	
10	FB (Filter Bias)	N/A	N/A	Not required as CMX865A internal amplifiers are internally biased.
11	TxD (Transmit Data)	N/A	N/A	Transmit data is loaded into the CMX865A Transmit Data ($E3) register over the C-BUS interface. CMX865A issues IRQ and sets a bit (Status register, $E6, b12) when the next byte of transmit data can be loaded.
12	V_{SS}	5,6	V_{SS}	V_{SSD}=5, V_{SSA}=6
13	MODE	N/A	N/A	Operational mode of CMX865A is determined through internal registers.
14	SQT (Transmit Squelch)	N/A	N/A	CMX865A Tx output amplifier ("line driver") is enabled and disabled by manipulation of its Transmit Mode ($E1) register.
15	RxA2 (Rx input amplifier, inverting input)	7	RXAN	CMX865A Rx input amplifier provides RXFB feedback pin (8). Rx gain can be adjusted through external component selection for the input amplifier, as well as through software control of internal gain settings.
16	RxA1 (Rx input amplifier, non-inverting input)	8	RXFB	
17	TxA (Transmit Carrier)	10, 11	TXAN, TXA	CMX865A provides differential or single-ended Tx drive.
18	ExI (External Input)	N/A	N/A	Auxiliary audio, if desired for transmission, must be injected into the signal path downstream of the CMX865A.
19	V_{AG} (Analog Ground)	9	V_{BIAS}	V_{BIAS}= V_{DD}/2
20	TLA (Transmit Level Adjust)	N/A	N/A	Transmit level from the CMX865A is not externally adjustable but can be adjusted with internal software-controlled gain stages.

Table 2: Pin Differences between MC145443 and CMX865A

A significant difference between the MC145443 and the CMX865A is their interface to the host processor. The MC145443 contains no internal registers and is configured with logic levels on device pins. The CMX865A uses its C-BUS serial interface to exchange configuration information and data with the host processor. C-BUS is a simple five-wire interface that is analogous to the SPI protocol. A dedicated SPI port or a simple 'bit-banging' routine with general purpose I/O pins can be used to control the CMX865A.

The following example demonstrates the simplicity of the C-BUS interface:

- Take CSN (Chip Select) pin low to start a C-BUS transaction.
- Write 8-bit address of desired register onto COMMAND DATA pin while observing timing of SERIAL CLOCK line.
- Write 8-bit or 16-bit configuration data for desired register onto COMMAND DATA pin while observing timing of SERIAL CLOCK line.
- Take CSN (Chip Select) pin high to end C-BUS transaction.
- Repeat as necessary.

Read operations, such as for status information or received data, are conducted in the same way except the information is read from the CMX865A REPLY DATA line. More information on the C-BUS protocol can be downloaded from the Applications Notes section of the CML website.

4 Operating Differences between MC145443 and CMX865A

4.1 Transmit and Receive Operation: MC145443

The desired mode of operation (e.g. Originate or Answer) is selected by manipulation of the MODE and SQT pins. DTMF tones from an external DTMF transmitter are injected into the DSI pin for amplification by the Tx line driver. Call progress monitoring is performed either with external circuits or by host processor monitoring of the line signal. Transmit data is supplied to the TxD pin and the modulated output is provided on the TxA pin. The transmit output level is determined by the value of resistance between pins TLA and V_{DD}. Auxiliary audio, if desired, can be injected into the ExI pin for amplification by the Tx line driver.

The receive signal is fed to the RxA1 and RxA2 pins, and no provision exists to adjust the receive level internal to the MC145443. The recovered data is provided at the RxD pin. The user can adjust the carrier detect threshold and response/de-response times with external components.

4.2 Transmit and Receive Operation: CMX865A

The CMX865A device registers can be configured while the device is in powersave mode or after the powerup procedure has been performed.

Many applications will have the CMX865A in powersave mode when not involved in a data session. The CMX865A powerup procedure should be followed when bringing the device out of powersave mode into normal operation mode.

A data session is initiated with a DTMF dialing sequence, and the CMX865A includes a DTMF transmitter for this purpose. The call progress detection capability of the CMX865A allows simple determination of the call status without requiring additional external circuitry. Once the data session is underway, data for transmission is loaded byte-wise into the Tx Data ($E3) register over the C-BUS interface. The corresponding C-BUS transaction will be sixteen-bits long, with eight bits of register address followed by eight bits of register contents. Interrupts can be issued for both Tx Data Ready and Tx Data Underflow; bits 5-0 of the General Control ($E0) register determine which interrupts are enabled.

The output power of the transmit signal can be internally adjusted with bits 11-9 of the Transmit Mode ($E1) register. The transmit line driver is enabled so long as bits 15-12 of the Transmit Mode register are not 0000. In other words, the transmit line driver is enabled whenever the transmitter is enabled.

During receive operation the input signal is brought into the Rx Input Amplifier, the gain of which is configured with components on its inverting and feedback terminals. Additional receive gain control is provided by the software-controlled internal Rx gain block. The CMX865A can issue an interrupt when energy is detected in the modem band or in the call progress band. The carrier detect threshold and response/de-response time are set internal to the CMX865A and cannot be adjusted.

Data is read out of the Rx Data ($E5) register in byte increments during receive operation. (This C-BUS transaction will involve eight bits of register address on COMMAND DATA line, followed by eight bits of received data on REPLY DATA line.) Rx Data Ready and Rx Data Overflow interrupts can be issued to assist the host processor with received data management. Bits 4-0 of the General Control ($E0) register determine which interrupts are enabled.

In addition to typical modem operation, the CMX865A also provides the designer with the capability to encode or decode user-defined tones by manipulation of the Programming register. The CMX865A datasheet discusses this type of operation in detail.

5 Bell 103 Device Configuration

A typical Bell 103 modem handshake is illustrated as follows:

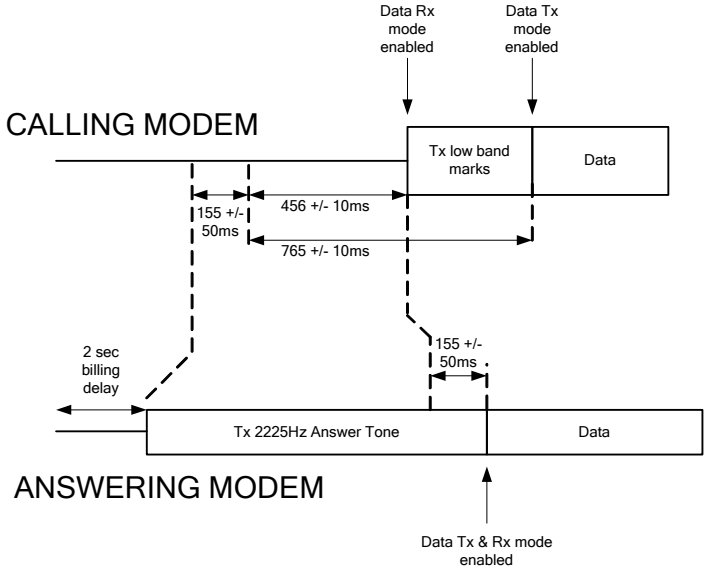
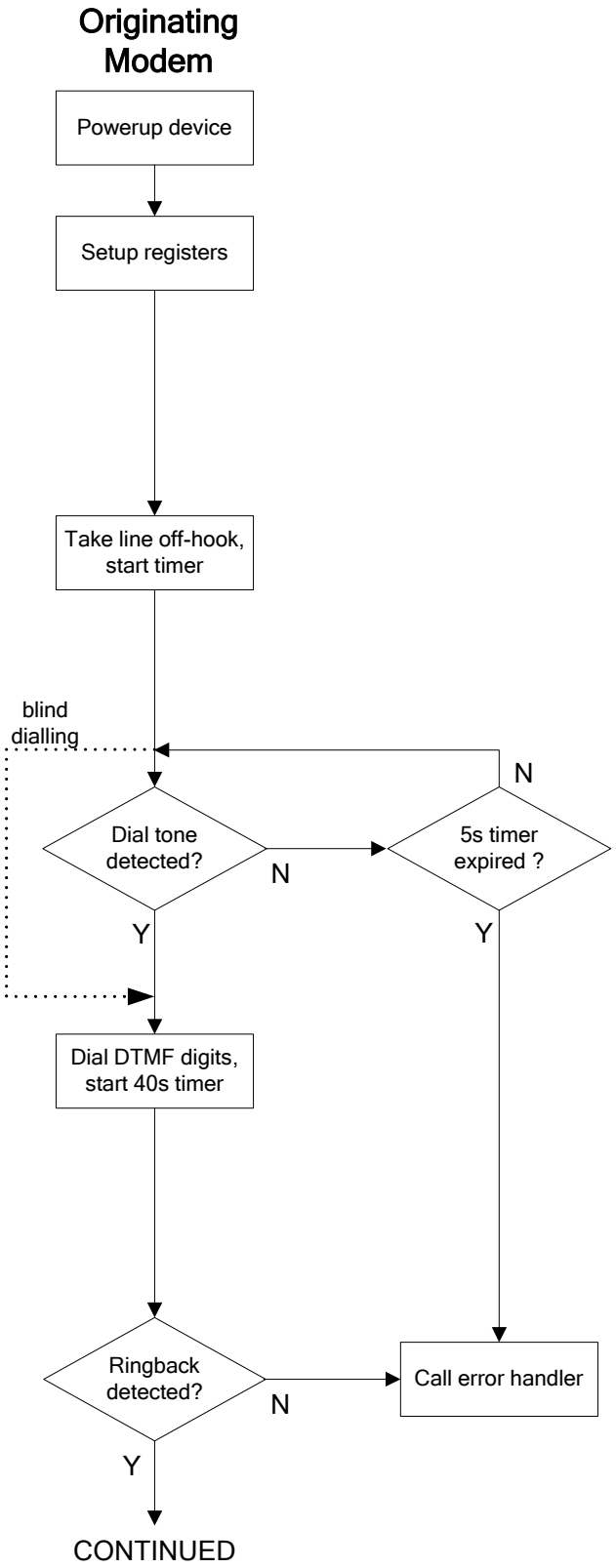


Figure 1: Typical Bell 103 'Handshake' Sequence

The following flowcharts illustrate the steps needed to configure the CMX865A for full-duplex Bell 103 communications as an originating or answering modem.



Powerup procedure provided in document and datasheet

Configure General Control register:
General Control ($E0)
b15..14 = 00 (differential Tx output drive)
b11 = 0 (no loopback)
b10 = 1 (equalizers disabled)
b8..7 = 10 (device powered up normally, not reset)
b6=1 (IRQ enabled)
b2=1 (Call progress detection IRQ enabled)

Setup for Call Progress tone detection
Rx Mode ($E2) -> Call progress tone detect mode
b15..12 = 0001 (select DTMF / Tones mode)
b11..9 = user defined (Rx level)
b8..3 = 000000 (for tones detection)
b2..0 = 011 (Call Progress tone detect)

Take telephone line off-hook, start a 5s timer (application dependent).
Note: If 'blind dialling', wait 3 seconds and jump to the section "Dial DTMF digits...".

Detect Dial Tone (before 5s timer expires)
At this point only the dial tone (or possibly busy tone) should be heard (country dependent).
Status ($E6) : On interrupt, monitor b10 for Call Progress energy detection. If CP energy detected within 5 secs, check whether dial tone (continuous CP energy) or busy tone (interrupted CP energy) is present.

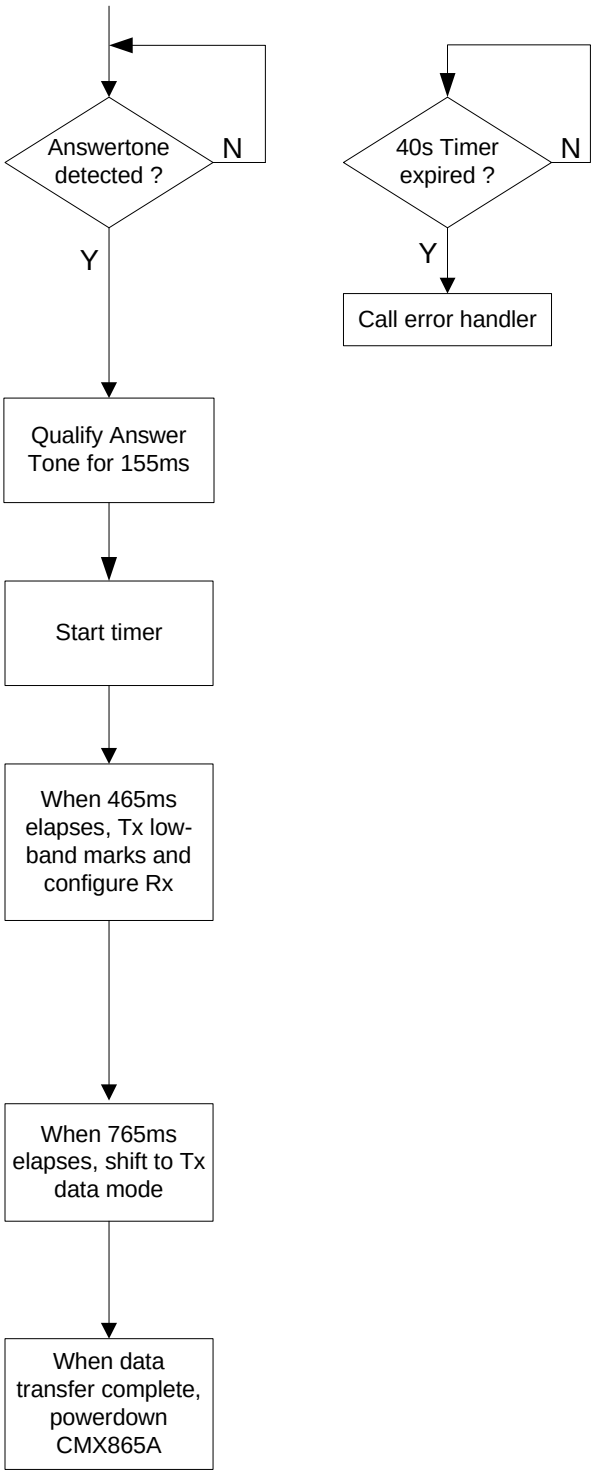
Dial DTMF digits, start 40s timer (application dependent)
Tone cadence of 100ms on and 100ms off (country dependent) is suggested.
General Control ($E0)
b2 = 0 (Call Progress IRQ disabled)
Tx Mode ($E1) -> DTMF transmit mode
b15..12 = 0001 (select DTMF / Tones mode)
b11..9 = user defined (Tx level)
b7..5 = user defined (DTMF twist)
b4..0 = 1xxxx (DTMF digit to be dialled)
Tone ON b4..0 = 1xxxx (DTMF digit to be dialled)
Tone OFF b4..0 = 00000 (select No Tone)

Detect Ringback Tone
General Control ($E0)
b2 = 1 (Call Progress IRQ enabled)

Status ($E6): On interrupt, monitor b10 for Call Progress energy. If CP energy detected, check cadence for ringback or busy tone.

Figure 2: CMX865A Settings for Bell 103 Originate Mode

Originating Modem
(continued)



Detect Answer Tone (before 40s timer expires)
Rx Mode ($E2)
b2..0 = 010 (Answer Tone detect mode)
General Control ($E0)
b2 = 0 (Call progress IRQ disabled)
b0 = 1 (2225Hz Answer Tone IRQ enabled)
Status ($E6): On interrupt, monitor b6 for 2225Hz Answer Tone.

Qualify Answer Tone for 155ms
Status ($E6): Monitor b6 for 2225Hz Answer Tone detection.

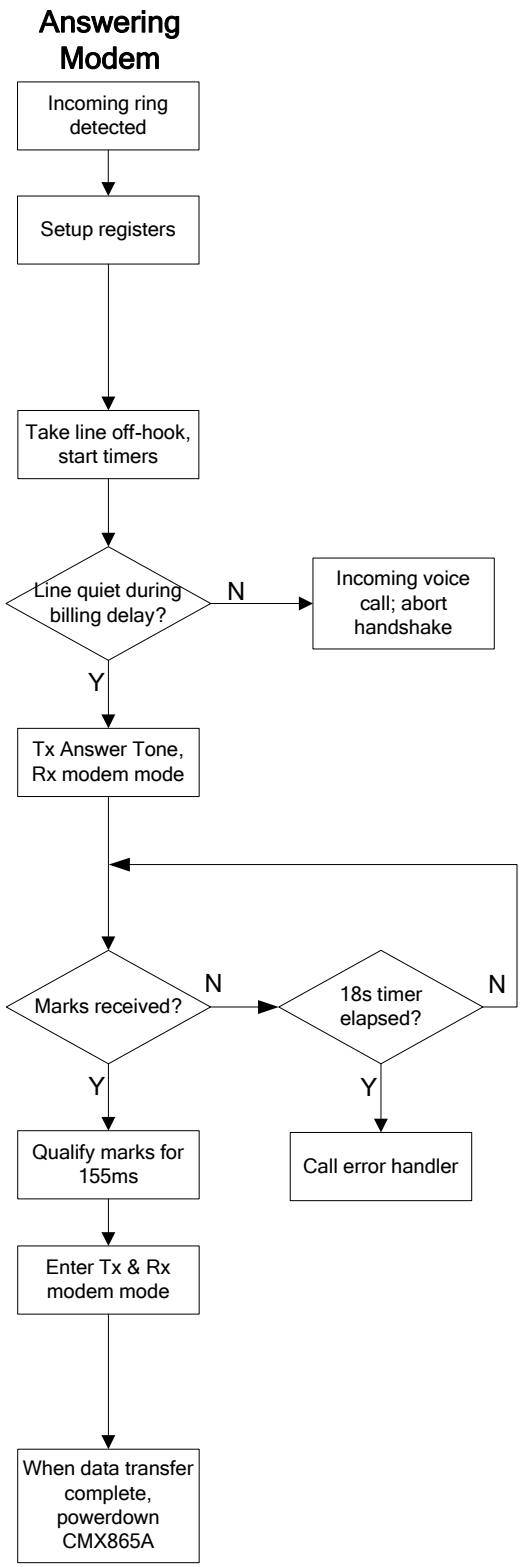
When Answer Tone qualified:
- Start single timer to be used for 456ms and 765ms.

When 456ms elapses...
Tx Mode ($E2) -> transmit low band marks
b15..12 = 0110 (Bell 103 low band)
b11..9 = user defined (Tx level)
b4..3 = 11 (synchronous mode)
b2..0 = 011 (continuous 1s)
Rx Mode ($E3) -> enter Rx modem mode
b15..12 = 0111 (Bell 103 high band)
b11..9 = user defined (Rx level)
b5..3 = 110 (start-stop mode)
b2..0 = 110 (8 data bits, no parity)

When 765ms elapses, enter Tx modem mode
General Control ($E0)
b3 = 1 (Tx data IRQs enabled)
b2 = 1 (modem carrier detect IRQ enabled)
b0 = 1 (Rx data IRQs enabled)
Tx Mode ($E1)
b4..3 = 10 (start-stop mode, no parity)
b2..0 = 110 (8 data bits, 1 stop bit)

Once data transfer complete, powerdown CMX865A
General Control ($E0)
b8 = 0 (powersave mode)

Figure 3: CMX865A Settings for Bell 103 Originate Mode (continued)



Host controller senses Ring Detect IRQ and performs CMX865A powerup procedure

Setup registers:
General Control ($E0)
b15..14 = 00 (differential Tx output drive)
b11 = 0 (no loopback)
b10 = 1 (equalizers disabled)
b8..7 = 10 (device powered up normally, not reset)
Rx Mode ($E2)
b15..12 = 0001 (select DTMF / Tones mode)
b11..9 = user defined (Rx level)
b8..3 = 000000 (for tones detection)
b2..0 = 011 (Call Progress tone detect)

Take telephone line off-hook, start timers:
- 2s for billing delay
- 18s for handshake abort (application dependent)
General Control ($E0)
b6 = 1 (IRQ enabled)
b2 = 1 (Call progress IRQ enabled)

Monitor line to ensure data call (e.g. no voice activity).
Status ($E6)
Monitor b10 to ensure that no call progress energy is present. Line should be silent at this time; if not, incoming call is voice call and modem handshake should stop.

After billing delay, transmit 2225Hz Answer Tone and prepare to receive low band marks.
Tx Mode ($E1)
b15..12 = 0001 (select DTMF / Tones mode)
b11..9 = user defined (Tx level)
b4..0 = 01011 (2225Hz Answer Tone)
Rx Mode ($E2)
b15..12 = 0110 (Bell 103 low band)
General Control ($E0)
b2 = 1 (modem carrier detect IRQ enabled)
b1 = 1 (pattern detect IRQ enabled)
b0 = 0 (Rx data IRQs disabled)

Monitor Status register for received low band marks:
Status ($E6)
b10 = 1 (modem carrier detected)
b7 = 1 (continuous 1s detected)

Qualify marks for 155ms.
Status ($E6)
Monitor b10 & b7 for presence of carrier & continuous 1s.

Enter modem mode for Tx & Rx
General Control ($E0)
b3 = 1 (Tx data IRQs enabled)
b0 = 1 (Rx data IRQs enabled)
Tx Mode ($E1)
b15..12 = 0111 (Bell 103 high band)
b4..3 = 10 (start-stop mode, no parity)
b2..0 = 110 (8 data bits, 1 stop bit)
Rx Mode ($E2)
b5..3 = 110 (start-stop mode)
b2..0 = 110 (8 data bits, no parity)

Once data transfer complete, powerdown CMX865A
General Control ($E0)
b8 = 0 (powersave mode)

Figure 4: CMX865A Settings for Bell 103 Answer Mode

6 Conclusion

Many designs have used the Motorola/Freescale MC145443 Bell 103 modem for low speed data communications, but those designs are now in jeopardy because the MC145443 has been made obsolete. The new CMX865A 1200bps/300bps modem from CML Microcircuits can be easily made to perform the same functions as the MC145443. The CMX865A also integrates additional features that had to be performed with external circuits in MC145443 designs, all while consuming much less current than the older Motorola/Freescale device. As with all CML devices, the CMX865A can be obtained as a RoHS product.

This document has attempted to describe how the CMX865A can be used in place of the obsolete MC145443 for Bell 103 products. It is hoped that the information in this application note will benefit designers as they attempt to migrate their designs to the new CMX865A.

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