CML Microcircuits

COMMUNICATION SEMICONDUCTORS

Application Note

Bell 212A Implementation with CMX869A

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1 Introduction

The Bell 212A data communications protocol, originally developed in the 1970s by AT&T, continues to be supported by modem designs three decades later. This robust protocol shares many of its attributes with V.22, a 1200bps full-duplex communications standard adopted by the International Telecommunication Union (ITU).

The CMX869A V.32bis modem IC from CML Microcircuits offers multiple modem protocol support in both automodem and manual modes, a rich telephony feature set, and low power consumption. The purpose of this document is to describe how Bell 212A can be supported using the V.22 mode of the CMX869A modem IC.

This document is designed to be used in conjunction with the CMX869A data sheet.

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2 CMX869A V.32bis Modem with Auto and Manual Connect Modes

The CMX869A V.32bis modem IC provides extensive functionality for low speed modem designs, including:

- Support for common V and Bell standards at speeds of 14.4kbps and below
- Automodem (V.22 and above) and manual modes (V.22 bis and below)
- High performance DTMF generator and detector
- Call progress tone Tx/Rx
- User-defined tone/dual-tone Tx/Rx
- USART support for synchronous, asynchronous, and HDLC formatting.
- Low power consumption

The CMX869A's V.22 manual mode can be used to allow the CMX869A to communicate with Bell 212A modems, and it is this mode that is used in this application note.

3 Bell 212A General Information

The Bell 212A specification was originally developed in the late 1970s by AT&T. This 1200bps, full-duplex, differential phase shift keying (DPSK) data transfer method has been implemented in millions of modems and continues to be supported by contemporary modem designs.

Detailed information on the Bell 212A physical layer implementation is very difficult to obtain, but an obsolete AT&T document entitled "Bell System Technical Reference, Data Set 212A Interface Specification, January 1978" contains useful information about the standard.

In addition to the "high-speed" 1200bps operating mode, Bell 212A also supports a "low-speed" operating mode of 300bps, which is commonly known as Bell 103. Both asynchronous and synchronous formats are supported by Bell 212A.

3.1 Bell 212A High Speed Connection Sequence

The Bell 212A high-speed connection sequence is illustrated in Figure 1:

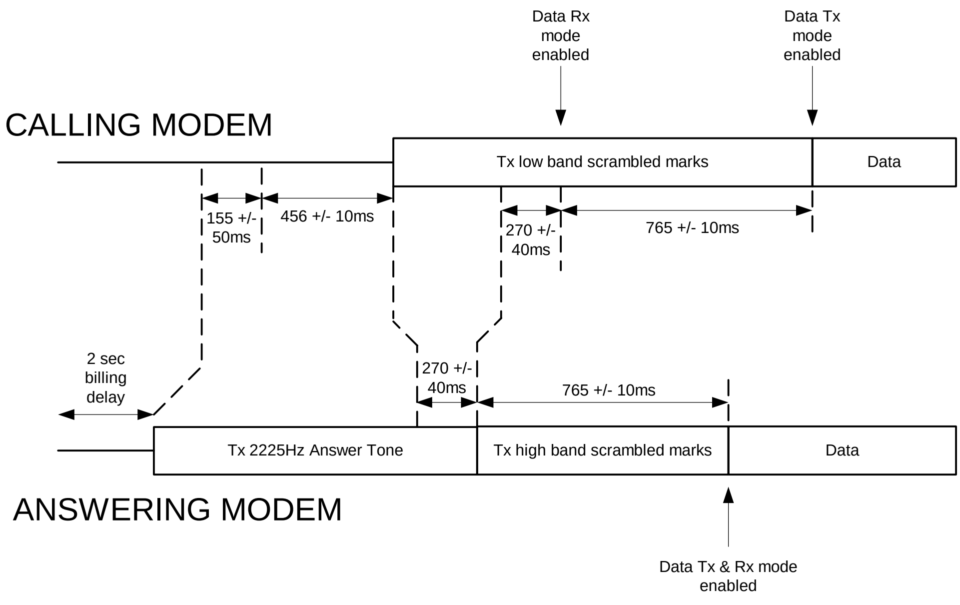


Figure 1: Bell 212A High-Speed (1200bps) Connection Sequence

The sequence begins when the calling modem goes off-hook and dials the DTMF digits for the answering modem. The answering modem goes off-hook to answer the call, observes a two second billing delay, and then begins to transmit the 2225Hz answer tone. The answer tone propagates back to the calling modem, which must detect and qualify the answer tone for 155±50ms. Once the answer tone has been qualified, the calling modem starts a 456±10ms timer. The calling modem begins transmitting low band scrambled marks once this 456ms timer has expired.

The low band scrambled marks propagate to the answering modem, where they are qualified for 270±40ms. After the low band scrambled marks have been qualified, the answering modem switches to high band scrambled marks transmission. A 765±10ms timer is also started at this time, and once this timer has elapsed, the answering modem enters data transfer mode.

The calling modem must qualify the presence of high band scrambled marks from the answering modem for 270±40ms. When this qualification is complete, data receive mode is entered and a 765±10ms timer is started. The calling modem begins transmitting data when the 765ms timer expires.

3.2 Bell 212A Low Speed Connection Sequence

The Bell 212A low speed connection sequence is illustrated in Figure 2:

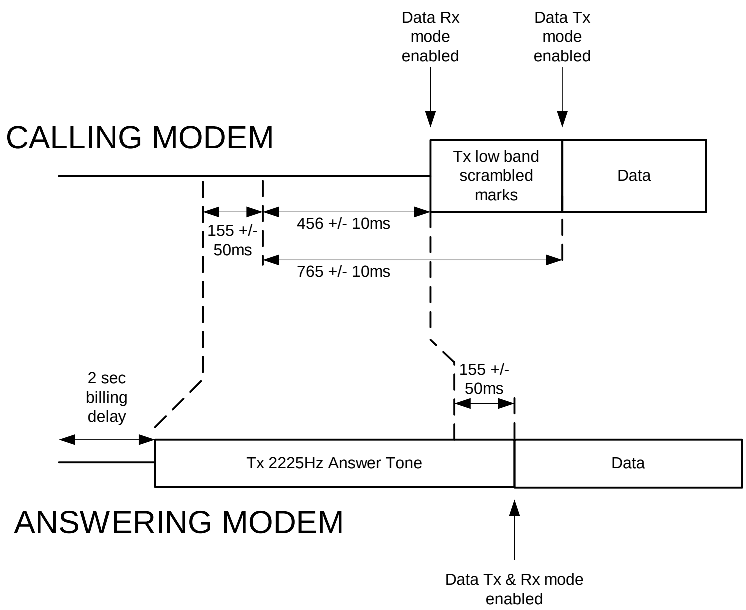


Figure 2: Bell 212A Low Speed Connection Sequence

The sequence begins when the calling modem goes off-hook and dials the DTMF digits for the answering modem. The answering modem goes off-hook to answer the call, observes a two second billing delay, and then begins to transmit the 2225Hz answer tone. The answer tone propagates back to the calling modem, which must detect and qualify the answer tone for 155±50ms. Once the answer tone qualification is complete, both a 456±10ms and a 765±10ms timer are started. When the 456ms timer has expired, the calling modem enters data receive mode and begins transmitting low band scrambled marks.

The scrambled marks propagate from calling modem to answering modem, which qualifies the signal for 155±50ms. The answering modem shifts to data transfer mode once the qualification is complete. The calling modem can begin data transmission when its 765ms timer elapses. At this point the handshake is complete and both modems are in data transfer mode.

3.3 Comparison of Bell 212A and V.22

The Bell 212A protocol shares many of its performance attributes with the V.22 standard adopted by the ITU. The following table illustrates some of the notable metrics for both of these 1200bps schemes:

Parameter	**Standard**	
	Bell 212A	**V.22**
Data rate	1200bps and 300bps	1200bps and 600bps
Baud rate	600 baud	600 baud
Bits per baud	2 (@ 1200bps)	2 (@ 1200bps)
Modulation type	DPSK (1200bps), FSK (300bps)	DPSK (1200, 600bps)
Possible Phase Changes (DPSK 1200bps)	0°, 90°, 180°, 270°	0°, 90°, 180°, 270°
Calling Modem Carrier Frequency	1200Hz	1200Hz
Answering Modem Carrier Frequency	2400Hz	2400Hz
Answer Tone Frequency	2225Hz	2100Hz
Supported Character Formats	9 & 10 bit characters	8, 9, 10, & 11 bit characters

Table 1: Bell 212A and V.22 Comparison

4 CMX869A Configuration for Bell 212A Operation

4.1 General Comments

(a) The modem can connect to the telephone line by setting the RDRVN output (CMX869A pin 2) to Vss in order to drive a relay or semiconductor switch. The on-hook level of RDRVN must be Vdd otherwise spurious line seizures could occur on initial power up or reset.

(b) Dial tone will typically be present 300ms after going off-hook. A pause of at least 2.7s (max. 8s) should be introduced before dialing commences if no dial tone detection is to be performed ('blind dialling'). The modem should return on-hook if no dial tone is detected within five seconds of going off-hook.

(c) DTMF digits should typically be 100ms long with 100ms silence gaps in between.

(d) On the Public Switched Telephone Network (PSTN), the calling modem should transmit on the low band and receive in the high band.

(e) Figures 3-6 are intended to give general guidance on the use of registers. They do not show software timeout features which avoid lockup on certain loops. The treatment of interrupts (enabling, servicing and disabling) is not fully shown since these are options that are application dependent. Guard tones are also not included.

(f) Error handling has not been included since this aspect is application dependent.

(g) The detection of in-band energy is indicated by b10 of the *Status* register ($E6). It is advisable to check this bit in both call set-up and data modes since noise can occasionally give false indication of bit patterns on a line which does not, in fact, have a true signal.

(h) The following bits in the *Transmit Mode* ($E1) and *Receive Mode* ($E2) registers need to be set according to the circuit and function requirement:-
Tx Mode b11…b9 = Tx gain
Tx Mode b4…b0 = USART mode and format
Rx Mode b11…b9 = Rx gain
Rx Mode b5…b0 = USART mode and format

(i) Register bit states on the flow charts assume a General Reset ($01) has been issued and the normal start-up procedure has been followed prior to entering the Calling and the Answering procedures. Each state in these two flowcharts lists only the register bit changes that are required to move from the previous state.

(j) The CMX869A passes only 8-bit data over the C-BUS to the host controller. The host controller must read the *Status* register ($E6) and check for parity, framing, and overflow errors before reconstituting the character in its original format for onward transmission to the remote data terminal.

4.2 CMX869A Powerup Procedure: Cold Boot to Powersave Mode

The following procedure will apply power to the CMX869A, place the device in powersave mode, and allow it to detect an incoming ring signal. Note: this condition is the intended initial condition of the CMX869A for both the “Calling Modem” and “Answering Modem” routines to follow:

1. Apply power to the CMX869A.
2. Issue a General Reset by writing $01 to the CMX869A.
3. Write to the General Control ($E0) register with:
    a. b8 = 1 (select normal operating mode)
    b. b7 = 1 (reset internal circuitry)
4. Wait 20ms.
5. Write to the General Control ($E0) register with:
    a. b8 = 0 (powersave mode selected)
    b. b7 = 0 (normal operation)
    c. b6 = 1 (enable IRQN output)
    d. b5 = 1 (unmask Ring Detect IRQ)

The CMX869A is now in powersave mode but programmed to interrupt the host controller when the ringing signal is detected. After detection, maintain the CMX869A in powersave mode but monitor the *Status* register ($E6) ring detect bit to check the cadence. When valid ringing has been received, proceed as shown in Figures 5-6, “Answering Modem”.

4.3 CMX869A Powerup Procedure: Powersave to Normal Operation

When it is desired to fully activate the CMX869A from powersave mode, the following steps should be performed:

1. Write to the General Control ($E0) register with:
    a. b8 = 1 (select normal operating mode)
    b. b7 = 1 (reset internal circuitry)
2. Wait 20ms.
3. Write to the General Control ($E0) register as needed for the desired configuration, with:
    a. b7 = 0 (normal operation)

4.4 CMX869A Treatment of Special Bell 212A Operating Conditions

The following section describes how the CMX869A can be configured to perform various aspects of Bell 212A operation.

1. Synchronous or Asynchronous Operation: Bell 212A defines both of these conditions for 1200bps, and the CMX869A supports either operating mode.

2. Speed Control: Bell 212A supports both 1200bps and 300bps operation, and the CMX869A supports both of these operating modes.

3. Transmitter Timing: Bell 212A defines three possible sources for 1200bps transmitter timing. Only one of these three sources, “internal”, are supported by the CMX869A.

4. Receiver Timing: Bell 212A indicates that the received signal’s timing should be made available to the host through a dedicated circuit. The CMX869A does not provide a ‘receive clock’ signal, but since the CMX869A provides the received characters to the host in byte form over the CBUS interface, this is not considered to be a limitation.

5. Character Length: Bell 212A supports both 9-bit and 10-bit characters, and the CMX869A Tx and Rx USARTs can be configured for either of these character lengths.

6. Send Space Disconnect: Bell 212A defines this call terminating condition as four seconds of spacing signal (logic zero), transmitted to the remote modem, to signal the end of a call. For systems that require this feature, the CMX869A can be made to transmit the “space disconnect” signal as follows:
    a. Wait until an IRQ with Tx Underflow flag is issued ($E6 b11=1). This means that the last character has been transmitted and framed correctly.
    b. Disable the Tx scrambler ($E1 b6..b5=00) and select ‘continuous 0s’ as “special mode” ($E1 b4..b0=11010).
    c. The host processor should monitor the time spent by the CMX869A in this condition so it can terminate the “space disconnect” when needed.

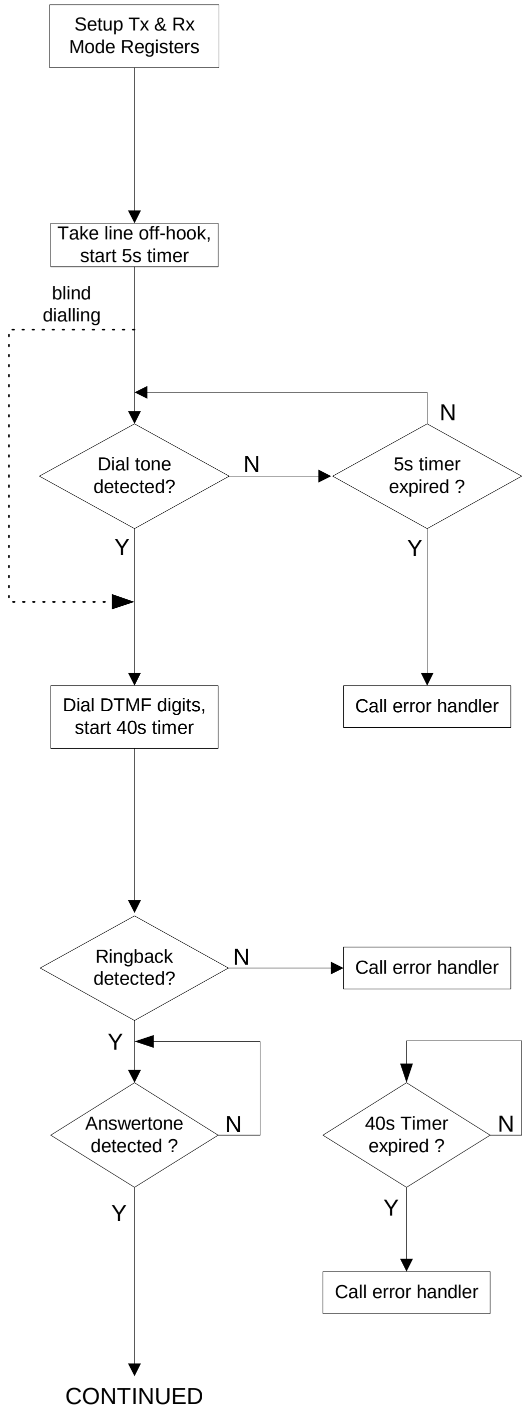
7. Receive Space Disconnect: Bell 212A defines a condition, to be used in conjunction with “Send Space Disconnect”, in which the receiver will disconnect the call after receiving 1.6 seconds of spacing signal (logic zero). The CMX869A will indicate reception of this signal by issuing an IRQ (if unmasked) with *Status* register ($E6) b8=1. The host processor should poll $E6 b8 after the initial IRQ and terminate the call if the space disconnect signal is present for the appropriate amount of time.

8. Abort: Bell 212A requires the answering modem to end its handshaking attempts if received carrier is not detected within approximately 18 seconds after going off-hook. The CMX869A does not support this directly, but the host controller can easily perform this function through a timer and hookswitch control.

4.5 CMX869A Configuration Flowcharts

The following flowcharts illustrate the steps needed to configure the CMX869A for both calling and answering Bell 212A modems. Please note that automatic detection of Bell 103 has not been included in these flowcharts.

Calling Modem



Setup Registers
Tx Mode ($E1)
b15..b12 = 0001 (select DTMF / Tones mode)
b11..b9 = user defined (Tx level)
Rx Mode ($E2)
b15..b12 = 0001 (select DTMF / Tones mode)
b11..b9 = user defined (Rx level)
b8..b3 = 000000 (for tones detection)
b2..b0 = 011 (Call Progress tone detect)

Take telephone line off-hook, start a 5s timer (application dependent).
General Control ($E0)
b9 = 1 (Relay drive pin pulled to Vss)
b6 = 1 (IRQ output pin enabled)
b5 = 0 (Ring Detect IRQ disabled)
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).
General Control ($E0)
b2 = 1 (Call Progress IRQ enabled)
Status ($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)
b7..b5 = user defined (DTMF twist)
b4 = 1 (DTMF Tx)
Tone ON b3..b0 = user defined digit (to be dialled)
Tone OFF b4..b0 = 00000 (select No Tone)

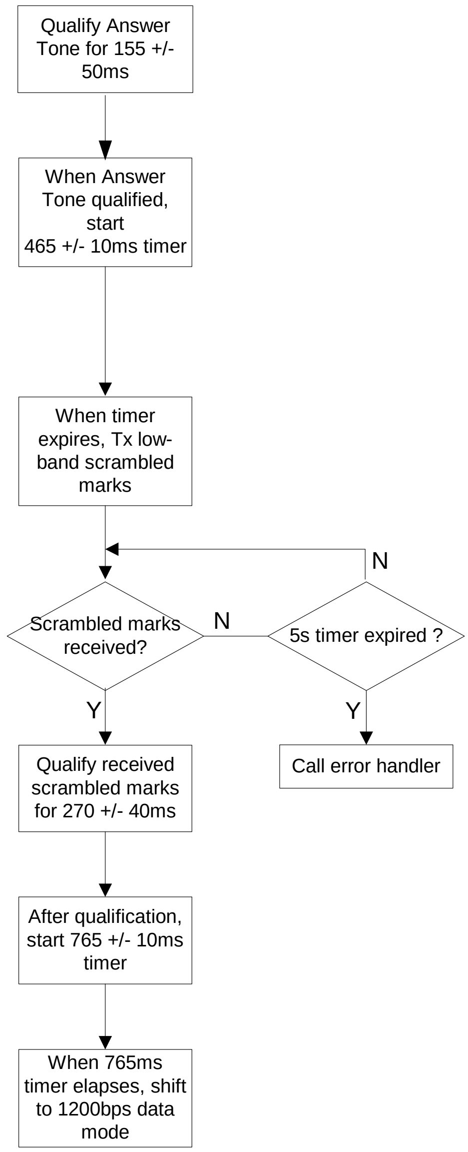
Detect Ringback Tone
General Control ($E0)
b2 = 1 (Call Progress IRQ enabled)
Status ($E6)
On interrupt, monitor b10 for Call Progress Energy. If CP energy detected, check cadence for ringback or busy tone.

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

Figure 3: CMX869A Configuration for Bell 212A “Calling Modem”

Calling Modem

(continued)



Qualify Answer Tone for 155 +/- 50ms
Status ($E6)
Monitor b6 for 2225Hz Answer Tone.

When Answer Tone qualified:
- Host controller asserts 'data set ready' (DSR).
- Start a 456 +/- 10ms timer.
- Prepare for incoming Bell 212A high-band scrambled marks

General Control ($E0)
b2 = 1 (carrier detect IRQ enabled)
b1 = 1 (pattern detect IRQ enabled)
b0 = 0 (modem mode: Rx data IRQs disabled)

Rx Mode ($E2)
b15..b12 = 1011 (V.22 high band mode)
b8 = user defined (equalizer)
b7..b6 = 11 (descrambler enabled)

When 456ms timer expires, transmit low-band scrambled marks:
Tx Mode ($E2)
b15..b12 = 1010 (V.22 low band)
b6..b5 = 11 (scrambler enabled)
b4..b3 = 11 (special modes)
b2..b0 = 011 (continuous 1s)

Monitor Status register for indication of received high-band scrambled marks:
Status ($E6)
b10 = 1 (carrier detected in modem signal band)
b8..b7 = 11 (scrambled 1s detected)

Qualify received scrambled marks for 270 +/- 40ms
Status ($E6)
Monitor b10, b8 & b7 for presence of carrier & scrambled 1s.

When received scrambled marks qualified:
- Host controller asserts 'data carrier detect' (DCD).
- Start a 765 +/- 10ms timer.

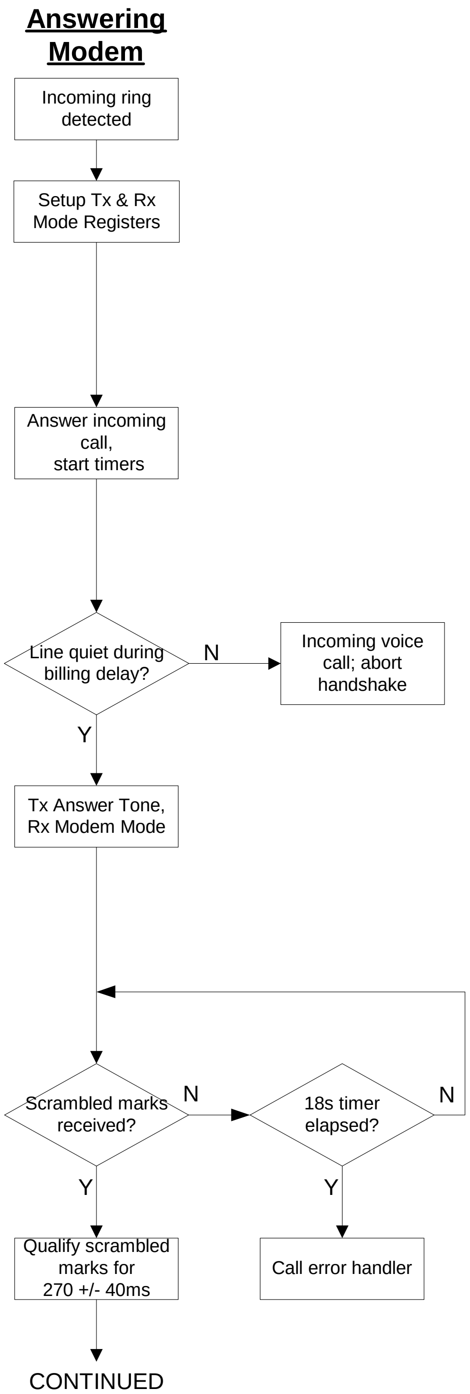
When 765ms timer elapses, shift to 1200bps data mode:
- Host controller asserts 'clear to send' (CTS).

General Control ($E0)
b15 = user defined (fixed compromise equalizer)
b3 = 1 (Tx data IRQs enabled)
b2 = 1 (modem carrier detect IRQ enabled)
b1 = 0 (pattern detect IRQs disabled)
b0 = 1 (Rx data IRQs enabled)

Tx Mode ($E1)
b6..b5 = user defined (scrambler operation)
b4..b3 = 10 (start-stop mode, no parity)
b2..b0 = 110 (8 data bits, 1 stop bit)

Rx Mode ($E2)
b7..b6 = user defined (descrambler operation)
b5..b3 = 110 (start-stop mode, no overspeed)
b2..b0 = 110 (8 data bits, no parity)

Figure 4: CMX869A Configuration for Bell 212A "Calling Modem" (continued)



Host controller senses Ring Detect IRQ

Setup Registers
Tx Mode ($E1)
b15..b12 = 0001 (select DTMF / Tones mode)
b11..b9 = user defined (Tx level)
Rx Mode ($E2)
b15..b12 = 0001 (select DTMF / Tones mode)
b11..b9 = user defined (Rx level)
b8..b3 = 000000 (for tones detection)
b2..b0 = 011 (Call Progress tone detect)

Take telephone line off-hook, start timers:
- 2s for billing delay
- 18s for handshake abort

General Control ($E0)
b9 = 1 (Relay drive pin pulled to Vss)
b2 = 1 (Call progress IRQ enabled)
b5 = 0 (Ring Detect IRQ disabled)

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.

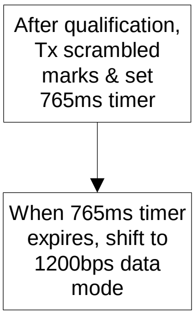
After billing delay, transmit 2225Hz Answer Tone and prepare to receive low band scrambled marks.
Tx Mode ($E1)
b4 = 0 (Tone Tx)
b3..b0 = 1011 (2225Hz Answer Tone)
Rx Mode ($E2)
b15..b12 = 1010 (V.22 low band)
b8 = user defined (auto-equalizer)
b7..b6 = 11 (descrambler enabled)
General Control ($E0)
b2 = 1 (modem mode: modem carrier detect IRQ enabled)
b1 = 1 (pattern detect IRQ enabled)
b0 = 0 (Rx data IRQs disabled)

Monitor Status register for indication of received low band scrambled marks:
Status ($E6)
b10 = 1 (carrier detected in modem signal band)
b8..b7 = 11 (scrambled 1s detected)

Qualify scrambled marks for 270 +/- 40ms.
Status ($E6)
Monitor b10, b8 & b7 for presence of carrier & scrambled 1s.

Figure 5: CMX869A Configuration for Bell 212A "Answering Modem"

Answering Modem
(continued)



After qualification, transmit high band scrambled marks.
- Start a 765 +/- 10ms timer.

Tx Mode ($E1)
  b15..b12 = 1011 (V.22 high band)
  b6..b5 = 11 (scrambler enabled)
  b4..b3 = 11 (special modes)
  b2..b0 = 011 (continuous 1s)

When 765ms timer expires, shift to 1200bps data mode.
- Host controller asserts 'data carrier detect' (DCD) & 'clear to send' (CTS).

General Control ($E0)
  b15 = user defined (fixed compromise equalizer)
  b3 = 1 (Tx data IRQs enabled)
  b1 = 0 (pattern detect IRQs disabled)
  b0 = 1 (Rx data IRQs enabled)

Tx Mode ($E1)
  b6..b5 = user defined (scrambler operation)
  b4..b3 = 10 (start-stop mode, no parity)
  b2..b0 = 110 (8 data bits, 1 stop bit)

Rx Mode ($E2)
  b7..b6 = user defined (descrambler operation)
  b5..b3 = 110 (start-stop mode, no overspeed)
  b2..b0 = 110 (8 data bits, no parity)

Figure 6: CMX869A Configuration for Bell 212A "Answering Modem" (continued)

5 Conclusion

Bell 212A, a data communication standard developed in the 1970s, continues to be supported by many contemporary modem designs. Bell 212A and V.22, another 1200bps full-duplex communications protocol, share many attributes with only minor differences. The V.22 manual mode capability of the CMX869A allows this low-power device to serve in applications that require support for Bell 212A. It is hoped that this document will assist designers integrate the CMX869A into their Bell 212A-compatible modem designs.

6 Reference

1. Bell System Technical Reference, “Data Set 212A, Interface Specifications, January 1978”, Publication 41214, American Telephone and Telegraph Company, 1978.

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For FAQs see: http://www.cmlmicro.com/products/faqs/index.htm

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CML Microcircuits (UK) Ltd COMMUNICATION SEMICONDUCTORS	CML Microcircuits (USA) Inc. COMMUNICATION SEMICONDUCTORS	CML Microcircuits (Singapore) Pte Ltd COMMUNICATION SEMICONDUCTORS	
Tel: +44 (0)1621 875500 Fax: +44 (0)1621 875600 Sales: sales@cmlmicro.com Technical Support: techsupport@cmlmicro.com	Tel: +1 336 744 5050, 800 638 5577 Fax: +1 336 744 5054 Sales: us.sales@cmlmicro.com Technical Support: us.techsupport@cmlmicro.com	Tel: +65 7450426 Fax: +65 7452917 Sales: sg.sales@cmlmicro.com Technical Support: sg.techsupport@cmlmicro.com	Tel: +86 21 63174107 +86 21 63178916 Fax: +86 21 63170243 Sales: cn.sales@cmlmicro.com.cn Technical Support: sg.techsupport@cmlmicro.com