Application Note

V.22bis Call Setup With the CMX868

This document provides details on the V.22bis wireline communications protocol and pointers on how the handshaking sequence can be achieved with the CMX868 modem IC. Additional information is included on the V.14 and V.25 protocols. This document should be used in conjunction with the CMX868 data bulletin.
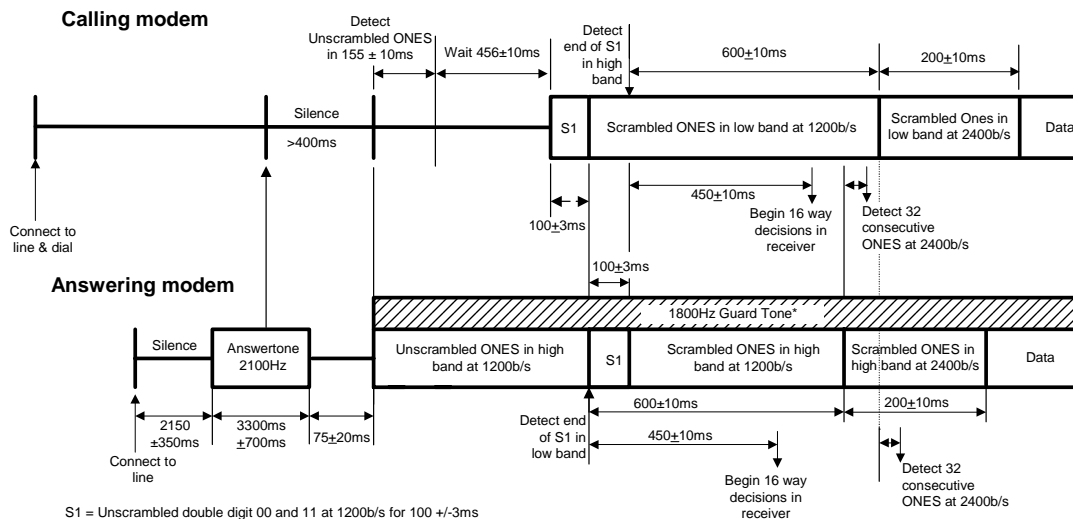

Fig. 1. V.22bis Connect Handshake.

* Guard tones are country dependent

1. V.22bis Handshake

Figure 1 above is an adaptation of the V.22bis Connect Handshake from Volume VIII - Fascicle VIII.1 of the Blue Book series published by the ITU (formerly CCITT) November 1988. The actions taken by the calling and answering modems are illustrated below with flow charts and C-BUS command strings for implementation on the CMX868.

1.1 Points to note

- The modem can connect to the line by setting the /RDRV output (CMX868 pin 3) to Vss in order to drive a relay or semiconductor switch. The on-hook level of /RDRV must be Vdd; otherwise spurious line seizures could occur on initial power up or reset.

- Dial tone will be present typically 300ms after going off-hook. If dialing without dial tone detection then a pause of at least 2.7s (max. 8s) should be introduced before dialing commences. If no dial tone is detected within 5 seconds of going off-hook, the modem should then be returned to the on-hook state.

- DTMF digits should be typically 100ms long with 100ms silence gaps in between.

- The diagrams are intended to give general guidance on the use of registers. They do not show software timeout features that avoid lockup on certain loops. The treatment of interrupts (enabling, servicing & disabling) is not fully shown since these are options that may be implemented for a particular design. Guard tones are also not included.

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

- Error handling has not been included since this aspect is implementation dependent.

- 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	b8…b7	= 550Hz/1800Hz Guard Tone enabling
Tx Mode	b4…b0	= USART mode and format
Rx Mode	b11…b9	= Rx gain
Rx Mode	b5…b0	= USART mode and format

- For clarity, Fig. 1 does not show the alternative route should only one modem be capable of V.22bis connection. However, the diagrams that follow show what steps are needed in this case to establish a V.22 connection.

- Some points are shown on the drawing in Fig. 1 that relate to circuit switching on the host external port. For example, the point labeled "Detect 32 consecutive ONES at 2400b/s" is a point at which the data channel received line signal detector (i.e. Data Carrier Detect pin on RS-232 port, also referred to as "circuit 109" in the V.22bis standard) can be switched.

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

For both Calling and Answering modems

Power up the modem:

    Issue a General Reset Command – C-BUS address $01 (no data)

If the modems need to be set to auto-answer mode:

    Write to the *General Control* ($E0) register

        b6 = 1 (enable /IRQ output)

        b5 = 1 (unmask ring detect IRQ)

The modem is now in powersave mode, but programmed to interrupt the controlling microcontroller when ringing is detected.

For the Calling modem when ready to dial out

Take the modem out of powersave mode:

    General Control ($E0)

        b8…b7 = 11 (power up and reset registers)

Wait 20ms

    General Control ($E0)

        b7 = 0 (remove reset condition)

Proceed as shown in the flow charts for Calling Modem.

For the Auto-Answering Modem when ring interrupt is serviced

Maintain the CMX868 in powersave mode but monitor the Status register ($E6) to

check the ring detect on/off timing. When valid ringing has been received,

proceed as shown in the flow charts for Answering Modem.

2. V.25 and V.14 implementation on the CMX868

- V.25 timing has been included within the flow diagrams below. The only point not covered is the optional transmission of 1300Hz by the calling modem in the period after dialing and before Answer tone recognition. The cadence is 0.6s ON, 1.75s OFF (typ.). For V.22bis and V.22 this tone is NOT permitted, but details are included below for other applications:

  TX Mode ($E1)

  > b15…b12 = 0001 (select DTMF / Tones)
  >
  > b3…b0 = 1001 (1300Hz Calling tone)

- The V.25 automatic answering sequence shall be transmitted from the answer mode modem on international PSTN connections. The transmission of the V.25 sequence may be omitted on point-to-point leased circuits, or on national connections on the PSTN where permitted by the administration.

- V.14 specifies stop bit omission / recovery where DTE data speed is different from modem speed and specifies two difference ranges, +1% to –2.5% (basic) and +2.3% to –2.5% (extended). The CMX868 enables stop bit deletion by providing two Tx Data registers, $E3 for normal transmission and $E4 for transmission with one stop bit removed from the current format. Consequently, the host can adjust the removal of stop bits according to V.14 by directing bytes to the appropriate Tx Data register. At the receiving end the CMX868 can tolerate missing stop bits if set to basic or extended over-speed mode:

  Rx Mode ($E2)

  > b5…b3 = 101 (for basic range)
  >
  > *or*   b5…b3 = 100 (for extended range)
  >
  > *or*   b5…b3 = 110 (for over-speed function disabled)

- The CMX868 passes only eight 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 DTE.

Calling Modem

```
        ┌──────────────────┐
        │  Set-up Tx & Rx  │
        │  Mode Registers  │
        └──────────────────┘
                 │
                 ▼
        ┌──────────────────┐
        │  Take Off-Hook   │
        └──────────────────┘
                 │
                 ▼
        ┌──────────────────┐
        │  Start 5s timer  │
        └──────────────────┘
                 │
                 ▼
           ◇ Dial tone ──N──► ◇ 5s timer ──N──┐
             detected ?         expired ?      │
                 │Y                 │Y         │
                 ▼                  ▼          │
        ┌──────────────────┐   ┌────────┐      │
        │ Dial digits to   │   │ Error  │      │
        │     line.        │   └────────┘      │
        └──────────────────┘                   │ (back to
                 │                              │  Dial tone)
                 ▼
        ┌──────────────────┐
        │ Start 40 second  │
        │      timer       │
        └──────────────────┘
                 │
                 ▼
           ◇ Answertone ──N──► ◇ 40s Timer ──N──┐
             detected ?          expired ?       │
                 │Y                 │Y           │
                 ▼                  ▼            │
        ┌──────────────────┐   ┌────────┐        │
        │ Wait for         │   │ Error  │        │ (back to
        │ Answertone       │   └────────┘        │  Answertone)
        │ to disappear     │
        └──────────────────┘
                 │
                 ▼
           ◇ Unscrambled ──N──┐
             1 detected for    │
               145ms           │
                 │Y            │
                 ▼
        ┌──────────────────┐
        │   Wait 456 ms    │
        └──────────────────┘
                 │
                 ▼
           CONTINUED
```

V.25 (bracket spanning from Take Off-Hook to Wait for Answertone to disappear)

Set-up 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 / Tone mode)
         b11..b9 = user defined   (Rx level)

Take Off-Hook
General Control ($E0)
         b9 = 1 (Relay drive pin pulled to Vss)

Note:- If blind dialing, wait 3 seconds before jumping
to the dialing section below.

Start a 5 second timer.

Dial Tone Detect (before 5s timer expires)
At this point only the dial tone (or possibly busy tone) should
be heard, (country dependent).
General Control ($E0)
   b2 = 1 (unmask Call Progress Energy detect IRQ)
         On interrupt, monitor Status Register ($E6) b10 for
         Call Progress Energy. If CP energy detected within
         5 secs, check whether dial tone (continuous CP
         energy) or busy tone (interrupted CP energy) is
         present.

Dial digits to line (DTMF)
Tone cadence of 100ms on and 100ms off (country
dependent) is suggested.
General Control ($E0)
         b2 = 0 (mask Call Progress Energy IRQ)
Tx Mode ($E1)
Tone ON   b4 = 1 (for DTMF generation)
         b3..b0 = user defined (digits to be dialed)
Tone OFF   b4..b0 = 00000 (select No Tone)

Start 40s timer

Detect Answer Tone (before 40s timer expires)
Rx Mode ($E2)
         b2..b0 = 010 (Answertone detect mode)
General Control ($E0)
         b1 = 1 (unmask 2100Hz Answertone IRQ)
      or   b0 = 1 (unmask 2225Hz Answertone IRQ)

Status ($E6)
         On interrupt, monitor bit 7 (2100Hz) or bit 6
         (2225Hz) for Answertone.

Wait for Answertone to disappear.

Detect Unscrambled 1s for 145ms
The 2225Hz Answertone detector will also trigger on
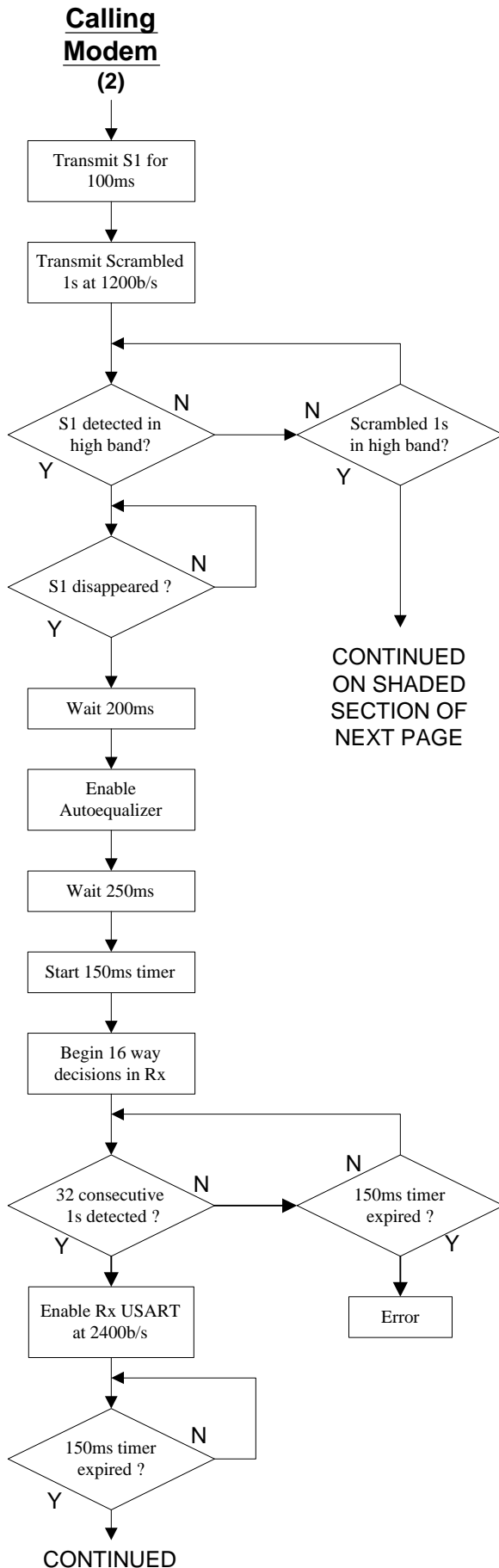unscrambled 1s.
General Control ($E0)
         b1 = 0 (mask 2100Hz Answertone IRQ)
         b0 = 1 (unmask 2225Hz Answertone IRQ)
Status ($E6)
         On interrupt, monitor bit 6 for 2225Hz Answertone
         which shows that unscrambled 1s are being
         received. Check that unscrambled 1s are
         received for at least 145ms.

Wait for 456ms

Calling Modem (2)

```
┌─────────────────┐
│ Transmit S1 for │
│      100ms      │
└─────────────────┘
         │
┌──────────────────┐
│ Transmit Scrambled│
│  1s at 1200b/s   │
└──────────────────┘
         │
    ╱ S1 detected ╲   N      ╱ Scrambled 1s ╲   N
   ╱  in high band? ╲ ────→ ╱  in high band? ╲ ────→ CONTINUED
   ╲                ╱        ╲                ╱        ON SHADED
    ╲              ╱     Y    ╲              ╱     Y   SECTION OF
         │ Y                       │              NEXT PAGE
    ╱ S1 disappeared ╲  N
   ╲                 ╱ ──┐
    ╲               ╱    │
         │ Y
┌─────────────────┐
│   Wait 200ms    │
└─────────────────┘
         │
┌─────────────────┐
│     Enable      │
│  Autoequalizer  │
└─────────────────┘
         │
┌─────────────────┐
│   Wait 250ms    │
└─────────────────┘
         │
┌─────────────────┐
│ Start 150ms timer│
└─────────────────┘
         │
┌─────────────────┐
│   Begin 16 way  │
│  decisions in Rx│
└─────────────────┘
         │
    ╱ 32 consecutive ╲  N     ╱ 150ms timer ╲  N
   ╱  1s detected ?   ╲ ───→ ╱   expired ?   ╲ ──┐
   ╲                  ╱       ╲               ╱   │
         │ Y                       │ Y
┌─────────────────┐         ┌─────────┐
│ Enable Rx USART │         │  Error  │
│   at 2400b/s    │         └─────────┘
└─────────────────┘
         │
    ╱ 150ms timer ╲  N
   ╲   expired ?   ╱ ──┐
         │ Y
    CONTINUED
```

Transmit S1 for 100ms at 1200b/s
Tx Mode ($E1)
   b15..b12 = 1100 (select V.22 low band)
   b4,b3 = 11 (select synchronous mode)
   b2..b0 = 00x (select continuous S1)

Transmit Scrambled 1s at 1200b/s
Tx Mode ($E1)
   b6,b5 = 11 (scrambler and 64 x 1s detect enabled)
   b2..b0 = 011 (select continous 1s)

Detect S1 or scrambled 1s in high band
Rx Mode ($E2)
   b15..b12 = 1101 (select V.22 high band)
   b7,b6 = 11 (descrambler and 64x1s detect enabled)
General Control ($E0)
   b1 = 1 (unmask S1 and scrambled 1s IRQ)
   b0 = 0 (mask IRQ)
Note that b0 was enabled earlier for 2225Hz Answertone IRQ, but is disabled here after selecting V.22 high band because no interrupt is yet required for Rx Data Overflow or Rx Data Ready.

On interrupt, check *Status* ($E6)
   If b10,b9 = 11(S1 found) then proceed a shown below.
   If b10..b7 = 1011 (scrambled 1s found) then go to shaded section on next page.

If S1 detected then wait for S1 to disappear.
General Control ($E0)
   b1 = 0 (mask S1 and scrambled 1s IRQ)

Wait 200ms

Enable Rx Auto-equalizer.
Rx Mode ($E2)
   b8 = 1 (Rx Auto-equalizer enabled)

Wait 250ms

Start 150ms timer

Begin 16 way decisions
RX Mode ($E2)
   b15..b12 = 1111 (select V.22bis high band)
General Control ($E0)
   b1 = 1 (unmask scrambled 1s IRQ)

If 150ms timer expires before 32 consecutive 1s detected then an error has occured.

On interrupt, check *Status* ($E6).
If b10 = 1 and b8,b7 = 11 then 32 scrambled 1s detected.

Enable Rx USART at 2400b/s
Rx Mode ($E2)
   b5..b3 = user defined (Rx USART settings)
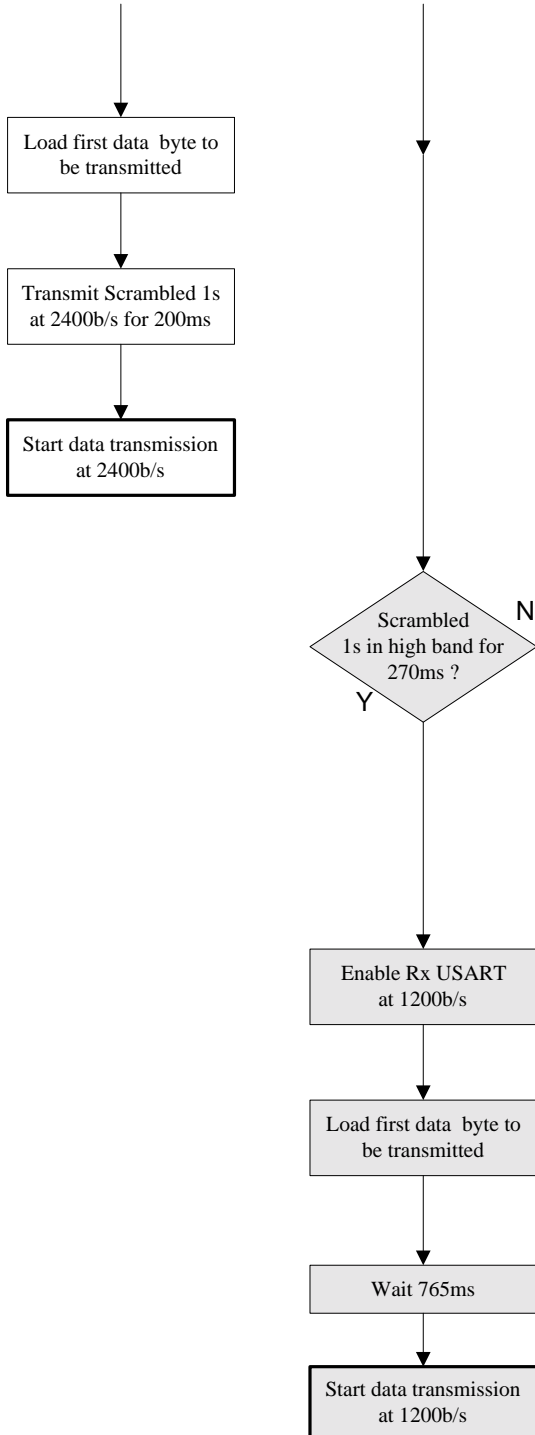   b2..b0 = user defined (data bits and parity settings)
General Control ($E0)
   b0 = 1 (unmask Rx Data Overflow & Rx Data Ready IRQ)
   b1 = 0 (mask scrambled 1s detection IRQ)

Wait until 150ms timer expired

Calling
Modem
(3)

Load first data byte to
be transmitted

Transmit Scrambled 1s
at 2400b/s for 200ms

Start data transmission
at 2400b/s

Load Tx Data register ($E3 or $E4) with first byte.
Note: Check that *Status* ($E6) b12 = 1 (Tx Data Ready) before
loading the data.

Transmit Scrambled 1s for 200ms at 2400b/s
TX Mode ($E1)
          b15..b12 = 1110 (select V.22bis low band)

Start data transmission at 2400b/s
TX Mode ($E1)
          b4,b3 = user defined (Tx USART settings)
          b2..b0 = user defined (data and stop bit settings)
General Control ($E0)
          b3 = 1 (unmask Tx Data Underflow and Tx
               Data Ready IRQ)

Scrambled
1s in high band for
270ms ?   **N** → Error

Y

Enable Rx USART
at 1200b/s

Load first data byte to
be transmitted

Wait 765ms

Start data transmission
at 1200b/s

**Check scrambled 1s are detected for 270ms (nom.) If not
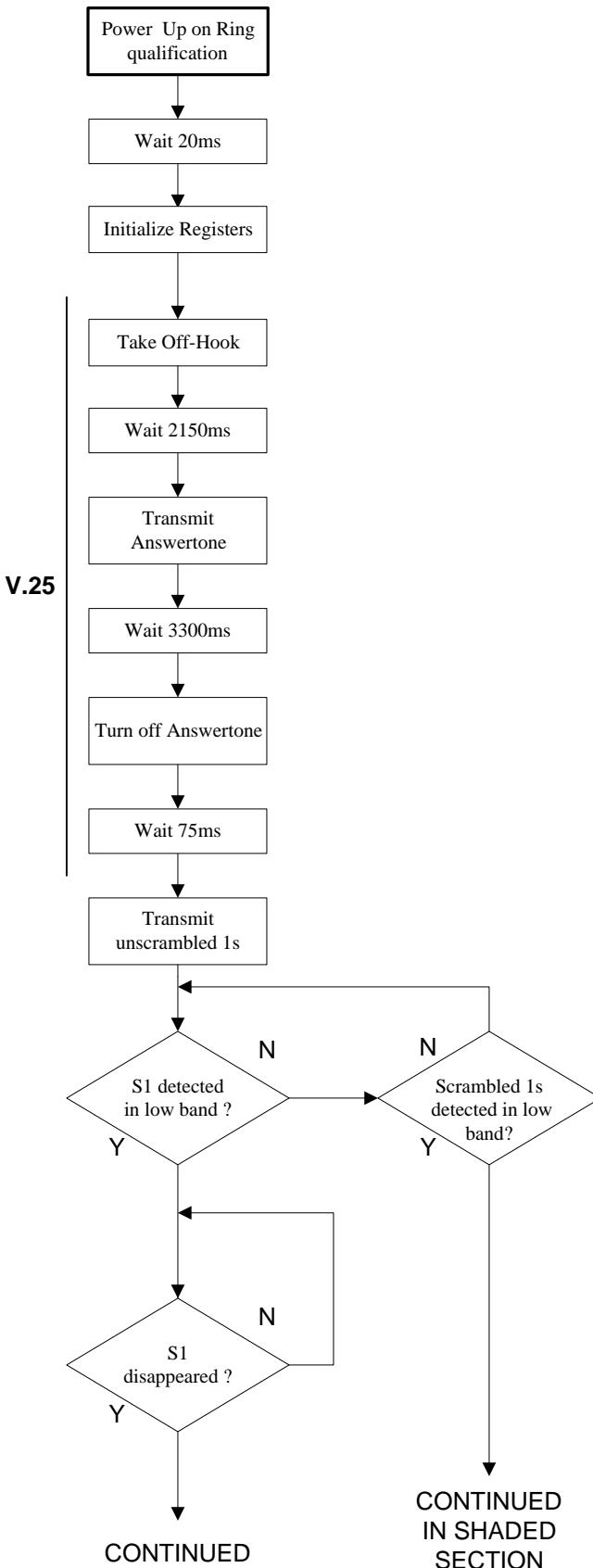then an error has occured.**

Enable Rx USART at 1200b/s
NOTE The use of the autoequalizer can improve performance
at 1200b/s
Rx Mode ($E2)
          b8 = user defined (autoequalizer setting)
          b5..b3 = user defined (Rx USART mode)
          b2..b0 = user defined (data bits and parity
                    settings)
General Control ($E0)
          b0 = 1 (unmask Rx Data overflow and Rx
               Data Ready IRQ)
          b1 = 0 (mask scrambled 1s detection IRQ)

Load *Tx Data* register ($E3 or $E4) with first byte
Note: Check that *Status* ($E6) b12 = 1 (Tx Data Ready)
before loading the data.

Wait for 765ms

Start data transmission at 1200b/s
Tx Mode ($E1)
          b4,b3 = user defined (Tx USART settings)
          b2..b0 = user defined (data and stop bit settings)
General Control ($E0)
          b3 = 1 (unmask TX Data underflow and Tx
               Data Ready IRQ)

Answering Modem

```
┌─────────────────────┐
│  Power  Up on Ring  │
│    qualification    │
└─────────────────────┘
          │
          ▼
┌─────────────────────┐
│     Wait 20ms       │
└─────────────────────┘
          │
          ▼
┌─────────────────────┐
│ Initialize Registers│
└─────────────────────┘
          │
          ▼
┌─────────────────────┐
│   Take Off-Hook     │
└─────────────────────┘
          │
          ▼
┌─────────────────────┐
│    Wait 2150ms      │
└─────────────────────┘
          │
          ▼
┌─────────────────────┐
│     Transmit        │
│    Answertone       │
└─────────────────────┘
          │
          ▼
┌─────────────────────┐
│    Wait 3300ms      │
└─────────────────────┘
          │
          ▼
┌─────────────────────┐
│ Turn off Answertone │
└─────────────────────┘
          │
          ▼
┌─────────────────────┐
│     Wait 75ms       │
└─────────────────────┘
```

V.25

```
┌─────────────────────┐
│     Transmit        │
│  unscrambled 1s     │
└─────────────────────┘
```

S1 detected in low band ? — N → Scrambled 1s detected in low band? — N →

S1 detected in low band? Y ↓

Scrambled 1s detected in low band? Y →

S1 disappeared ? — N →

S1 disappeared? Y ↓

CONTINUED

CONTINUED IN SHADED SECTION

On Ring Interrupt
A ring interrupt should wake the host controller to perform a ring qualification routine and power up the CMX868.

Power up
General Control ($E0)
         b8 = 1(Device powered normally)
         b7 = 1(Reset internal circuitry)

Wait 20ms

Initialize Registers
General Control ($E0)
         b7 = 0 (Normal operation)

Tx Mode ($E1)
         b15..12 = 0001 (select DTMF/Tones mode)
         b11..9 = user defined (Tx level)

Rx Mode ($E2)
         b15..12 = 1100 (select V.22 low band)
         b11..9 = user defined (Rx level)
         b7,b6 = 11 (descrambler enabled)

Take Off-Hook
General Control ($E0)
         b9 = 1 (Relay drive pin pulled to Vss)

Wait for 2150ms.

Transmit Answertone
Tx Mode ($E1)
         b3..0 = 1010 (2100Hz Answertone)
     or b3..0 = 1011 (2225Hz Answertone)

Wait for 3300ms

Turn off Answertone
Tx Mode ($E1)
         b3..0 = 0000 (No Tone)

Wait for 75ms

Transmit Unscrambled 1s at 1200b/s
Tx Mode ($E1)
         b15..12 = 1101 (select V.22 high band)
         b8,b7 = user defined (Tx guard tone)
         b4,b3 = 11 (select synchronous mode)
         b2..b0 = 011 (select continuous 1s)

Detect S1 or scrambled 1s
General Control ($E0)
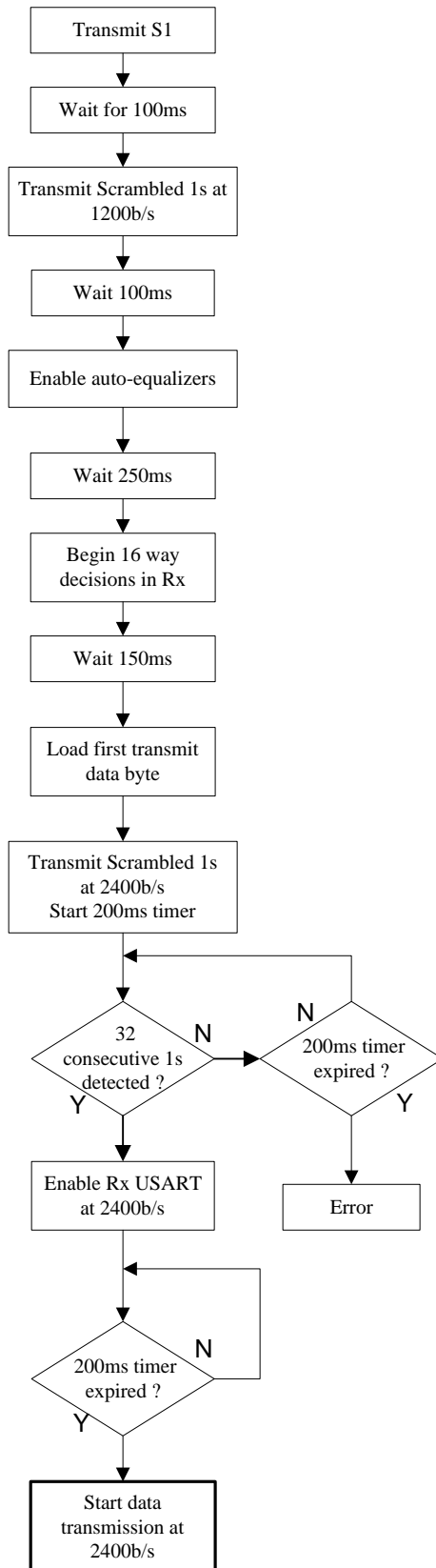   b1 = 1 (unmask S1 or scrambled 1s detect IRQ)

On interrupt, check *Status* ($E6)
         If b10,b9 = 11 (S1 found) then proceed as shown below.
         If B10..b7 = 1011 (scrambled 1s found)
then go to shaded section on later page

If S1 detected then wait for S1 to disappear.

Answering
Modem
(2)

Transmit S1

↓

Wait for 100ms

↓

Transmit Scrambled 1s at 1200b/s

↓

Wait 100ms

↓

Enable auto-equalizers

↓

Wait 250ms

↓

Begin 16 way decisions in Rx

↓

Wait 150ms

↓

Load first transmit data byte

↓

Transmit Scrambled 1s at 2400b/s Start 200ms timer

↓

32 consecutive 1s detected ? — N → 200ms timer expired ? — N (loop back)

Y ↓   Y ↓

Enable Rx USART at 2400b/s   Error

↓

200ms timer expired ? — N (loop back)

Y ↓

Start data transmission at 2400b/s

Transmit S1 at 1200b/s
Tx Mode ($E1)
b2..b0 = 00x (select S1)
General Control ($E0)
b1 = 0 (mask S1 or scrambled 1s detect IRQ)

Wait for 100ms

Transmit Scrambled 1s at 1200b/s
Tx Mode ($E1)
b6,b5 = 11 (scrambler enabled)
b2..b0 = 011 (select continuous 1s)

Wait for 100ms

Enable Auto-equalizer
Rx Mode ($E2)
b8 = 1 (enable auto-equalizer**)**

Wait for 250ms

Begin 16 way decisions and look for scrambled 1s
RX Mode ($E2)
b15..b12 = 1110 (select V.22bis low band)
General Control ($E0)
b1 = 1 (Unmask scrambled 1s detection IRQ)

Wait for 150ms

Load *Tx Data* register ($E3 or $E4) with first byte
Note: Check that *Status* ($E6) b12 = 1 (Tx Data Ready) before loading the data.

Transmit scrambled 1s at 2400b/s and start 200ms timer
Tx Mode ($E1)
b15..b12 = 1111 (select V.22bis high band)

If 200ms timer expires before 32 consecutive 1s detected then an error has occured.

On interrupt, check *Status* ($E6).
If b10 = 1 and b8,b7 = 11 (32 consecutive 1s detected)
then **enable Rx USART at 2400b/s**
Rx Mode ($E2)
b5..b3 = user defined (Rx USART settings)
b2..b0 = user defined (data bits and parity settings)
General Control ($E0)
b1 = 0 (mask scrambled 1s detection IRQ)
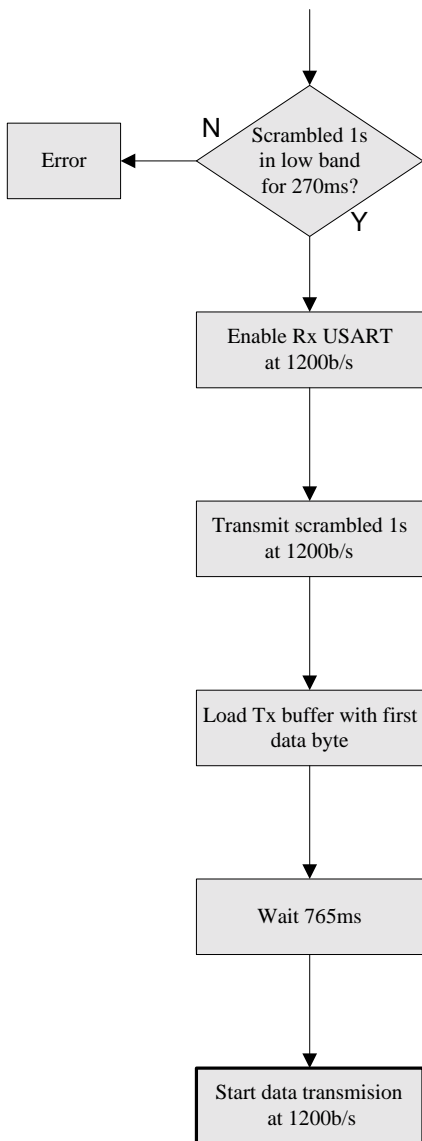b0 = 1 (unmask Rx Data Overflow & Rx Data
Ready IRQ)

Wait until 200ms timer expires

Start data transmission at 2400b/s
Tx Mode ($E1)
b4,b3 = user defined (Tx USART settings)
b2..b0 = user defined (data and stop bit settings)
General Control ($E0)
b3 = 1 (Unmask TX Data Underflow and Tx Data
Ready IRQ)

Answering Modem
(3)

Scrambled 1s in low band for 270ms?

N → Error

Y

Enable Rx USART at 1200b/s

Transmit scrambled 1s at 1200b/s

Load Tx buffer with first data byte

Wait 765ms

Start data transmision at 1200b/s

Check that scrambled 1s are detected for 270ms (nom.) If not then an error has occured.

Enable Rx USART at 1200b/s
NOTE The use of the autoequalizer can improve performance at 1200b/s
Rx Mode ($E2)
          b8 = user defined (autoequalizer setting)
          b5..b3 = user defined (Rx USART mode)
          b2..b0 = user defined (data bits and parity settings)
General Control ($E0)
          b0 = 1 (unmask Rx Data Overflow & Rx Data Ready IRQ)
          b1 = 0 (mask scrambled 1s IRQ)

Transmit scrambled 1s at 1200b/s (for 765ms)
Tx mode ($E1)
          b6,b5 = 11 (scrambler enabled)

Load *Tx Data* register ($E3 or $E4) with first byte
Note: Check that *Status* ($E6) bit 12 = 1 (Tx Data Ready) before loading the data.

Wait 765ms

Start data transmission at 1200b/s
Tx Mode ($E1)
          b4,b3 = user defined (Tx USART settings)
          b2..b0 = user defined (data and stop bit settings)
General Control ($E0)
          b3 = 1(Unmask TX Data Underflow and Tx Data Ready IRQ)