Application Note

CML Microcircuits

COMMUNICATION SEMICONDUCTORS

NOAA Weather Radio and the CMX7031/CMX7041

Publication: AN/2WR/7031_41_NOAA/ 1 March 2006

1 Introduction

The National Oceanographic and Atmospheric Administration (NOAA), a USA government agency, continuously transmits weather and public emergency information throughout the United States. These broadcasts, commonly referred to as NOAA Weather Radio or NWR, can be freely received by radios that have been designed to receive these signals. NWR reception can be easily added to two-way radios such as Family Radio Service (FRS) units, thereby increasing their value for customers.

The CMX7031 and CMX7041 two-way radio baseband processors from CML integrate many commonly required radio features into a small surface-mount package. These innovative devices, built with *FirmASIC* ® technology, share much of their functionality and both support NWR signal reception.

This purpose of this document is to describe the NOAA Weather Radio (NWR) service and how the CMX7031 or CMX7041 can serve in this application. Anyone designing two-way radio equipment with the CMX7031 or CMX7041 can potentially benefit from the information contained in this application note.

The current CMX7031 or CMX7041 datasheet should be used in conjunction with this application note.

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2 CMX7031 and CMX7041

The CMX7031 and CMX7041 two-way radio baseband processors are highly integrated solutions targeted for innovative radio designs. While both devices share much of their functionality, some differences exist between them. The following table highlights some of their common areas as well as their differences:

Parameter	CMX7031	CMX7041
Voice Processing	Yes	Yes
Sub-Audio Tone Processing	Yes	Yes
In-band Tone Processing	Yes	Yes
System Clock Generator Outputs	2	2
RF Synthesizers	2	0
Number of Device Pins	64	48

Table 1: CMX7031 and CMX7041 Feature Comparison

The CMX7031 and CMX7041 are configured for operation by loading a Function Image™ file into the appropriate device. The Function Image™ file, which can be downloaded from the "My CML" area of the CML website, determines the specific device functionality.

3 NOAA Weather Radio (NWR) and the Emergency Alert System (EAS)

The NWR system broadcasts weather forecasts 24 hours a day, 7 days a week, using VHF transmitters located throughout the United States. These analog FM broadcasts use 25kHz channels between 162.400MHz and 162.550MHz. To locate the NWR transmitter for a particular area, please visit http://www.nws.noaa.gov/nwr/nwrbro.htm.

In addition to the NWR service, the U.S. Government also operates an Emergency Alert System (EAS). The EAS relays various public safety warnings to NWR, broadcast television, broadcast AM and FM radio, and cable television stations. Those stations, in turn, retransmit the warnings from their respective facilities to listeners and viewers (e.g. NWR broadcasts the warnings from its National Weather Radio transmitters). A well-known example of an EAS warning is an AMBER Alert, formally known as a 'Child Abduction Emergency' event.

NWR constantly announces weather forecasts, unless they are interrupted by warnings. The NWR system includes two special features, WAT (Warning Alert Tone) and SAME (Specific Area Message Encoding), to warn users of important or dangerous events.

3.1 WAT (Warning Alarm Tone)

A special feature of the NWR system is the transmission of the Warning Alarm Tone (WAT), a single 8-10 second audio tone burst at 1050Hz. The WAT is transmitted prior to broadcasting any NWR message about a threatening natural or civil event, such as tornadoes, severe thunderstorms, etc.

Since it can be boring to constantly listen to the routine NWR weather forecasts, it is desirable for the receiver to be quiet until a warning is received. The WAT allows NWR receivers to open speaker squelch only when they detect the WAT.

3.2 SAME (Specific Area Message Encoding) Warnings

The broadcast area of a NWR 'tower' is about 5,000 square miles, which is about the size of 7 to 10 typical counties. This large broadcast area does not allow warnings to be pinpointed to specifically affected areas, and the long range of NWR broadcasts can make WAT broadcasts a false alarm for many in the listening area. For example, using WAT to warn of a tornado will cause all the NWR receivers in a 10 county range to receive the warning, but none will know specifically where the tornado is.

To overcome these limitations, a special mode of NWR broadcasts named SAME (Specific Area Message Encoding) allows digital messages to indicate the affected location to within a fraction of a county or a body of water. It also transmits more detail about the nature of the warning e.g. the time over which the warning applies. Lastly, SAME receivers can visually display received warning messages on electronic displays, e.g. roadside signs for AMBER Alerts.

3.2.1 SAME Protocol

The protocols for NWR WAT and SAME are described in National Weather Service NOAA Weather Radio (NWR) Transmitters, NWR Specific Area Message Encoding, NWR SAME, Update #4.43, July 13, 1999. (At the time of this writing, that document can be downloaded from www.weather.gov/nwr/resources/same.pdf.)

The SAME digital signal fits within the audio bandwidth of an NWR receiver and so can be supported without modifying an NWR receiver. SAME digital signals use the following format:

Parameter	Details
Modulation type	Frequency Shift Keying (FSK)
Data rate	520.83 bits per second
Mark ("1") frequency	2083.3Hz
Space ("0") frequency	1562.5Hz
Data format	Asynchronous, 8-bit bytes, no start bits, no stop bits, no parity bits. Bit & byte synchronization achieved by preamble detection. ASCII characters used with 8th bit set to zero. LSB transmitted first.
FM Deviation	80% minimum (±4.0kHz minimum, ±5.0kHz maximum)
Transmit signal processing	Pre-emphasis, 6dB per octave increasing slope from 300Hz-3000Hz

Table 2: SAME Signaling Format

SAME messages share the same RF channel as NWR voice and WAT signals, but only one signal uses the channel at a given instant. The protocol for NWR is somewhat of a hybrid; it usually broadcasts analog voice weather forecasts that are occasionally interrupted by a WAT, which is followed by an analog voice warning, or it is occasionally interrupted by a SAME digital signal. A typical sequence can be:

1. SAME digital preamble (which always is sent three times)
2. WAT (optional)
3. Analog voice warning message (optional)
4. SAME digital 'end of message' (which is always sent three times)

A SAME message will typically consist of the following information:

1. Preamble ($AB)
2. Header code (preamble and header code always transmitted three times)
3. WAT/Attention Signal (may or may not be present)
4. Voice Message (may or may not be present)
5. Preamble ($AB)
6. End of Message (EOM: preamble and EOM always transmitted three times)

The following diagram illustrates a typical SAME transmission:

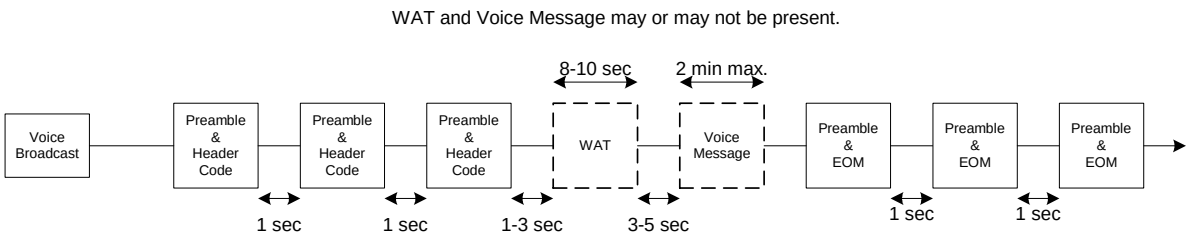

Figure 1: Typical SAME Transmission

The SAME message preamble must be recognized in order to properly decode the content of the SAME data that follows.

The header code of a SAME message contains critical information about the type of event warning and the geographical area it applies to. The following information is contained within the SAME header code:

1. Specific code to identify the start of the message block (ASCII “ZCZC”).
2. Identifier as to the type of message that follows (e.g. voice or data).
3. Type of event, including:
   a. Immediacy of event (warning, watch, or emergency alert)
   b. Whether the event is of national or local significance.
   c. Specific type of event, such as tornado watch, radiological hazard warning, etc.
4. Geographic area that may be affected by the event (state, county, and specific portion of county).
5. Duration of warning (e.g. when the warning expires).
6. Date and time when the warning was originally issued.
7. Station that originated the message.

The SAME message can pinpoint the exact geographical area of relevance for the event. A NWR-equipped radio can then be programmed to only open speaker squelch for SAME messages that apply to the user’s geographical area. This capability allows weather radio users to be notified of events that apply to their area, thereby increasing the efficiency of the warning system and potentially giving users more time to prepare for emergencies.

4 CMX7031/CMX7041 Support for WAT and SAME Signaling

The CMX7031/CMX7041 provide unique functions to support NWR WAT and SAME reception to support two-way radio, weather radio, and similar applications. Its highly integrated and powerful feature set, combined with *FirmASIC* ® technology, make it a powerful solution for a wide range of products.

To provide WAT and SAME signal reception, NWR receivers must include a WAT detector and SAME data demodulator. The CMX7031/CMX7041 loaded with the appropriate Function Image™ provides both of these critical functions.

To simplify NWR radio designs, the CMX7031/CMX7041 SAME demodulator includes a preamble detector which searches for a pattern of four preamble bytes and indicates when they are received. The CMX7031/CMX7041 SAME demodulator byte-aligns the received SAME data stream to simplify the interpretation of SAME data by the host uC. The CMX7031/CMX7041 can be configured to provide an interrupt after receipt of each SAME data byte, and these SAME data bytes should be read until the host uC recognizes the end of the SAME frame.

Note that because a SAME preamble is 16 bytes long and the CMX7031/CMX7041 will detect four bytes of preamble, the CMX7031/CMX7041 will deliver some received preamble bytes to the host uC. The host will need to interpret these bytes as preamble and avoid treating them as incoming SAME data bytes.

The following procedure should be used to configure the CMX7031/CMX7041 for NWR SAME reception:

- Ensure CMX7031/CMX7041 has been powered up and initialized into idle mode.
  - "Idle" mode refers to Mode Control register ($C1) b1-0=00.
- Clear Modem Control register ($C7) b12=0 to disable NWR data interrupts.
- Unmask NWR interrupts by writing $C000 to Interrupt Mask register, $CE.
- Enable NWR reception by configuring the Mode Control register ($C1) with either:
  - $1001 (if input is applied to Input1 Rx signal path).
  - $3001 (if input is applied to Input2 Rx signal path).
- After receipt of interrupt, read Status register ($C6) to determine cause of interrupt.
  - If $C6=$C000, the interrupt was caused by an NWR detection event. Read the NWR Status register ($BB) to determine the detected NWR event.
    - If $BB=$4000, the SAME preamble has been detected. Set Modem Control register ($C7) b12=1 to enable SAME data interrupts.
- Regular interrupts should be issued with $C6=$C000 and $BB=$20xy, where xy=received data byte.

Detection of the WAT is also available while NWR processing is active. WAT detection will be indicated by an interrupt with NWR Status and Data register ($BB) b15=1.

The host uC will need to monitor the received data bytes and determine the end of the SAME frame. Once the end-of-frame has been detected, the uC can disable NWR signal reception by clearing Mode Control ($C1) b12=0.

5 Simultaneous Voice Radio and NWR Reception

Many two-way voice radios also support NWR reception, e.g. FRS and GMRS radios with a weather radio function, but they are not able to simultaneously support both modes. Because of this, the user is either in two-way radio mode and missing incoming weather alerts, or in weather radio mode and missing two-way radio reception.

The CMX7031/CMX7041 resolve this by providing separate Rx input signal paths and parallel processing capabilities that can simultaneously process two-way radio and weather radio signals. This allows an incoming weather alert (either a WAT or a SAME message) to interrupt two-way radio reception; a unique and powerful capability. (The CMX7031 also features two RF synthesizers that could each be dedicated to a separate RF receiver path, if desired, to support reception on two bands.)

6 Conclusion

The ability to support NOAA weather radio broadcasts adds value to two-way radio designs. The CMX7031 and CMX7041 support NWR reception while providing significant functionality commonly required for voice radios. The ability to support both NWR reception and two-way voice radio functions make the CMX7031 and CMX7041 attractive platforms for innovative radio designs.

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

For a full data sheet listing see: http://www.cmlmicro.com/products/datasheets/download.htm

For detailed application notes: http://www.cmlmicro.com/products/applications/index.htm

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