



**CML Microcircuits**

COMMUNICATION SEMICONDUCTORS

# DE6491

**CMX649 Wireless Voice Link  
Demonstration Kit  
User Manual**

UM6491/2 July 2005

Provisional Information

## Features

- **Full-Duplex Wireless Voice-Link Communication Demonstration using the CMX649 ADM Voice Codec**
- **Operates in the 863 – 865 MHz European Licence Free Band**
- **20m Range - Line of Sight**
- **Privacy via CMX649 Digital Scrambler**
- **On/Off, Volume and RF Channel Pushbutton Controls**
- **Phone Quality Voice Transmission using TDD Airlink Protocol**
- **Selectable RF Power**



## 1. Brief Description

The DE6491 is a CMX649-based wireless voice link demonstration kit that demonstrates CMX649 ADM Codec IC operation in a low-power, cordless headset application. Operating as a short range RF device in the 863 – 865 MHz European licence-exempt band, this demonstration kit consists of two separate stand-alone PCBs each with the following sections: CMX649-based audio, RF transceiver and control. The basic design may be user adapted to other RF frequencies. Full-duplex voice operation at up to 20 metres range is provided via a single RF channel Time Division Duplex (TDD) link. With the supplied headsets a user can investigate two-way voice-audio transfer between units.

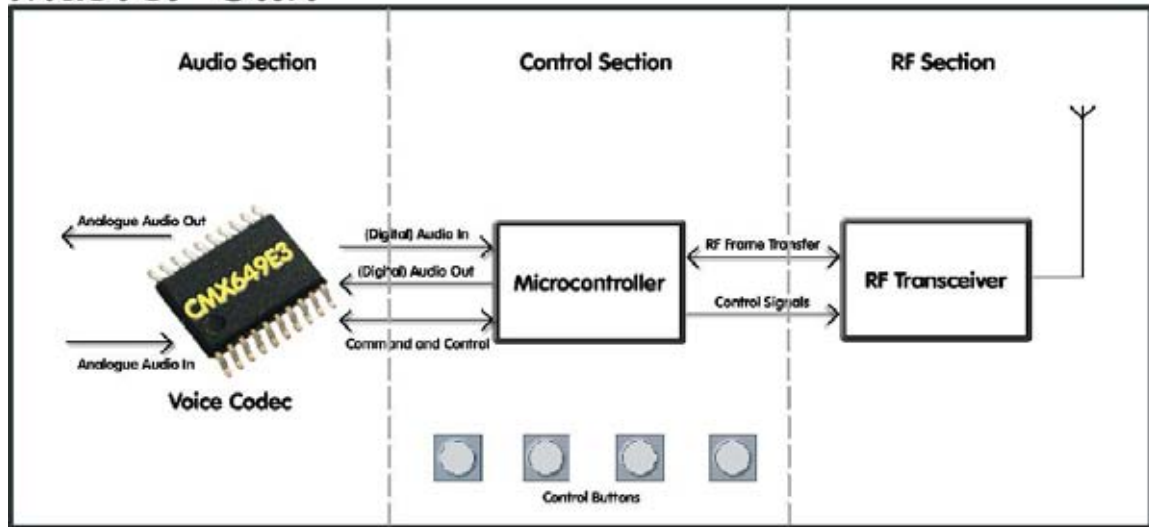
Each PCB can be powered, standalone, from a choice of AAA batteries or a bench power supply. Intelligent power saving reduces supply current when not communicating. Each terminal draws between 17 – 25.5 mA when communicating or 850 $\mu$ A, typical, when powersaved.

Each on-board  $\mu$ Controller's FLASH memory comes programmed with the latest version of operating firmware. If desired, a user may reprogram and in-circuit debug the  $\mu$ Controller themselves, using a proprietary programmer (not included).

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It is always recommended that you check for the latest product datasheet version from the Datasheets page of the CML website: [[www.cmlmicro.com](http://www.cmlmicro.com)].

# Master Unit



RF Link

# Slave Unit

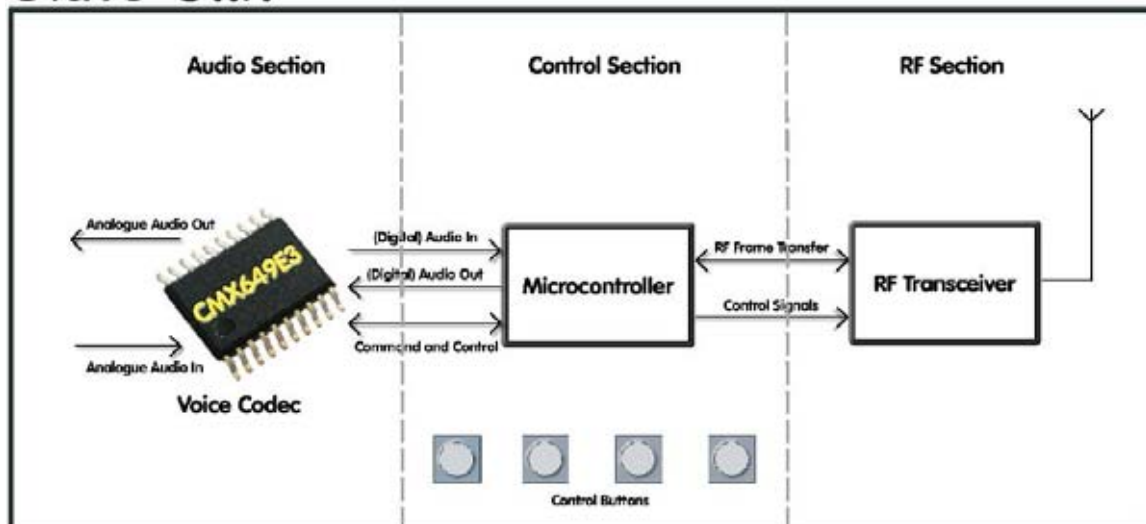


Figure 1 Interactive Block Diagram

## **2. Preliminary Information**

### **2.1 Laboratory Equipment**

The following laboratory equipment is needed to use each evaluation board:

- Two Alkaline AAA batteries or a 2.9 – 5.5 V power supply.

### **2.2 Handling Precautions**

Like most evaluation kits, this product is designed for use in laboratory environments. The following practices will help ensure its proper operation:

#### **2.2.1 Static Protection**

This product uses low power CMOS circuits which can be damaged by electrostatic discharge. Partially damaged circuits can function erroneously, leading to misleading results. Observe ESD precautions at all times when handling this product.

#### **2.2.2 Contents - Unpacking**

Please ensure that you have received all of the items on the separate information sheet (EK6491) and notify CML within 7 working days if the delivery is incomplete.

### **2.3 Approvals**

Each board contains a low-power radio frequency transceiver operating with FSK modulation in the 863 – 865 MHz band and is not approved by any regulatory agency or body. The boards are intended for experimental use only and the user is responsible for ensuring that the operation of these boards is both appropriate and lawful.

### 3. Quick Start

This section provides instructions for users who wish to experiment immediately with the demonstration kit. A fuller description of the kit and its use appears later in this document.

#### 3.1 Setting-Up

Communication between the Master and Slave boards (see silk screen label for board type identification) can be established after the following steps are performed:

1. Connect the provided headsets to each board. The red microphone plug should be inserted into socket J7 and the light grey earpiece plug should be inserted into socket J3.
2. Select the power supply for each board, either:
  - Install 2 Alkaline AAA batteries (not supplied) in J1 and connect JP1 pin 1 to pin 2.
  - Connect a 2.9 – 5.5 V power supply to J2 and connect JP1 pin 2 to pin 3.
3. Pair the boards - With the boards within RF range of each other (see section 3.2.5), perform the pairing sequence described in section 3.2.1.

The boards will now be operational and the pairing process will not need to be performed again as the pairing information is retained in the microcontroller's non-volatile memory.

#### 3.2 Operation

Once a Master and Slave board (see silk screen label for board type identification) have been paired, they will be operational and audio communication can be achieved between them. Audio input to the Master board from the microphone will be heard in the Slave board's earpiece and audio from the Slave board's microphone will be heard in the Master board's earpiece.

The four buttons provided on each board allow the user to turn the power on/off, reset the boards, control the volume, control RF channel selection and the pairing of two boards, as described below.

##### 3.2.1 Pairing Boards

Before the Master board and Slave board can communicate with one another, they must first be "paired". To perform the pairing process:

1. Power the master and slave boards and place in close proximity
2. Press and release the reset button (RST) on each board.
3. Press and hold down the VOL- and VOL+ buttons on either the Slave or Master board.
4. After 3 - 4 flashes of the LED, the LED will remain constantly on.
5. While still holding the first pair of buttons, press and hold down the VOL- and VOL+ buttons on the other board.
6. After 3 - 4 flashes of the LED on the second board, the LED on the first board will go out. This indicates the new pairing ID codes have been successfully exchanged, the buttons on both boards can now be released.
7. The new pairing ID codes will be saved into non-volatile memory the next time the boards enter powersave mode.

Once the two boards have been paired audio communication will be possible between them. The pairing process will only need to be performed once. Only if one of the paired boards is to be used with a different board should pairing need to be performed again.

### 3.2.2 Power Functions

The LED (D1) present on each board indicates the power state of the board as:

- When the board leaves powersave mode and is powered up, the LED will stay on for approximately 0.5s.
- The LED will flash periodically, once every second, when a board is powered.
- The LED will flash twice in quick succession when the board is entering powersave mode.
- When in powersave mode the LED will be inactive.

Both automatic and manual powersave functions are provided.

#### 3.2.2.1 Automatic Power Functions

The automatic power functions allow the boards to power up and powersave when appropriate without any user interaction. If voice is absent on both boards for a period greater than approximately 30 seconds, the boards will enter powersave mode. The Master board and the Slave board, if paired, will wake from powersave mode if voice is present at the audio input to the Master board, i.e. from its microphone.

Also, the Slave board will automatically powersave if an RF connection to a paired Master board is lost for an extended period (approximately 300ms), i.e. if the Slave board is moved out of range or the Master board ceases communicating abruptly. Once an RF connection can again be established with an active paired Master board, the Slave board will wake from powersave mode.

#### 3.2.2.2 Manual Power Functions

Both boards provide controls to manually power up or powersave. By simultaneously pressing both the VOL- button and VOL+ button on a board, the power state of the board will be toggled. If a Master board is manually powersaved or powered up, a paired Slave board will also be powersaved or powered up, if it is in range. Manually changing the power state of the Slave board will not effect a paired Master board.

**NB** – Due to the automatic power functions, described in section 3.2.2.1, a board manually powersaved or powered up may not remain power saved or powered up.

### 3.2.3 Adjusting Volume Levels

Two buttons are provided for earpiece volume controls, VOL+ and VOL-, which increase or decrease the volume, respectively. Simply press and release either the VOL+ button or the VOL- button to adjust the volume. Holding the button down will not ramp the volume. There are 32 volume increments available using the DE6491 board's volume control buttons.

The volume level selected is retained when the boards are powersaved. The selected volume level will only be lost if the power supply is removed or if the board is reset.

### 3.2.4 RF Channel Selection

The Channel button (CHNL) on each board allows the RF channel used for communication to be changed; which may be required if RF interference is disrupting communications. To change the RF channel simply press and release the channel button (CHNL) on one of the boards. Both boards will then attempt to communicate on a different RF channel.

If the interference is too great and the RF channel cannot be changed successfully, communication may be lost. To force both boards to use the same default RF channel again, both boards must be reset, as described in section 3.2.6.

### 3.2.5 RF Power Selection

Four settings are available to allow the RF power output of each board to be adjusted. The setting is selected by inserting or removing shorting links between pins 5 and 6 and pins 7 and 8 on header J4.

RF_POW0 and RF_POW1 (J4 pins 5 and 6)	RF_POW2 and RF_POW3 (J4 pins 7 and 8)	RF Power setting	Approx. RF Power (dBm)	Typical Current Draw (mA)	Maximum RF range* (metres)
Link	Link	Maximum (default)	+5.0	25.5	20.0
Open	Link	High	-2.0	20	12.0
Link	Open	Low	-8.0	18	8.0
Open	Open	Minimum	-19.0	17	3.0

\*These range figures are for when the embedded PCB antenna is used and both paired boards use the same RF power setting. The achievable RF range may vary depending on the environmental conditions, including a building's structure and any obstacles between the boards.

### 3.2.6 Reset Function

To reset a board press and release the RST button. Resetting a board will set both the volume level and RF channel to their default values.

Communication may be lost between two paired boards if only one is reset. To recover communications simply reset the other board to ensure both boards are communicating using the default RF channel.

#### 4. Signal Lists

CONNECTOR PINOUT				
Connector Ref.	Connector Pin No.	Signal Name	Signal Type	Description
J2	1	V <sub>SS</sub>	Power	External Power Supply Connection
	2	V <sub>IN</sub>	Power	External Power Supply Connection
J3	B	V <sub>SS</sub>	Power	V <sub>SS</sub> Connection
	C	SPKR-OUT	O/P	Analogue Voice Output to Headset Earpiece
	D	SPKR-OUT	O/P	Analogue Voice Output to Headset Earpiece
J4	1	SPARE1	BI	Spare MSP430 I/O
	2	SPARE2	BI	Spare MSP430 I/O
	3	SPARE3	BI	Spare MSP430 I/O
	4	SPARE4	BI	Spare MSP430 I/O
	5	RF_POW0	O/P	RF Transmit Power Selection Pin
	6	RF_POW1	I/P	RF Transmit Power Selection Pin
	7	RF_POW2	O/P	RF Transmit Power Selection Pin
	8	RF_POW3	I/P	RF Transmit Power Selection Pin (See section 3.2.5 for details)
J5	9	V <sub>DD</sub>	Power	V <sub>DD</sub> Connection
	10	V <sub>SS</sub>	Power	V <sub>SS</sub> Connection
	1	TDO	O/P	MSP430 JTAG Output
	2	-	-	No Connection
	3	TDI	I/P	MSP430 JTAG Input
	4	VDD	Power	MSP430 JTAG Reference Voltage Output
	5	TMS	I/P	MSP430 JTAG Input
	6	-	-	No Connection
	7	TCK	I/P	MSP430 JTAG Input
	8	-	-	No Connection
	9	V <sub>SS</sub>	Power	V <sub>SS</sub> Connection
10	-	-	No Connection	
11	RST	I/P	MSP430 JTAG Input	
	12,13,14	-	-	No Connection



CONNECTOR PINOUT				
Connector Ref.	Connector Pin No.	Signal Name	Signal Type	Description
J6	N/A	ANT_EXT	Antenna	External Antenna Connection (See section 6.1.3 for details)
J7	B	MIC-IN1	I/P	Analogue Voice Input from Headset Microphone
	C	MIC-IN2	I/P	Analogue Voice Input from Headset Microphone
	D	-	-	No Connection

TEST POINTS		
Test Point Ref.	Default Measurement	Description
TP1	2.7V	V <sub>DD</sub>
TP2	0V	V <sub>SS</sub>
TP3	N/A	TEST0
TP4	N/A	TEST1
TP5	N/A	TEST2
TP6	2.7V	2.7V_RF – CC1000 Power Supply
TP7	N/A	CC1000 DIO Signal
TP8	N/A	CC1000 DCLK Signal
TP9	0V	V <sub>SS</sub>

JUMPERS			
Link Ref.	Positions	Default Position	Description
JP1	1 - 2: J1 - AAA Battery Holder 2 - 3: J2 - External Power Supply	1 - 2	Power Supply Source – Selects which power supply to use

**Notes:** I/P = Input  
O/P = Output  
BI = Bi-directional

### 5. Circuit Schematics and Board Layout

For clarity, circuit schematics are available as separate high resolution files.

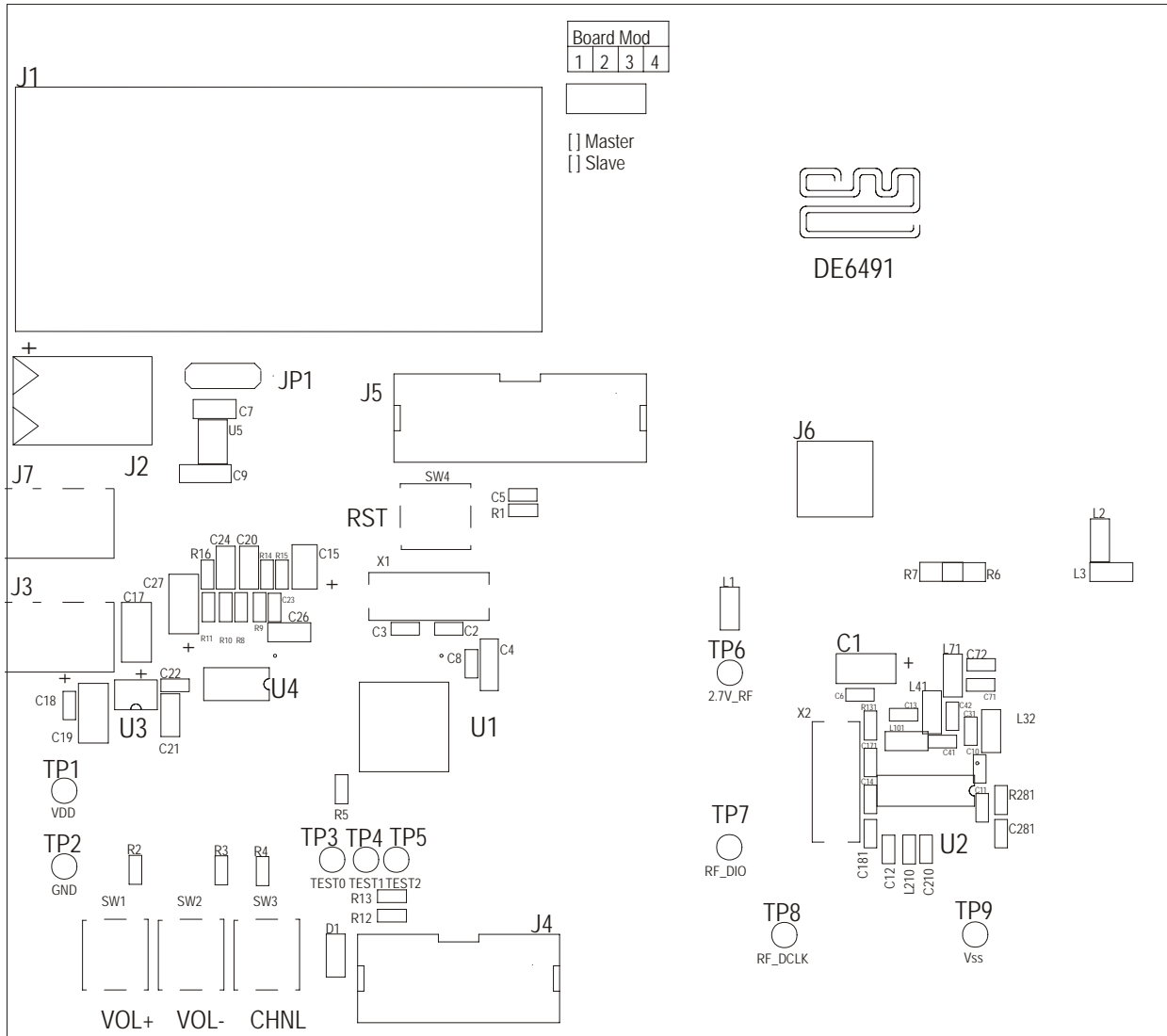


Figure 2 Demonstration Board Layout

## 6. Detailed Description

### 6.1 Hardware Description

Both boards consist of three main ICs: the CML Microcircuits CMX649, as the voice codec, the Chipcon CC1000, for the RF communication, and the Texas Instruments MSP430F147 microcontroller to control and transfer the data between the other two ICs and support the user interface and airlink protocol.

#### 6.1.1 Voice Codec Circuitry

The voice codec circuitry consists of the CMX649 and external passive components recommended by the CMX649 datasheet. The microphone amplifier has low and high  $-3\text{dB}$  frequency roll-off points of approximately 150Hz and 15kHz, respectively. To reduce the codec circuitry's footprint and cost, the CMX649 clock signal is provided by the MSP430F147 and not by a crystal oscillator.

A Maxim MAX4368 audio amplifier is used to drive the earpiece with the Audio Out signal from the CMX649. Its external components are designed for a highpass roll-off frequency of approximately 150Hz when used with the  $16\Omega$  impedance headset speaker.

#### 6.1.2 RF Transceiver Circuitry

The RF transceiver circuitry is based on the Chipcon CC1000PP reference design and the passive components have been chosen to provide operation in the European wireless audio band of 863 – 865 MHz, as stated in the CEPT ERC recommendation 70-03 Annex 13. Changes in passive component values, firmware adjustments and the use of an external antenna would allow a different RF band to be used for communication, see Chipcon documentation for details.

#### 6.1.3 RF Antenna

Two options are provided for the RF antenna: an embedded antenna printed on each PCB (default) and an external antenna which can be connected via the SMA connector J6. The embedded antenna is selected when R6 is a shorting link and R7 is not fitted, the external antenna is selected when R6 is not fitted and R7 is a shorting link.

#### 6.1.4 Headsets

Connectors J3 and J7 allow the supplied headsets, each consisting of a microphone and earpiece, to be attached to the boards.

#### 6.1.5 Expansion

Connector J4 is provided for user expansion. Four unused I/O lines of the MSP430F147 and  $V_{DD}$  and  $V_{SS}$  are available at this header.

#### 6.1.6 In-Circuit Programming

Connector J5 provides connections to the MSP430F147 microcontroller's JTAG interface to allow the device to be reprogrammed and debugged using the proprietary programmer, Texas Instruments MSP430 Flash Emulation Tool MSP-FETP430IF (not provided). The following instructions are a guide to program and debug the MSP430F147 firmware:

1. Connect the MSP-FET430IF to J5
2. Connect a power supply or battery
3. Start the programming or debug sequence in accordance with the programming tool manufacturer's specifications.

## 6.2 Firmware Description

A Texas Instruments MSP430F147IPM microcontroller is fitted to each of the DE6491 boards and has been programmed by CML, before shipment, with the latest version of firmware. Please read the separate information sheet (EK6491) and check the CML website for firmware status. The latest source code and programming files (EF6491xxM.d43 and EF6491xxS.d43, for the Master firmware and Slave firmware, respectively, 'xx' represents the version number) can be downloaded from the CML website.

There are two types of firmware included with the DE6491 demonstration kit, one for the Master board and one for the Slave board (see silk screen label for board type identification), both have the same basic structure, as shown in Figure 3. The firmware controls the CML Microcircuits CMX649 Voice Code, the Chipcon CC1000 RF transceiver and handles the transfer of data between them. All communication is synchronised by the Master board.

### 6.2.1 The MSP430F147's Interaction with the CMX649

On both the Master board and the Slave board, the CMX649 and its data are handled in the same way. The CMX649 is set to use 31.25kbps ADM to encode and decode the audio, which is created by dividing down a 4MHz clock signal provided by the MSP430F147. The CMX649 is sent control commands from the MSP430F147 via the CBUS serial interface, see the CMX649 datasheet for details on the CBUS. The MSP430F147 buffers data received from the CMX649 into packets, each one containing approximately 30ms of audio, to be exchanged over the RF link.

The Master board's firmware also takes advantage of the CMX649's programmable voice activity detector (VAD) to determine when voice/audio is present. This allows the Master board to decide when to powersave, i.e. after periods where voice/audio is consistently absent, and to wake from powersave, i.e. when voice/audio has been detected.

### 6.2.2 The MSP430F147's Interaction with the CC1000

The CC1000 and its data are handled by the MSP430F147 in an almost identical manner on both the Master board and the Slave board. Control signals are sent to the CC1000 by the MSP430F147 via the CC1000's 3-wire serial interface. Data is transferred over the RF link by the CC1000 at 76.8kbps and, therefore, data is transferred between the CC1000 and the MSP430F147 at the same rate. The audio packets collected from the CMX649 are converted into RF frames by the MSP430F147 and transmitted over the RF link by the CC1000.

Data is transferred over the RF link as half-duplex but provides the user with full-duplex audio communication because the CC1000's data rate is over twice the CMX649's data rate; i.e. two RF frames can be exchanged serially over the RF link, one in each direction, within the time it takes the CMX649 to encode one audio packet and decode another audio packet in parallel.

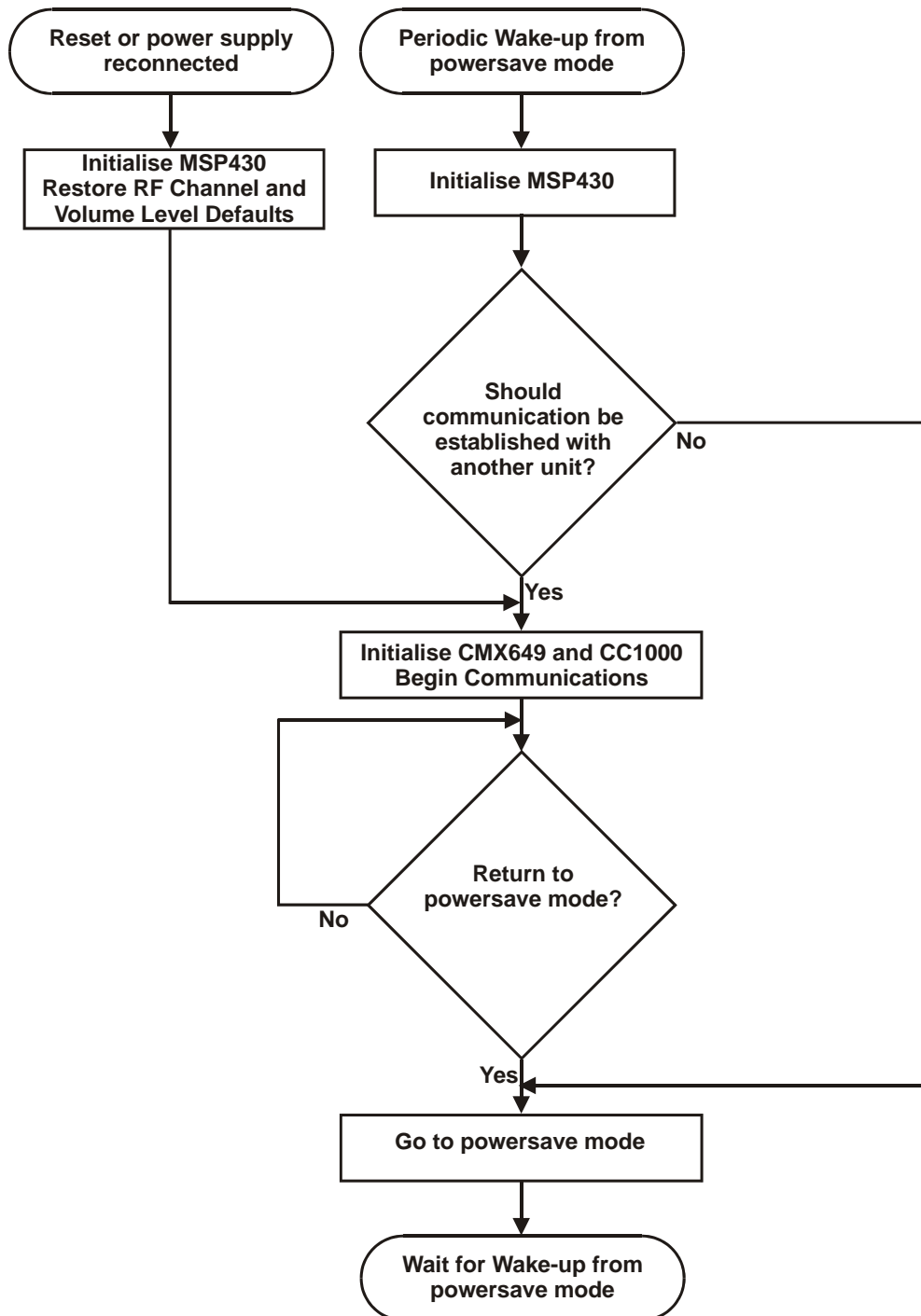


Figure 3 MSP430F147 Firmware Program Flow

### 6.2.3 Firmware Structure

The firmware is event driven with time-critical functions being performed in interrupt routines. There are four events that can cause an interrupt to be signalled:

- The CMX649 is ready to transfer digital audio, one byte that has been encoded by the CMX649, received by the MSP430F147, and one byte transmitted by the MSP430F147, to be decoded by the CMX649. (Handled by firmware function "CMX649\_TRANSFER").
- The CC1000 has received a byte from the RF link when in receive mode. (Handled by firmware function "RFCHIPRX").
- The CC1000 is ready to transmit a byte over the RF link when in transmit mode. (Handled by the firmware function "RFCHIPTX").
- The VOL-, VOL+ or CHNL button has been pressed. (Handled by the firmware functions "BUTTON\_DEBOUNCE" and "BUTTONS").

As well as performing their own functions, the interrupt handlers can set flags to request that the board:

- Switches to RF receive mode or RF transmit mode.
- Toggles the power state.
- Changes the volume level
- Exchanges a new RF channel to communicate on.

When a board is powered and communicating, the firmware function "MAINLOOP" continuously executes so that when a flag is set "MAINLOOP" can call the appropriate subroutine to perform the requested function, see Figure 4. These functions are performed by "MAINLOOP" as they are less time critical than those performed by the interrupt handlers.

### 6.2.4 CMX649 Register Configuration

The firmware configures the CMX649 registers as follows:

Register Name	Register Address (hex)	Register Value (hex)
AAF/AIF BANDWIDTH	61	00
AUDIO INPUT LEVEL CTRL	63	C0
POWER CONTROL 1	64	55
POWER CONTROL 2	65	55
CODEC MODE CONTROL	70	00
SCRAMBLER CONTROL	71	9xxx (where 'xxx' is a random number)
CLK DIVIDER CONTROL	72	E340
CLK SOURCE CONTROL	73	30F8
CODEC INTERRUPT CONTROL	81	88
DECODER MODE AND SETUP	D0	01B8
DECODER ADM CONTROL	D1	4999
DECODE VAD THRESHOLD	D2	0400
DECODE OFF-SET LEVEL	D3	0004
ENCODER MODE AND SETUP	E0	01B8
ENCODER ADM CONTROL	E1	499A
ENCODE VAD THRESHOLD	E2	0400
ENCODE OFF-SET LEVEL	E3	0004

## 6.3 Troubleshooting

Communication may be lost between two paired boards after a reset or reconnection of the power supply to one of the boards. Both of these events will cause the RF channel that board uses for communication to be reset to the default channel. Performing a reset on the other board will force both boards to use the same default RF channel and communication can be re-established.

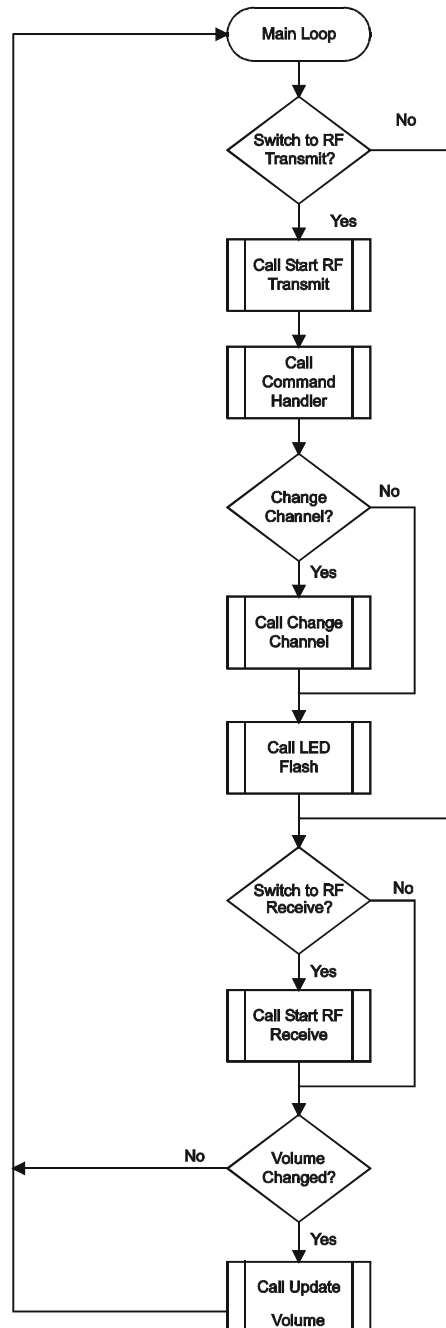


Figure 4 MAINLOOP Flow

## 7. Performance Specification

### 7.1 Electrical Performance

#### 7.1.1 Absolute Maximum Ratings

Exceeding these maximum ratings can result in damage to the Demonstration Kit.

	Min.	Max.	Units
Supply ( $V_{IN} - V_{SS}$ )	-0.3	6	V
Voltage on any connector pin to $V_{SS}$	-0.3	3.0	V
Current into or out of $V_{IN}$ and $V_{SS}$ pins	0	+30	mA
Current into or out of any other connector pin	-2	+2	mA

#### 7.1.2 Operating Limits

Correct operation of the Demonstration Kit outside these limits is not implied.

	Notes	Min.	Max.	Units
Supply ( $V_{IN} - V_{SS}$ )		2.9	5.5	V
Operating Temperature		+10	+35	°C
Operating Frequency (RF)		863	865	MHz

#### 7.1.3 Operating Characteristics

$V_{IN} - V_{SS} = 3.0V$ ,  $T_{amb} = +25^{\circ}C$ .

	Notes	Min.	Typ.	Max.	Units
<b>DC Parameters</b>					
$I_{DD}$ (powersave, Master)		–	500	–	$\mu A$
$I_{DD}$ (powersave, Slave)		–	420	–	$\mu A$
$I_{DD}$ (periodic wake from powersave, Master)		–	2.1	–	mA
$I_{DD}$ (periodic wake from powersave, Slave)		–	13.0	–	mA
$I_{DD}$ (powered and communicating, RF Range setting = Minimum)		–	17.0	–	mA
$I_{DD}$ (powered and communicating, RF Range setting = Low)		–	18.0	–	mA
$I_{DD}$ (powered and communicating, RF Range setting = High)		–	20.0	–	mA
$I_{DD}$ (powered and communicating, RF Range setting = Maximum)		–	25.5	–	mA
<b>RF Range with:</b>					
RF Power Setting = Minimum		–	–	3.0	m
RF Power Setting = Low		–	–	8.0	m
RF Power Setting = High		–	–	12.0	m
RF Power Setting = Maximum		–	–	20.0	m






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Oval Park, Langford, Maldon, Essex, CM9 6WG - England.  Tel: +44 (0)1621 875500 Fax: +44 (0)1621 875600  Sales: <a href="mailto:sales@cmlmicro.com">sales@cmlmicro.com</a>  Technical Support: <a href="mailto:techsupport@cmlmicro.com">techsupport@cmlmicro.com</a>	4800 Bethania Station Road, Winston-Salem, NC 27105 - USA.  Tel: +1 336 744 5050, 800 638 5577 Fax: +1 336 744 5054  Sales: <a href="mailto:us.sales@cmlmicro.com">us.sales@cmlmicro.com</a>  Technical Support: <a href="mailto:us.techsupport@cmlmicro.com">us.techsupport@cmlmicro.com</a>	No 2 Kallang Pudding Road, #09 to 05/06 Mactech Industrial Building, Singapore 349307  Tel: +65 6745 0426 Fax: +65 6745 2917  Sales: <a href="mailto:sg.sales@cmlmicro.com">sg.sales@cmlmicro.com</a>  Technical Support: <a href="mailto:sg.techsupport@cmlmicro.com">sg.techsupport@cmlmicro.com</a>	No. 218, Tian Mu Road West, Tower 1, Unit 1008, Shanghai Kerry Everbright City, Zhabei, Shanghai 200070, China.  Tel: +86 21 6317 4107 +86 21 6317 8916 Fax: +86 21 6317 0243  Sales: <a href="mailto:cn.sales@cmlmicro.com.cn">cn.sales@cmlmicro.com.cn</a>  Technical Support: <a href="mailto:sg.techsupport@cmlmicro.com">sg.techsupport@cmlmicro.com</a>