Freescale Semiconductor
Application Note

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Interfacing the MC68HC908QF4 Evaluation Board to RD68HC908RKE

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Introduction

This application note describes how to interface the MC68HC908QF4 (QF4) evaluation board to *RD68HC908RKE: Radio Frequency Reference Design for Remote Keyless Entry* through RF communication. Because the reference design was originally based on the RF2, this document highlights the differences between the RF2 and the QF4. Also, RF data transfer from the QF4 evaluation board to the reference design receiver board is demonstrated with example software.

Connecting the QF4 evaluation board to the receiver of the RKE demo allows a visual representation of the UHF transmissions generated by the QF4. This is ideal for people who do not have their own receiver board and would like a demonstration of the capabilities of the QF4.

An example of how to create a Metrowerks CodeWarrior® application with the QF4 evaluation board and debug it using a Cyclone™ or MultiLink™ tool is also provided.

NOTE

With the exception of mask set errata documents, if any other Freescale Semiconductor document contains information that conflicts with the information in the device data sheet, the data sheet should be considered to have the most current and correct data.

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RF2 versus QF4

The QF4 is an RF product in the HC08 Family. It combines the features of an HC08 microcontroller unit (MCU) with a PLL-tuned UHF transmitter in a 32-pin LQFP package.

The QF4 provides an alternative for the RF2, which contains the same UHF transmitter. These MCUs are ideal for applications such as remote keyless entry, garage door openers, remote sensing, and other applications that require RF data transfer.

The RF2 and the QF4 contain the same UHF transmitter module, but there are some differences between these MCUs.

- The pinouts are different. For this reason, the QF4 is not a drop-in replacement for the RF2.
- Code designed for the RF2 will not work the same way on the QF4 without modifications. The required hardware and software changes are not very significant, and they will be discussed in this document.
- The methods of internal clock generation are different. The RF2 contains the ICG (internal clock generator) module that can be used to generate a range of bus speeds. The QF4 contains an internal oscillator that is hard-wired to produce only a trimmed 1-MHz bus speed.

For a more complete explanation of the differences between these two MCUs, please reference their individual data sheets. (See References)

Hardware Description

The critical components of the QF4 evaluation board are shown in Figure 1.

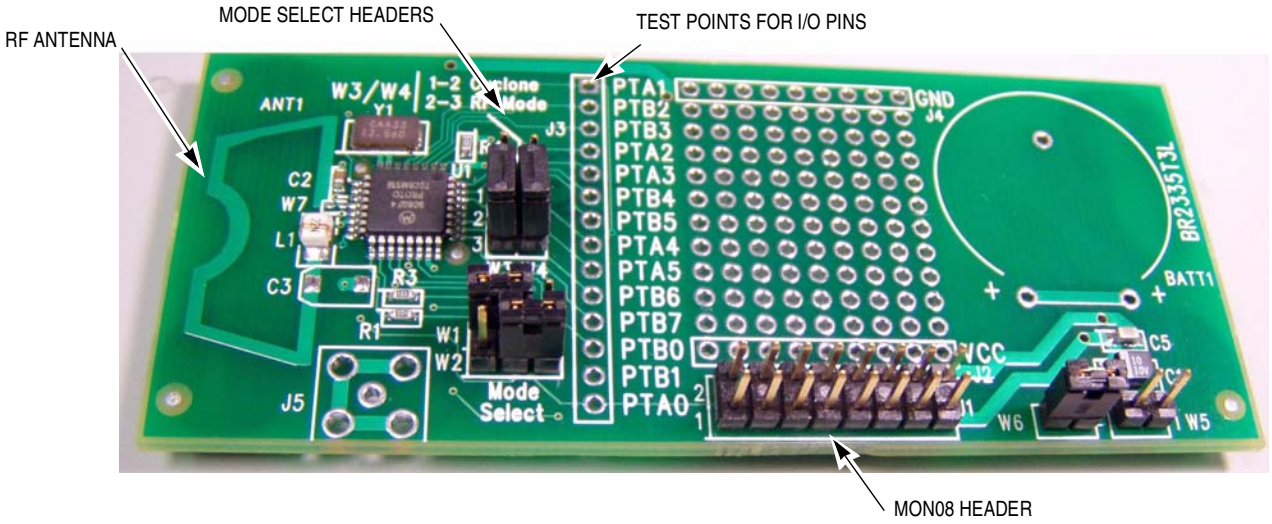

Figure 1. QF4 Evaluation Board

Description of the QF4 Evaluation Board

The QF4 evaluation board provides the hardware necessary to demonstrate RF transmission from the UHF transmitter. The provided hardware allows RF transmission at 868 MHz or 434 MHz (based on a 13.56-MHz crystal), but it has not been optimized for RF performance. Nor has the antenna on this board been tuned to demonstrate optimum transmit range. For these reasons, the QF4 evaluation board should not be used to measure RF performance.

The board contains a MON08 header so that a MultiLink08™ or Cyclone tool can be used for programming and debugging.

NOTE

When using a MultiLink or Cyclone tool, be sure to configure 3-V operation. Please refer to the documentation for the version of the MultiLink or Cyclone tool you are using to determine how to configure 3-V operation.

QF4 Evaluation Board Header Description

BAND and MODE Select Headers (W1 and W2)

W1, W2, BAND, and MODE pins can be pulled high or low to configure the desired operation. Connecting a header at pins 1 and 2 connects a pullup. Connecting a header to pins 2 and 3 connects a pulldown. The BAND pin can be used to configure either 434-MHz or 868-MHz operation.

Table 1. Frequency Band Selection and Associated Divider Ratios

Band Input Level	Frequency Band (MHz)	PLL Divider Ratio	Crystal Oscillator Frequency (MHz)
High	315	32	9.84
	434		13.56
Low	868	64	

The MODE pin selects modulation. On/off keying (OOK) or frequency shift keying (FSK) can be selected as shown in Figure 2.

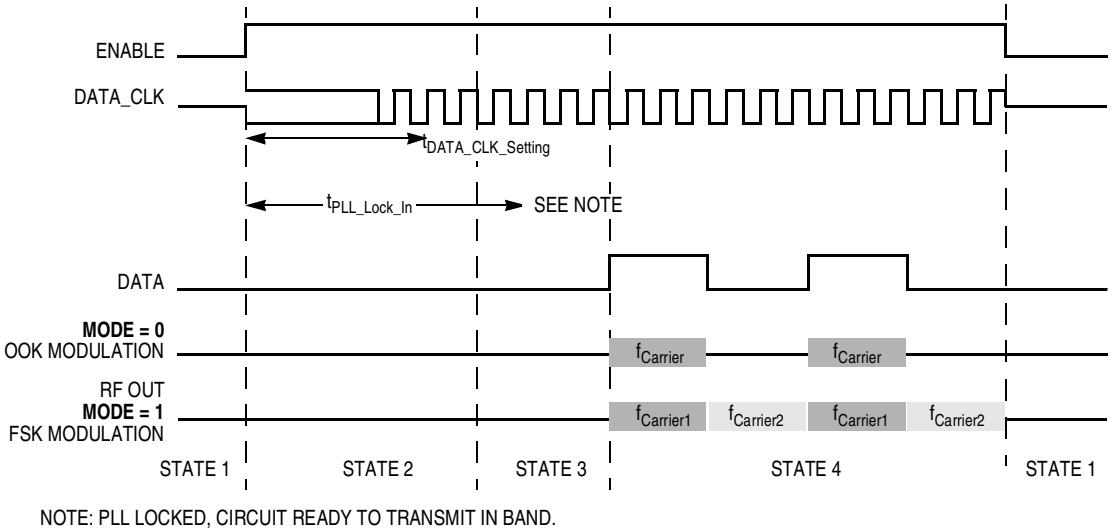

Figure 2. System Clocks

Debug and RF Mode Select Headers (W3 and W4)

W3 and W4 are used to place the QF4 evaluation board in RF mode or debug mode. The board shown in Figure 1 is configured in RF mode. In this mode, normal operation occurs. To program or debug the QF4 evaluation board, the jumpers for both headers (W3 and W4) should be moved to locations 1 and 2 (See Debug Mode section for more information).

Power Select Headers (W5 and W6)

Power to the QF4 evaluation board can be supplied at the W5 header. W6 must be placed when power is provided by W5 (W5 pin 2 is V_{CC}; pin 1 is GND). If a lithium battery is placed on the board, W6 can be used to connect or disconnect this battery. The battery must be disconnected so that a Cyclone or MultiLink08 tool can be used. W6 can also be used to place a current meter so that power consumption can be measured.

MON08 Header (J1)

This is where a Cyclone or MultiLink08 tool would be connected to perform programming and debugging operations.

NOTE

Always configure the Cyclone or MultiLink08 tool for 3-V operation *before connecting to the QF4 evaluation board. Note the location of pin 1 of the MON08 header. This header can also be used to provide power to the board. V_{DD} is pin 15 and V_{SS} is pin 2 on this header.*

SMA Connector Headers (J5)

The QF4 evaluation board contains the footprints for the circuit that is necessary to place an SMA connector.

Test Points for I/O Pins (J3)

This header allows easy access to the I/O pins.

V_{CC} Header (J2) and V_{SS} Header (J4)

These headers allow easy access to V_{CC} and V_{SS}.

Schematic

See Figure 14 for the schematic.

Evaluation Board in RF Mode

Figure 3 illustrates the connections made when the QF4 evaluation board is in RF mode.

To implement the interface needed to create RF transmission:

- PTB0 must be connected to the enable pin of the QF4 on the evaluation board.
- PTA1/TCH1 must be connected to the DATA pin.
- PTA2/$\overline{\text{IRQ}}$/TCLK must be connected to DATA_CLK. (This is done by jumper W4.)
- W3 and W4 are set to locations 2 and 3 for RF mode.

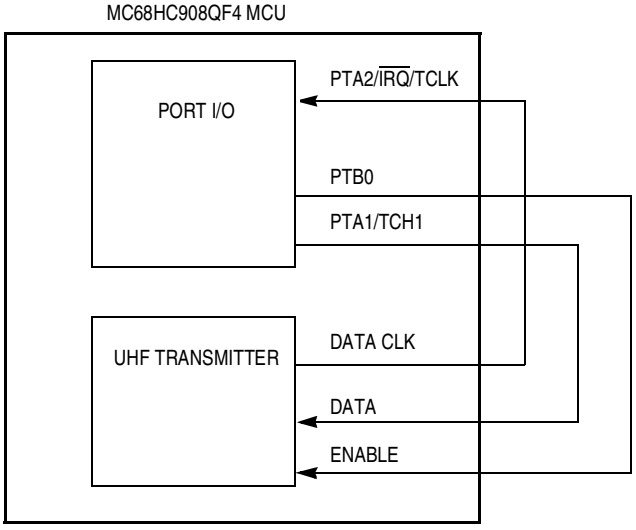

Figure 3. High-Level Block Diagram

Debug Mode versus RF Mode

The block diagram shown in Figure 3 illustrates the connections made when jumpers W3 and W4 are configured for RF mode. When in debug mode, these jumpers connect PTA1 and PTA2 to the appropriate MON08 header pin (J1). In RF mode, they connect PTA1 and PTA2 to DATA and DATA_CLK. W3 and W4 are set to locations 1 and 2 for debug mode.

Debug Mode

The QF4 evaluation board silkscreen shows the location of the mode-select headers, W3 and W4, which are used to configure debug mode. In this configuration, a Cyclone or MultiLink08 tool can be connected to the MON08 header, J1. Then software such as P&E or CodeWarrior tools can be used for programming and debugging.

Advantages and Limitations of the QF4 Evaluation Board

The evaluation board is a good way to begin QF4 applications and makes debugging easier. The board can transmit RF data in monitor mode because of the hardware configuration. This document describes how to do this in Generating RF Transmissions.

The evaluation board accommodates different modes of operation for the QF4, but it may not be the best solution for all QF4 applications. For example, to achieve 315-MHz operation, you must change the crystal on the board. Also, you should optimize the antenna design for the specific frequency of your application.

RKE (Remote Keyless Entry) Reference Design

This section explains how to interface the QF4 evaluation board to the receiver board of the RKE reference design. The product page for the RKE reference design contains the software and hardware used to create this design. This reference design can be purchased at:
http://www.elektronikladen.de/en_rke08rd.html

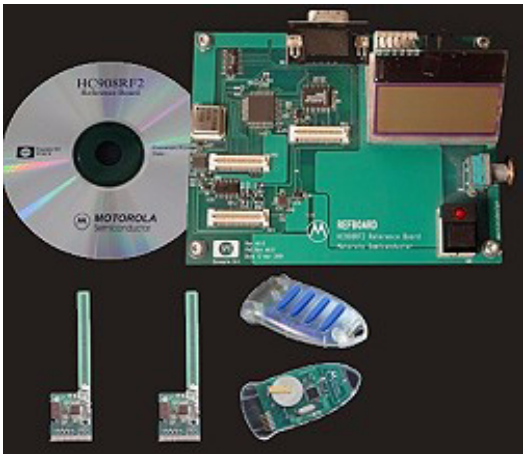

Figure 4. Contents of RKE Reference Design

The RKE reference design contains a motherboard that uses an MC68HC908GP32 (GP32) and an MC33493 antenna module that receives RF data and provides feedback on an LCD. The RKE reference design documentation contains the schematic for this board.

The receiver board normally receives RF data from the RF2 key fob modules that come with the reference design. When a button is pressed on the battery-operated key fob, RF data is transmitted from the key fob to the motherboard. This data can then be displayed on the LCD.

Running the RKE Demo

Here are some simple steps that outline how to run the RKE demo.

1. Apply power to the receiver board (9 V).
2. Navigate the menu by rolling the control knob and select “Receive” by pressing the square button.
3. Navigate the menu by rolling the control knob and select “Rolling” by pressing the square button.
4. Push the control knob in (towards the board).

This puts the motherboard into rolling view demo mode. Rolling view demo mode will be used to demonstrate the data transfer from the QF4 evaluation board to the receiver board.

When RF data transfer is initiated (by pressing any button on the key fob), the corresponding data on the LCD will appear.

Converting the Key Fob Software

The RKE reference design implements data encoding and CRC-checks to ensure that proper RF communication occurs. When data is transmitted, it is coded by rolling—or rotating—the data. So before a data transmit, the software shifts the data when it creates the message frame. One of the bytes that is sent during the transmit (shown in the following code excerpt) contains the key so the receiver board can decode the data.

```
              TRANSMISSION FRAME COMPOSITION

 NNNNNNNN-RRRRRRRR-DGGGTTTT-IIIIIIII-IIIIIIII-IIIIIIII
| EXTRA  | --CRC--|  CODE  |--------ID  NUMBER--------|
I=ID NUMBER -> FIXED IDENTIFICATION CODE (3 BYTES)
G=GROUP     -> SELECTED GROUP
D=DIRECTION -> 1=INCREASE 0=DECREASE
T=BUTTON    -> BUTTON SELECTED CODE
R=CRC       -> CRC
N=UNUSED    -> THEY MUST BE 0 To Initiate communication
```

This same method must be used when creating software that will interface to the receiver board for the RKE reference design. When creating the code, the sections that create the message frame must match the frame composition demonstrated above.

Modifying the RF2 Application Code for the QF4

When modifying code from an RF2 application to a QF4 application, the main modifications to the code are required because of pinout differences. Table 2 shows the modifications necessary to compensate for the pinout differences.

Table 2. Pinout Modifications

	RF2	QF4
ENABLE	PTA0	PTB0
DATA	PTB2	PTA1
DATA_CLK	PTB3	PTA2

Other minor changes have been made to convert the software:

- To create a simple demonstration, no keyboard pins or interrupts are used to initiate transmissions. The code that supported KBI interrupts has been removed.
- To provide visual feedback, a counter is incremented each time a transmission is made. This data can be seen on the receiver board of the RKE demo. The receiver board should be set to receive rolling data as described in Running the RKE Demo.
- PTA1/TCH1 is used to provide data to the MC33594 UHF transmitter. The timer module uses DATA_CLK from the UHF transmitter as a reference to generate the bit timing.
- The UHF transmitter is enabled by PTB0. Setting PTB0 enables the PLL of the UHF transmitter and DATA_CLK that is fed into the timer module through PTA3/$\overline{\text{IRQ}}$.

Software Flow

To generate a transmission, the software first creates the transmission frame. The CRC is calculated and placed in the frame. After the frame has been built, PTB0 is set so the UHF transmitter is enabled. The UHF transmitter then generates DATA_CLK, and this reference clock is provided to the timer module. PTA1, the DATA signal, is controlled by a timer channel. RF data is fed serially out of PTA1. After the frame has been sent, PTB0 is cleared so the UHF transmitter is disabled.

The software flow is illustrated in Figure 5.

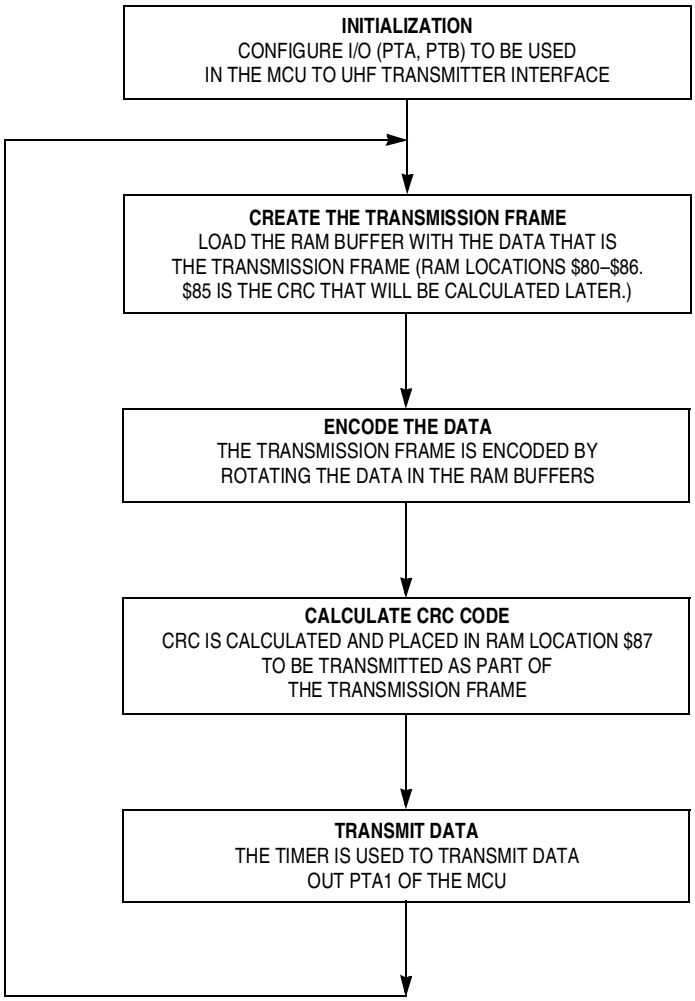

Figure 5. Software Flow Chart

Debugging with the QF4

To create a debugging interface using the CodeWarrior development tool, create a new project with the QF4 as the target. This is done by creating an HLC908QY4 project as explained in this section.

With this patch is installed, the CodeWarrior tool can create an MC68HLC908QY4 target. This will allow you to interface with the QF4 evaluation board.

How to Create a CodeWarrior project to interface to the QF4

1. Open the CodeWarrior IDE.
   Click: Start -> Programs -> Metrowerks CodeWarrior ->CodeWarrior IDE
2. Open a new file.
   Click: File -> New
3. Select HC(S)08 New Project Wizard as shown in Figure 6a.
4. Select MC68HLC908QY4 as the Target Derivative (Figure 6b).

NOTE

If the derivatives menu does not have MC68HLC908QY4 available as a target derivative, you must install the HLC_QT_QY patch from the Metrowerks website.

5. Complete the CodeWarrior New Project Wizard, which will guide you through the rest of setting up your project. As soon as you have completed the Wizard, the project can be used to interface with the MC68HC908QF4.

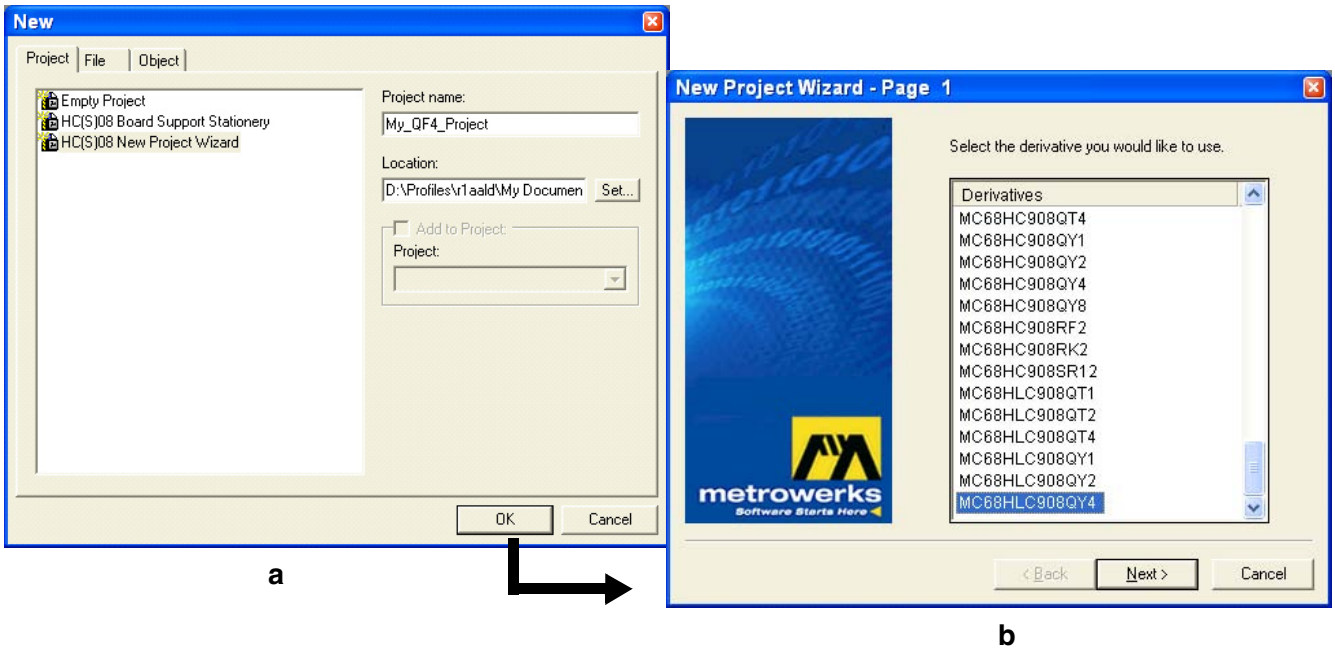

Figure 6. Selecting MC68HLC908QY4 as Target Derivative

A CodeWarrior project that is pre-configured to interface with the evaluation board, AN2602SW.zip, is available from the Freescale Semiconductor website: http://freescale.com.

For the following demonstration, download the compressed file, extract the files, and open the .mcp project file. With the project open, click the green arrow (debug button) to activate the True-Time Simulator and begin debugging the EVB code.

The screenshots in Figure 7 through Figure 12 show the code necessary to generate a UHF transmission. Set the breakpoints at the locations shown in the screenshots. By single-stepping and using the debugging interface, you can see how the code works.

1. **Initialization** — Figure 7 shows the initialization code for the transmit code that is implemented on the QF4 evaluation board. This code disables the COP and configures the I/O so that the critical signals (ENABLE and DATA) are prepared for proper operation.

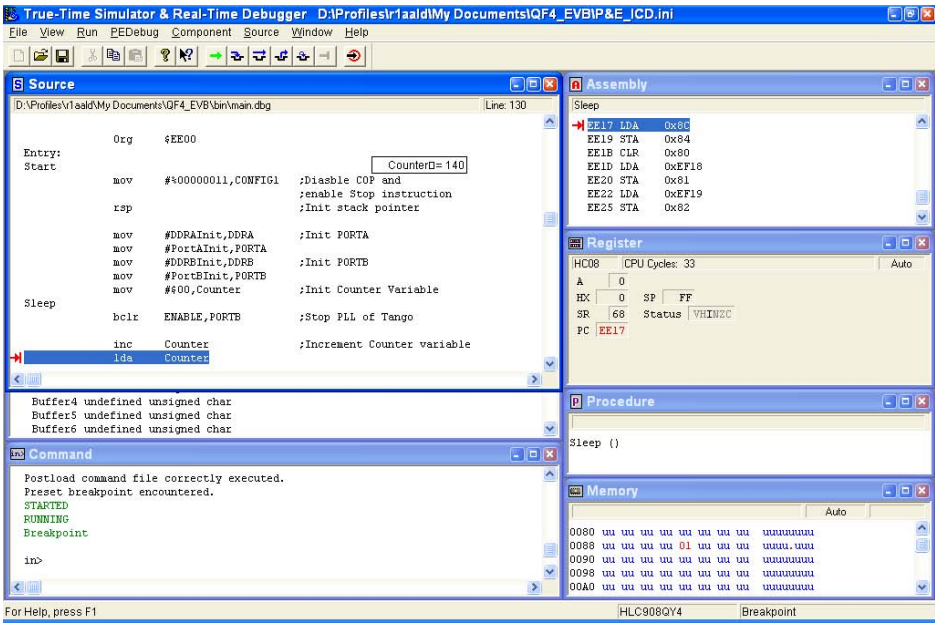

Figure 7. Initialization

2. **Creating the Transmission Buffer** — The code shown in Figure 8 creates the transmission buffer by loading the counter variable and ID constants into the RAM space that is defined as the buffer area.

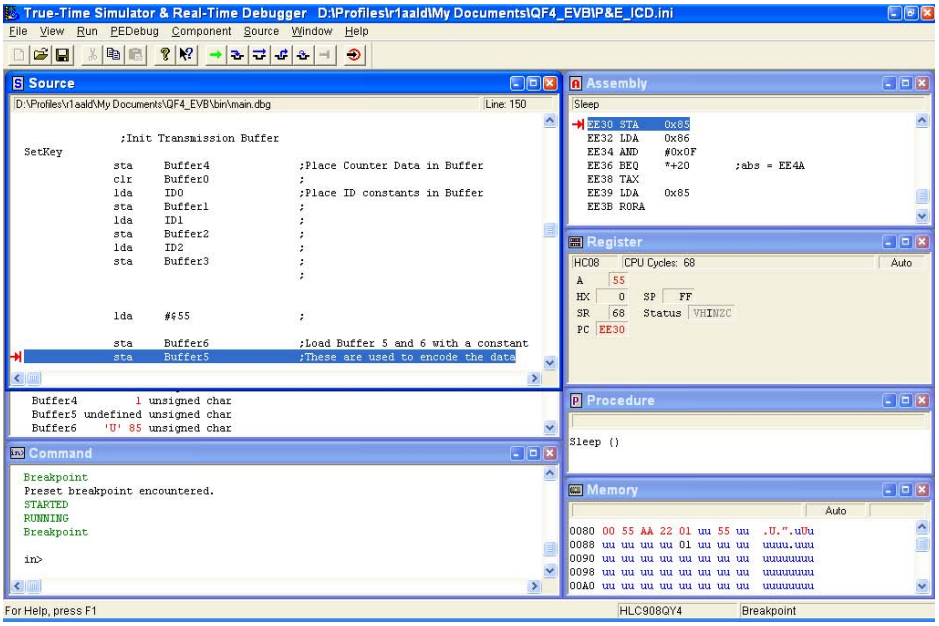

Figure 8. Creating the Transmission Buffer

3. **Encoding the Data** — After the buffer has been created, it is encoded by rotating the data in the transmission buffers. The number of rotations is sent in the transmission frame so the code can be decoded by the receiver. See Figure 9.

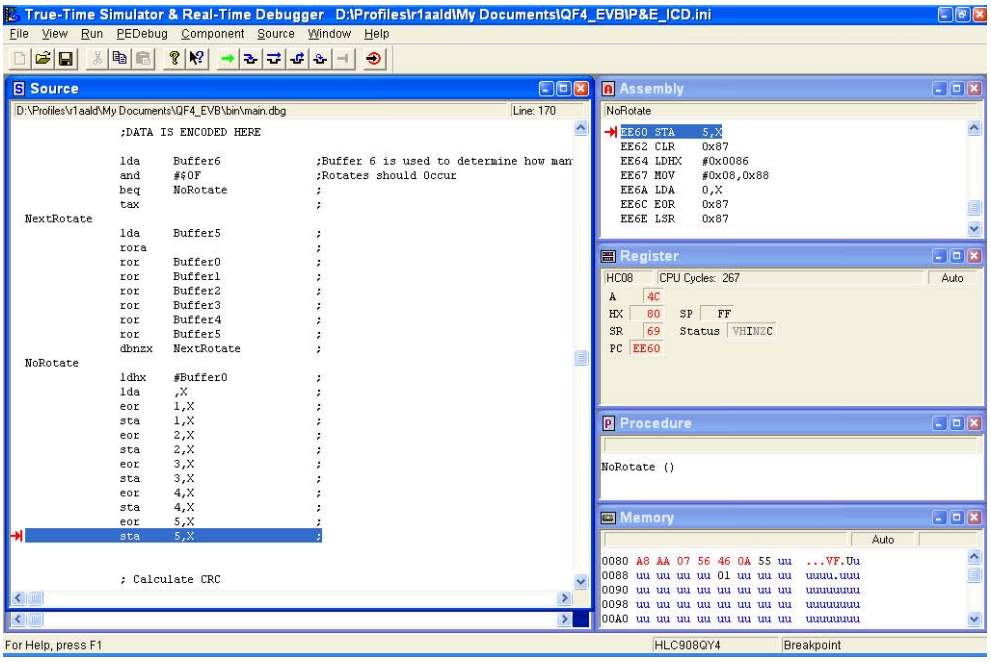

Figure 9. Encoding the Data

4. **Calculating the CRC** — The CRC byte is calculated using the code shown in Figure 10. The CRC is checked by the receiver to ensure proper transmission.

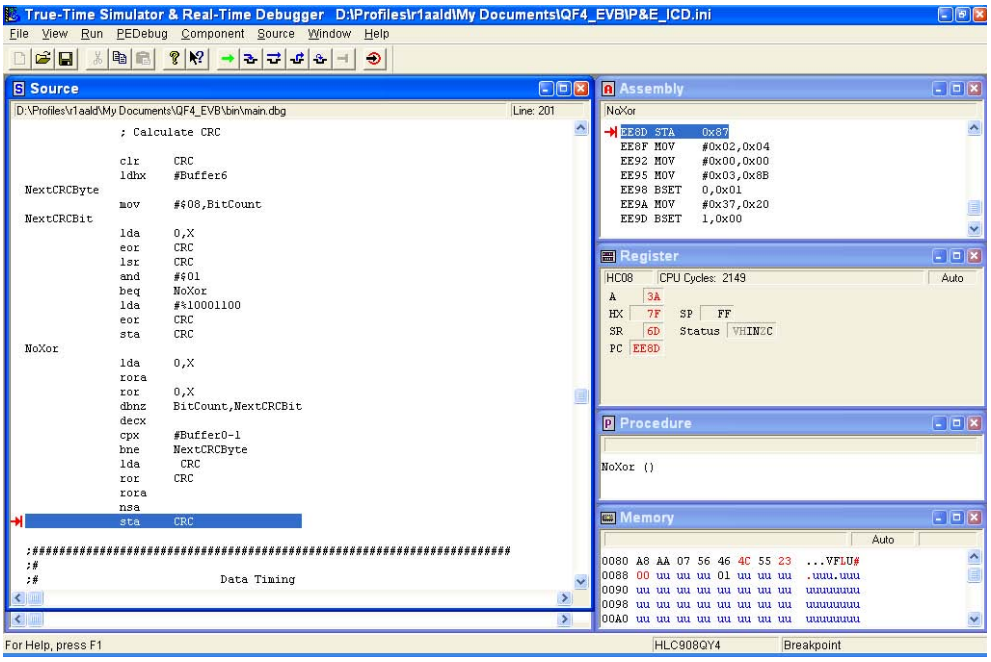

Figure 10. Calculating the CRC

5. **Transmission Loop** — Transmissions are done using a software loop that uses the timer to control PTA1, the DATA signal. Because TCLK is provided by DATA_CLK from the UHF transmitter, this is used as a timebase for the data transmission. See Figure 11.

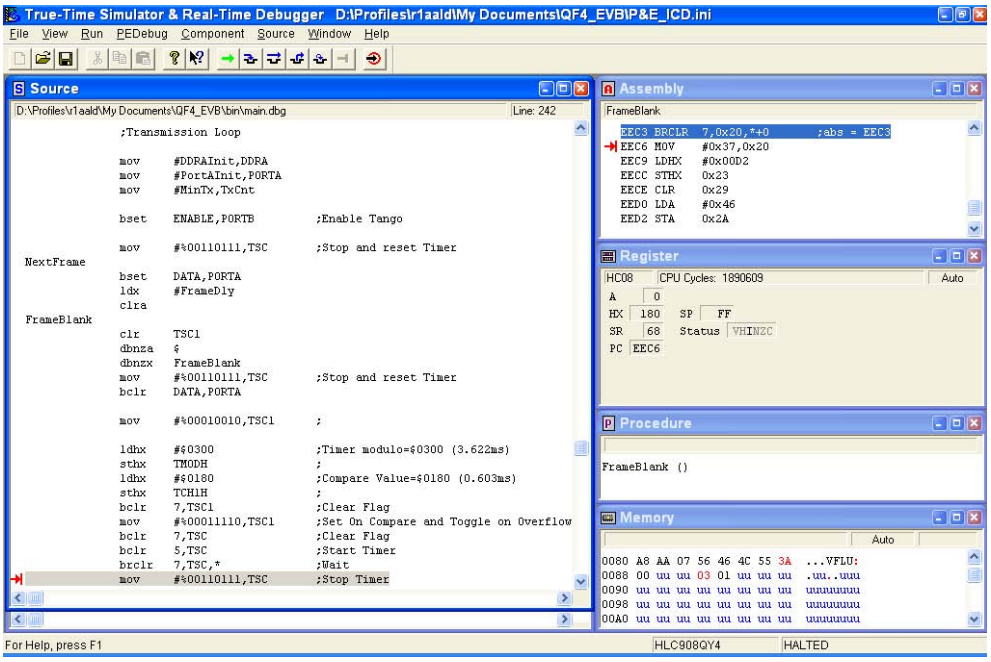

Figure 11. Transmission Loop

6. **Returning to the Main Routine** — After transmissions are complete, the code returns to the main routine so that the counter can be incremented and the sequence can be repeated. See Figure 12.

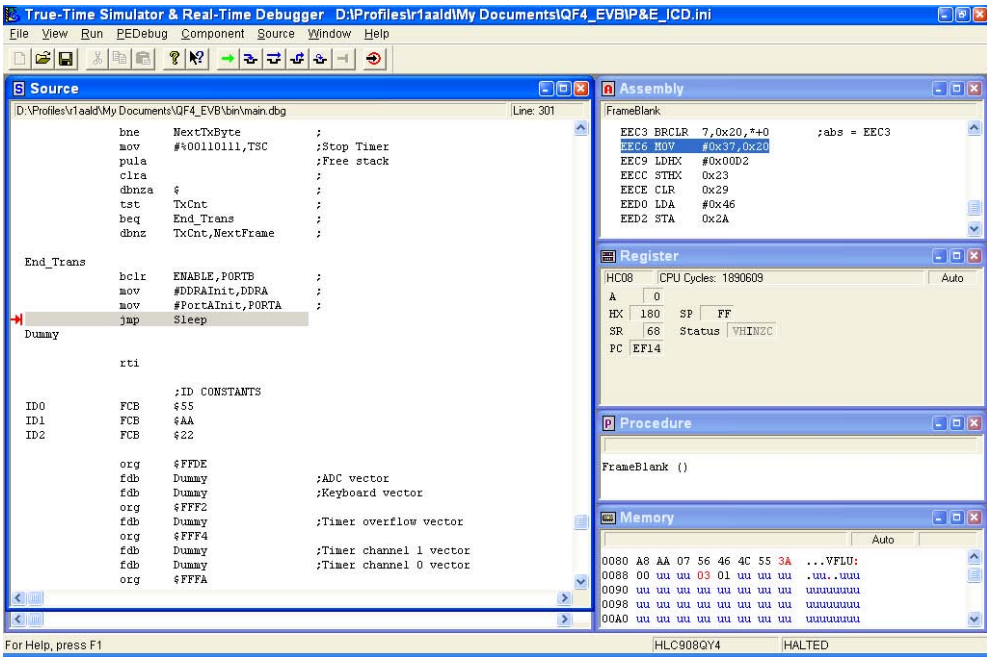

Figure 12. Returning to the Main Routine

Generating RF Transmissions

One benefit of the QF4 evaluation board is that you can generate RF transmissions while in monitor mode using the True-Time Simulator. To do this, enter monitor mode by selecting In-Circuit Debugging/Programming in the True-Time Simulator as shown in Figure 13.

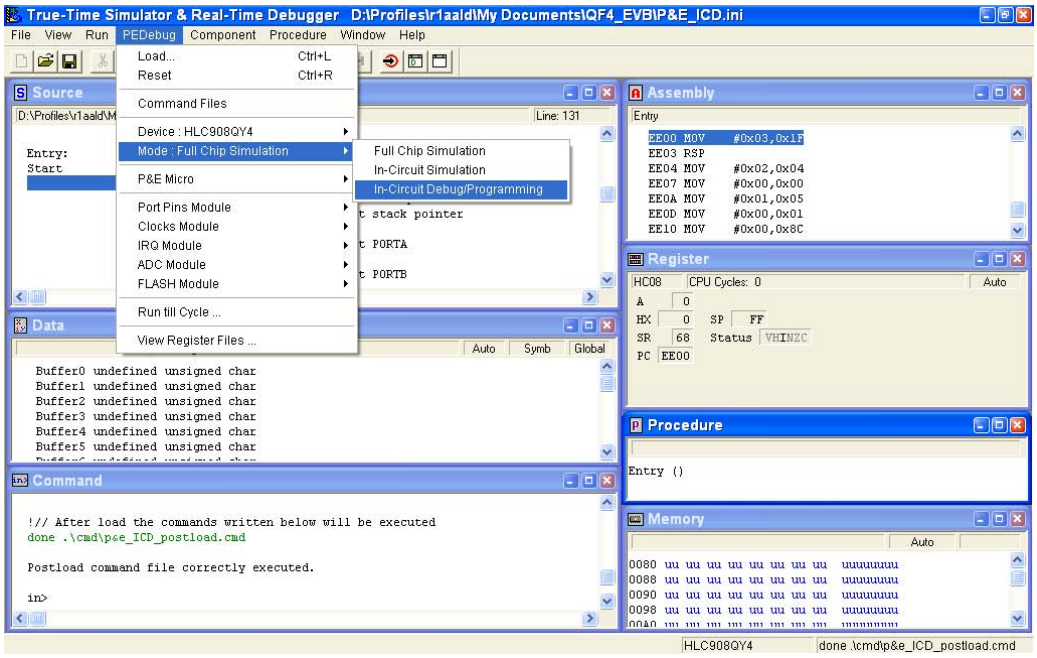

Figure 13. Entering Monitor Mode by Selecting In-Circuit Debugging/Programming

Your Multilink or Cyclone tool will place the QF4 evaluation board in monitor mode. As soon as the board is in monitor mode, you can change the W3/W4 headers from debug mode (1–2) to RF mode (2–3). Using the screen shots in Figure 7 through Figure 12, you can run the code on the hardware and generate RF transmissions while debugging.

Conclusion

Using the code provided with this application note (AN2602SW.zip), RF transmission with the QF4 evaluation board can be accomplished. The differences between the RF2 and the QF4 are explained.

References

From Freescale Semiconductor Website, www.freescale.com

AN2602SW.zip: *Software Files for AN2602/D*

RD68HC908RKE: *Radio Frequency Reference Design for Remote Keyless Entry* summary page

MC68HC908RF2/D: *MC68HC908RF2 Data Sheet*

MC68HC908QF4/D: *MC68HC908QF4 Data Sheet*

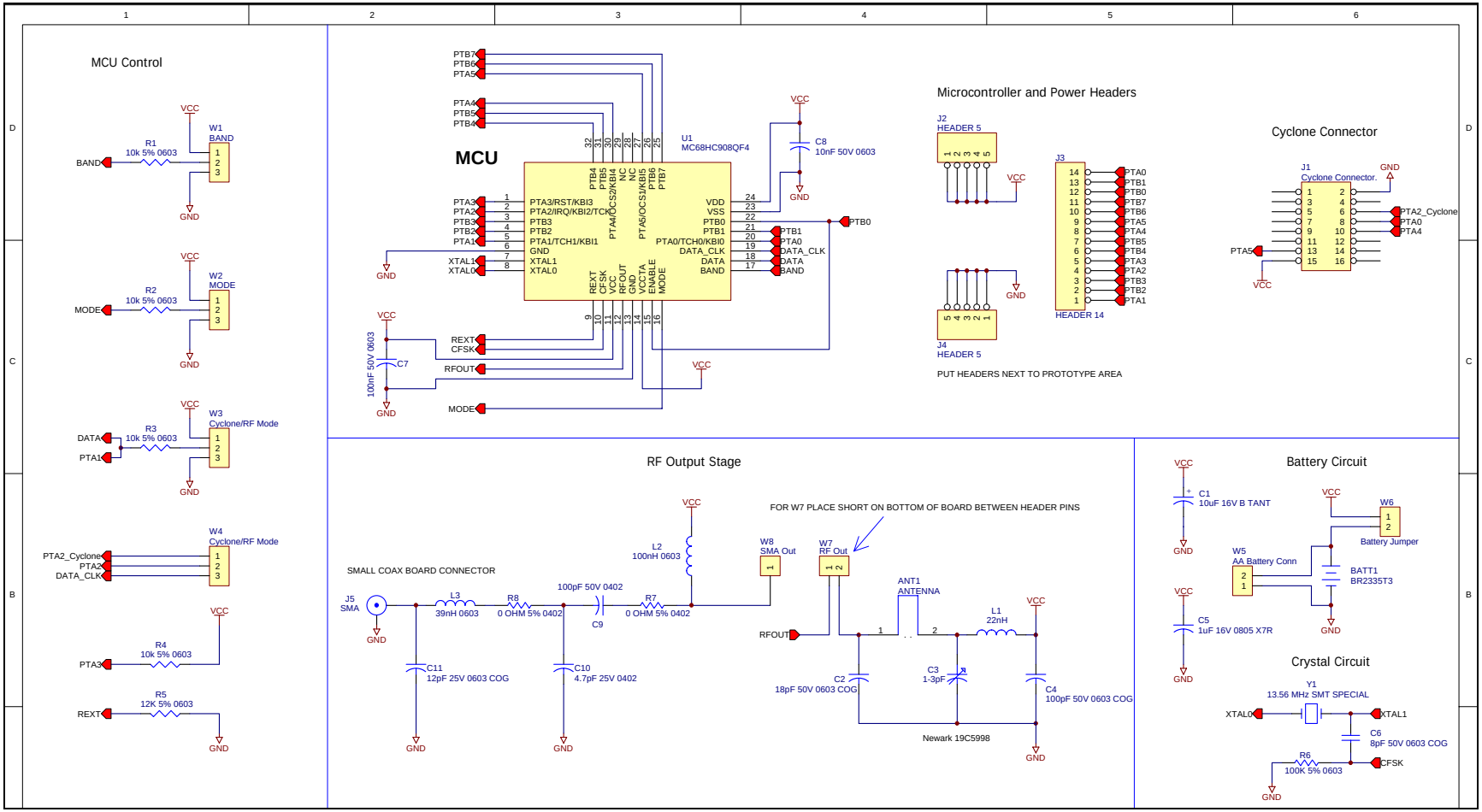

Figure 14. Schematic

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