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Eval Board and Programming Tool Guide for Mixers and Modulators with Integrated Synthesizers

RFMD Multi-Market Products Group

REVISION HISTORY

Version	Date	Description of change(s)	Author(s)
2.1	27-Feb-12	Minor edits	Chris Shepherd, Eric Schonthal
2.0	22-May-11	Addition of several menu items	Chris Shepherd, Robert Pipkin
1.0	22-Oct-10	First publication	Robert Pipkin
0.2	20-Oct-10	Prep for publication	Robert Pipkin
0.1	01-Jul-10	Second Draft	Chris Shepherd
0.0	29-Jun-10	Initial Draft for second revision of the chip	Chris Shepherd

CONTENTS

1. EVALUATION BOARDS AND DESIGN KITS

1.1 OVERVIEW

This guide gives instructions on how to connect to and operate the evaluation boards for RFMD's Integrated Synthesizer/Mixer devices, with focus on the RFFC5071 device and the DKFC5071 design kit. Information on other devices can be found in "Simplified Schematics for Evaluation Boards". This guide includes setup information for the evaluation boards and instructions on how to use the programming tool, sometimes referred to as the GUI (Graphical User Interface).
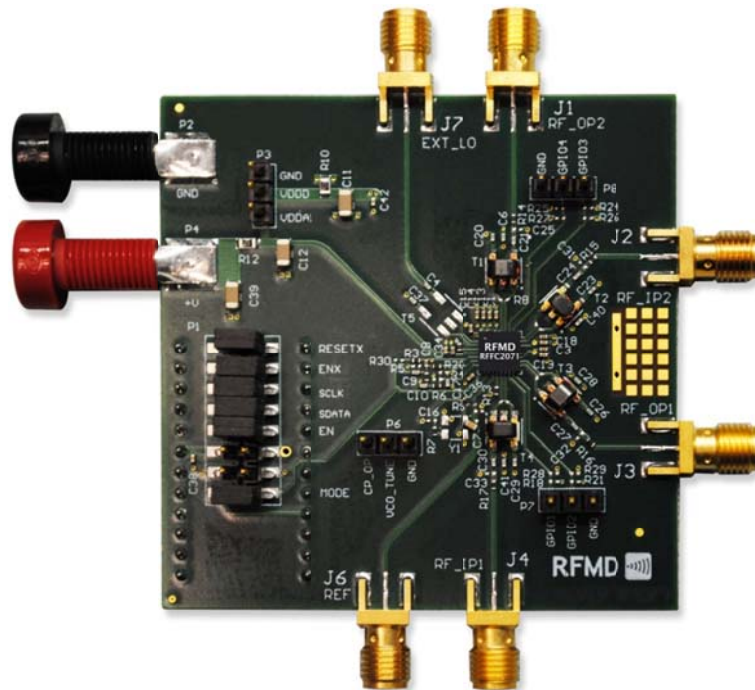

Figure 1. RFFC2071 Evaluation Board

RFMD's integrated synthesizer devices incorporate a proprietary serial interface which is driven from a software programming tool through a USB-to-serial interface chip. The programming tool programs the PLL to the desired LO frequency, and enables and biases the mixer(s) as required, while controlling other features within the chip. Before evaluation of the device can begin, the various software components need to be installed on a suitable PC, as described later in this document.

These evaluation boards incorporate wideband baluns on the mixer input and output ports to enable wideband characterization of the device. Performance is improved for narrowband applications by optimizing the balun type and matching for the frequencies of interest. These boards are fitted with a 26MHz reference oscillator that provides the PLL reference clock. They can be configured to accept an external reference signal of between 10MHz and 104MHz. A complete circuit diagram and bill of materials are available.

1.2 DESIGN KIT DISCLAIMER

These kits are intended for evaluation purposes only. RFMD expressly disclaims all warranties, either express or implied, including the implied warranties of fitness for a particular purpose and merchantability, with respect to the use of this design material in connection with the design or use of any product. RFMD also disclaims all responsibility for any actual, direct, indirect, special, consequential, or incidental damages incurred by any person resulting from any error or defect in or misuse of this circuit design and any related specifications or information. These devices have not been authorized as required by the rules of the Federal Communications Commission. These devices are not, and may not be, offered for sale or lease, or sold or leased, until authorization is obtained.

1.3 EVALUATION BOARD SETUP

The UM232R interface module on the evaluation board should be connected to a USB port on the PC running the programming tool. The UM232R is a USB-to-serial interface chip. It has been programmed at RFMD in order to operate correctly with the programming tool.

Figure 2. FTDI UM232R interface module

The evaluation board comes fitted with a 26MHz reference oscillator providing the reference clock. The board can be configured for an external reference clock, provided via an SMA connector. This requires the crystal to be removed and 1nF capacitors fitted to connect the input clock to pin 10 of the chip.

With these connections in place the device is ready to be programmed. The RF and/or baseband ports (SMA) can be connected to test equipment as required.

Function	Type
Power supply (+3V)	Banana plugs
RF inputs and outputs	SMA
Baseband inputs and outputs	SMA
External reference input	SMA
UM232R USB-to-serial adaptor	24-pin DIL (0.6")
GPOs	SIL header
Serial interface	DIL header

Table 1. Evaluation board setup details

1.4 PREPARING THE FTDI UM232R UART TO CONTROL A DEVICE ON A USER'S OWN BOARD

If the following conditions are met the programming tool automatically detects whether the board being used is configured as a MultiSlice board or has a single device. It will also be able to detect which device is being used on the board and display appropriate graphics to aid programming:

1. If using a new UM232R, the correct code needs to be used in the module. The code is available from RFMD.
2. The control lines must be connected to the device(s).
3. Two signal lines on the USB interface must be correctly terminated to ensure the programming tool operates in the correct mode (single device or MultiSlice).

Installing the FTDI UM232R USB drivers

If this is the first time connecting the FTDI UM232R, "Device not found" and a dialog box display. Install the USB drivers.

To install the FTDI UM232R USB drivers:

1. Select "No, not this time".
2. Select Next.
3. Select "Install from a list or specific location (Advanced)".
4. Select Next.
5. Select "Don't search, I will choose the driver to install".
6. Select Next.
7. Select "Show all devices".
8. Select Next.
9. Select Have Disk...
10. Select Browse.
11. Navigate to FTDI and select the driver .inf file.
12. Select Open.
13. Select OK. The driver installs.
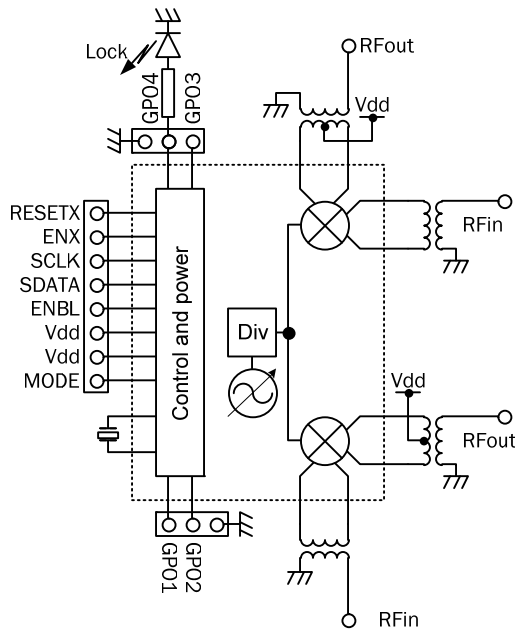
1.5 SIMPLIFIED SCHEMATICS FOR EVALUATION BOARDS

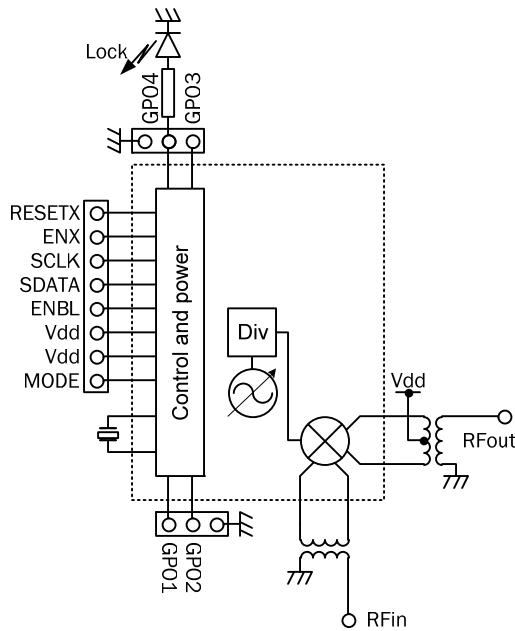**Figure 3. RF2051/RF2056/RF2057/RF2059/RFFC2071/RFFC5071**

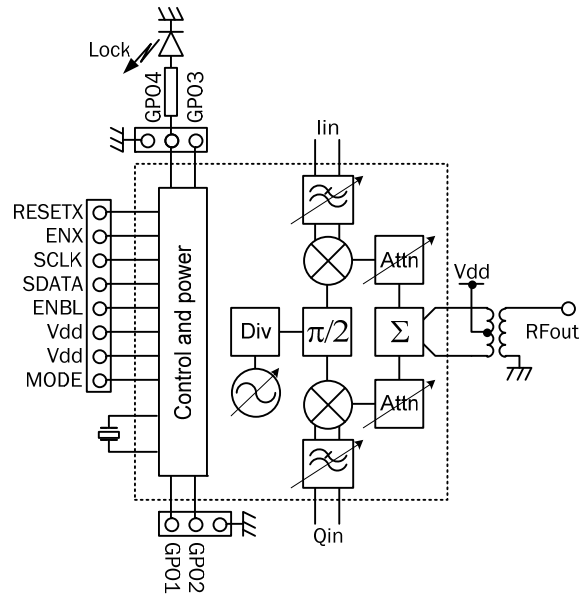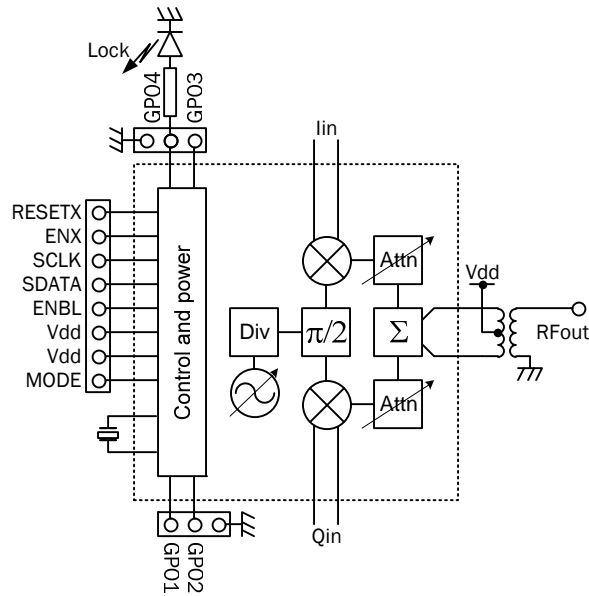**Figure 4. RF2052/RF2053/RFFC2072/RFFC5072**

Figure 5. RFMD2080

Figure 6. RFMD2081

2. THE PROGRAMMING TOOL

2.1 DOWNLOADING AND INSTALLING THE TOOL

Download the programming tool software from http://www.rfmd.com/products/IntSynthMixer/default.aspx. The FTDI USB drivers are also available for download.

Figure 7. RFMD's Software Download Site

To download and install the programming tool software:

1. Go to the landing page for integrated synthesizer/mixer parts at http://www.rfmd.com/products/IntSynthMixer/default.aspx.
2. Go to the GUI Software Tools towards the bottom of the page.
3. Click on the link for the latest version of the code.
4. Open the .zip file and run the setup.

2.2 RUNNING THE TOOL WITH NO DEVICE PRESENT

It is possible to run the programming tool with no device present. This allows the user to:

- get a feel for the way the programming tool works.
- explore the register contents and evaluate register settings,such as register settings for a given VCO frequency.
- use the other tabs within the programming tool.

If the application is started with no device present, a warning box displays indicating the device is not connected:

Figure 8. Warning that displays when the programming tool starts with no device connected

Selecting Abort closes the software. Selecting Retry causes the programming tool to attempt to reconnect to the device (this may be required if the supply is not connected to the device or the device is not present). Selecting Ignore lets the software continue to run without a device present, as shown below:
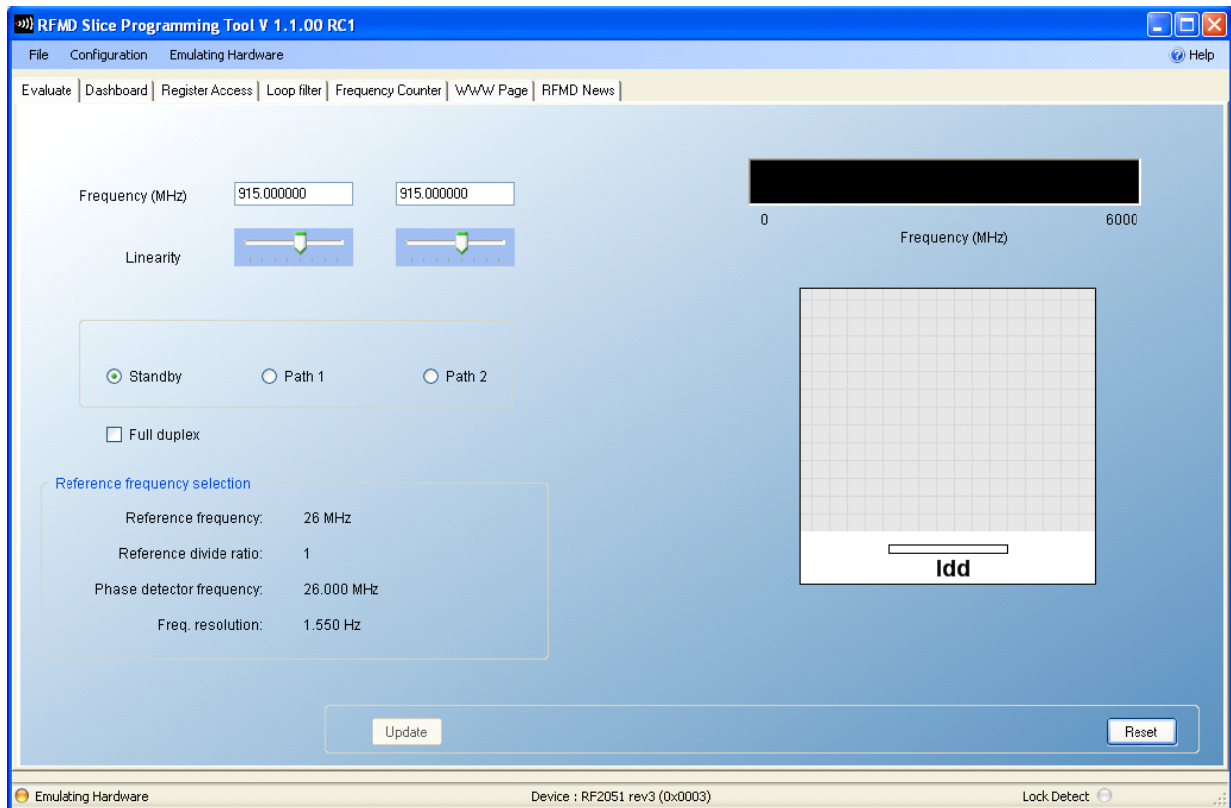
Figure 9. The programming tool running without a device present

The tool behaves as if an RFFC5071 device were connected but the lock detect indicator is not working. Any attempt to read the device register contents will produce a warning. It is still possible to save the register contents to a file. Change the emulated device using the "Emulating Hardware" pull-down menu. This allows selection of RFFC5071, RFMD2080, or RF2051.

If the initial attempt to connect the chip to the computer has accidentally failed, select Retry after connecting the device. This will allow the software to connect.

2.3 RUNNING THE TOOL WITH A DEVICE PRESENT

Pull-down resistors on the boards allow the software to automatically determine whether MultiSlice operation is required. Descriptions in the text generally refer to the RFFC5071; however these will be applicable to other related parts as well.

If a device is detected when the software starts the the Evaluate tab displays. The user can perform basic operations on the device such as changing the frequency or the device linearity. This is described further later in this document.

Please note that when the programming tool starts it performs a few housekeeping tasks to determine which device is connected and what the register contents are. This means that a number of writes and reads to and from the device are performed. In normal operation these would not normally be required and should be ignored if the user is monitoring the serial bus during this period.

2.4 STATUS INDICATORS

Figure 10.   Status indicators at the bottom of the programming tool window

Within the programming tool, in an information bar at the bottom of the window, there are three indicators showing the status of the device.

- On the left is the status of the USB interface module. If that hardware is present a green circle displays. If not, the circle is yellow.
- If a device is present, the device ID number displays in the center of the information bar when the programming tool reads the CHIPREV field within the device and checks it has a valid value.
- The third indicator (displayed in the Evaluate tab only) is the synthesizer lock status. This displays a green circle if the device has been enabled. Grey indicates the device is in standby mode. Orange indicates the synthesizer is not locked.

2.5 PROGRAMMING TOOL TABS

There are six tabs providing access to device programming and additional features.

Figure 11.   Programming Tool Tabs

2.5.1 Evaluate Tab

The Evaluate tab gives controls mixer selection, operating frequency, and mixer linearity.
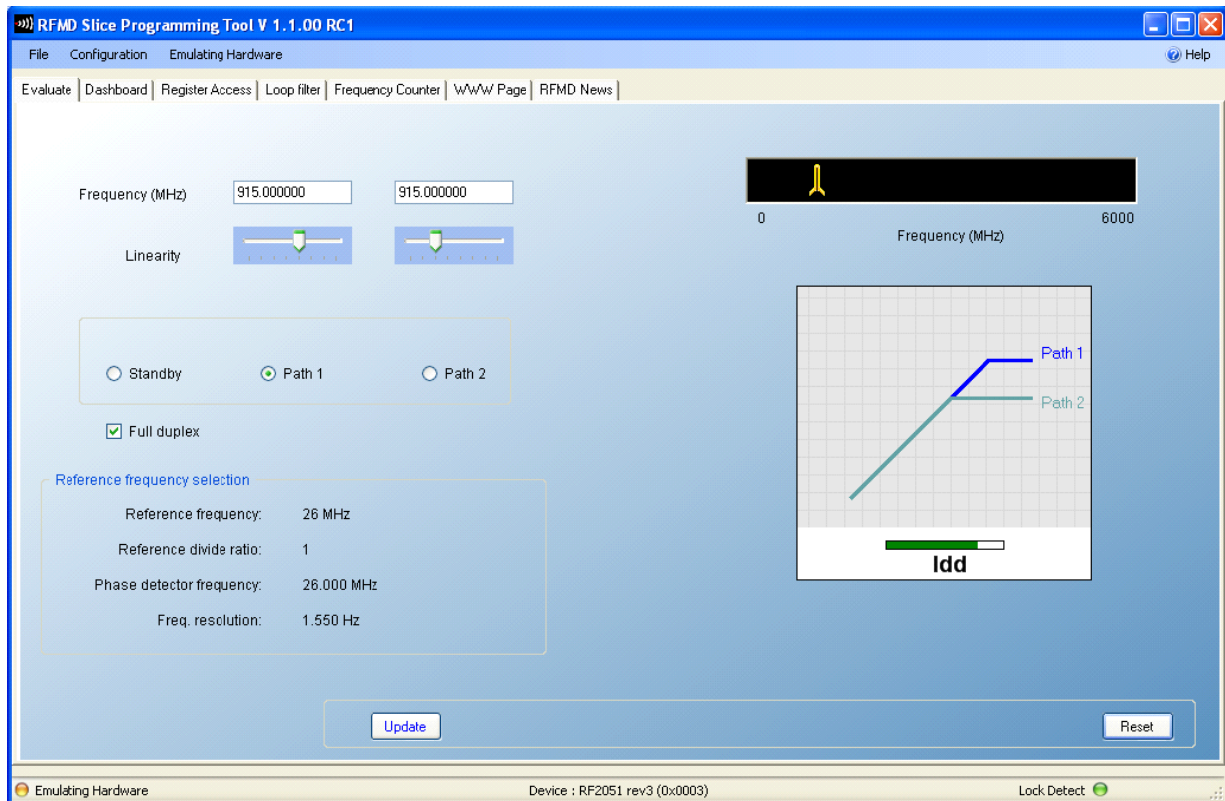

Figure 12.   The Evaluate tab, showing the linearity graph in duplex mode

1. Set operating frequency by entering a new frequency (in MHz) into the appropriate box. Operating frequency is shown graphically via the frequency bar to the right. If an out-of-range value is entered (for example, an LO frequency that is too low) the value displays in orange to indicate the error.
2. Set mixer linearity using the Linearity sliders. Linearity and current consumption are shown by the graph on the right. In full duplex mode two linearity graphs are shown, one for each path.
3. Set desired state (Standby, Mixer 1 operating, or Mixer 2 operating) using the Control Mode Hardware Pins radio buttons.

4. Set duplex mode (both mixers operating) by selecting Full Duplex.
5. Set reference frequency division ratio via the Reference Divide Ration dropdown menu. The corresponding phase detector frequency displays below the dropdown.
6. PLL lock detect status displays in the bar at the bottom of the window.
7. When the frequency changes the display shows a blue background to indicate that the new frequency has not yet been programmed into the device. Select Update to calculate the required register values and program the device. The Update button is unavailable if there is nothing to program.
8. Select Reset to restore the default status of the device.

Please note that when using this tab a number of additional read/write operations are performed on the device to determine the type of device present and the status of the lock flag to control the lock indicator. If monitoring the serial bus reads and writes to check against the user's own board, use the Dashboard tab where extraneous read and writes are not performed.

2.5.2 Dashboard Tab

The Dashboard tab gives more control over device functionality while ensuring that illegal values are not programmed into the device (for example, if an LO frequency is entered that is too low). The device is only changed when Update is selected. Until then, changed values are highlighted.
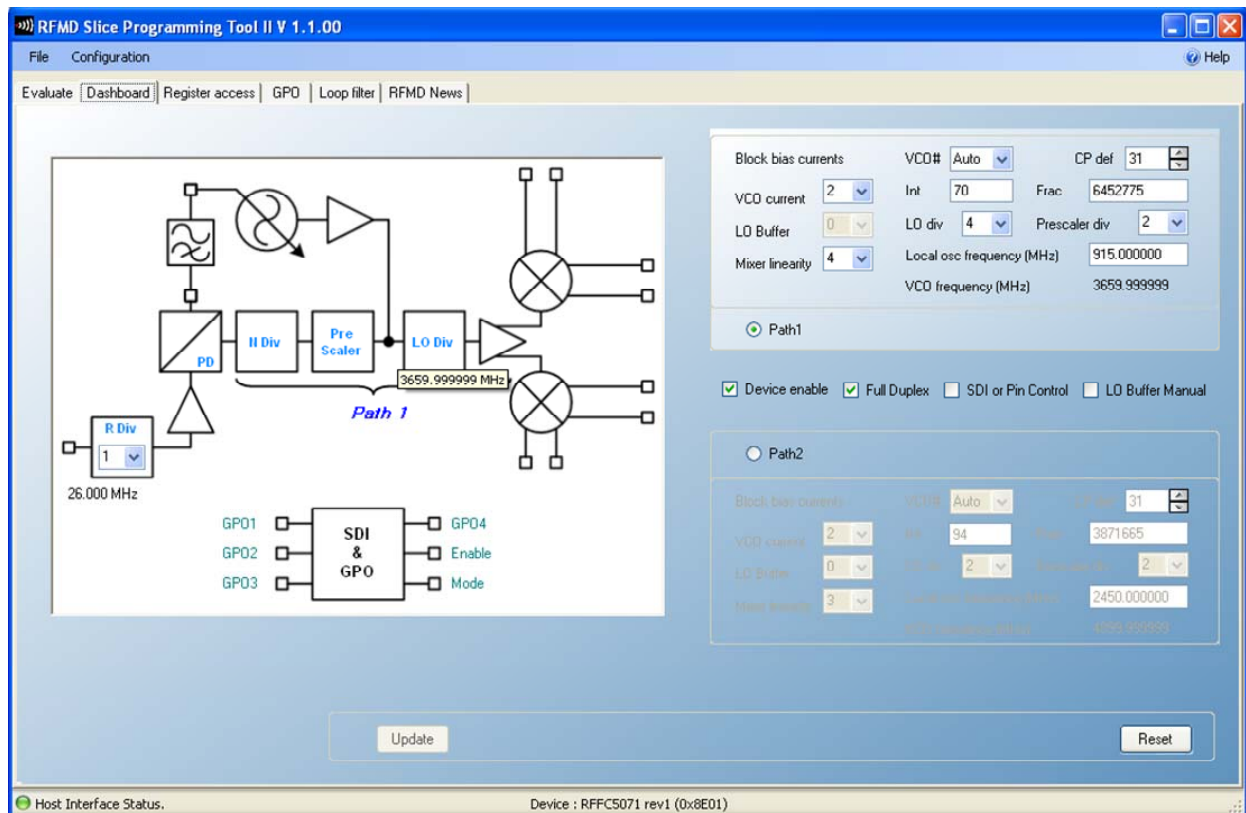

Figure 13.   The Dashboard tab, displaying prescaler divider output frequency

The central panel shows a block diagram of the device indicating the active circuit blocks. The image shown depends on which path has been selected and whether the device is in full duplex mode. The signal path within the device is selected using the radio buttons (Path 1/Path 2) and the Full Duplex check box.

As shown in the diagram, additional information (prescaler divider output frequency, in this example) about the device operation displays when the mouse pointer hovers over the circuit.

1. Select a value from the reference divider dropdown menu to determine the phase detector reference frequency.
2. Select bias current settings (independent for each path within the device) to set the mixer bias current (mixer linearity), the LO buffer current, and the VCO bias current.
3. Enter a value into the Local Osc Frequency box to determine the operating frequency for the local oscillator.
4. Enter the integer and fraction parts of the divider ratio to program the synthesizer registers. Enter the LO division ratio required to achieve the desired LO frequency and the VCO number to select the correct VCO.
5. Vary the charge pump current in the VCO chain by selecting a value from CP Def. This allows optimization of the loop bandwidth if required. The Mixer Bias dropdown menu varies the mixer bias current to trade off mixer linearity for power consumption.

2.5.3 Register Access Tab

The Register Access tab gives access to all the registers within the device.
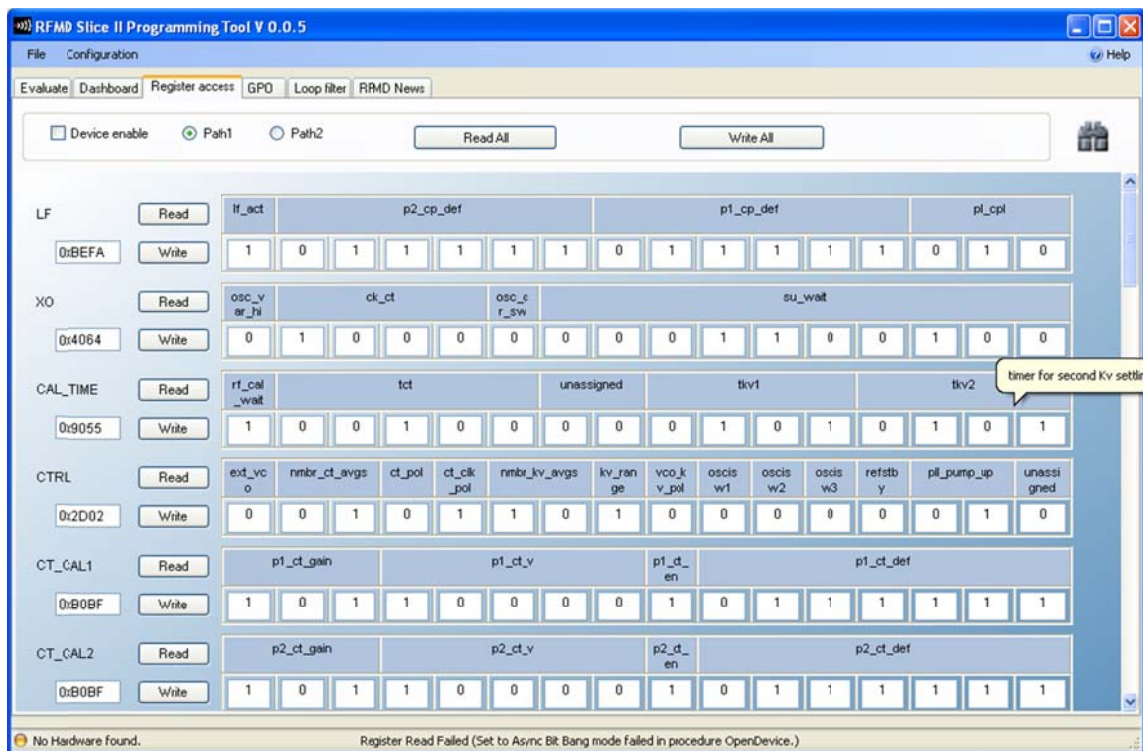

Figure 14.   The Register Access tab

The register contents can be edited in a number of ways:

- The hexadecimal value of the register contents can be entered in the box below the register name.

- The binary values of individual bits can be edited in the editable fields to the right of the Write button. Double-clicking the value toggles between 1 and 0.

When field values are edited they are highlighted to indicate that they have not yet been programmed into the device.

1. Select Write to independently program individual registers. Select Read to display the current value of the register. Use the Read All and Write All buttons to read from or write to the chip's entire register set.
2. Select Reset Chip to perform a hard reset on the chip. This will not change the register contents displayed so there is an option to reprogram the registers as before or read back the chip register contents which will contain their default values.
3. Use the search facility ( ) to search the register contents for a particular field. Double-click the field name in the search results to display the register's values. The actual register map presented will vary depending on the device connected.
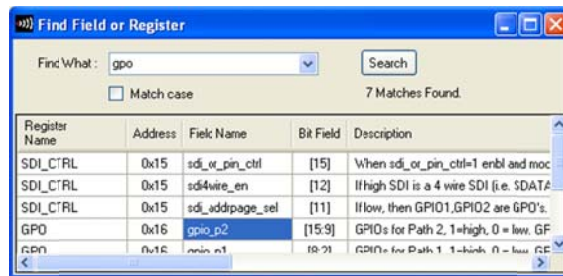

Figure 15.   The Search facility

4. The registers displayed in this tab will depend on the device present or being evaluated since not all registers are valid for all devices.

2.5.4 GPO Tab

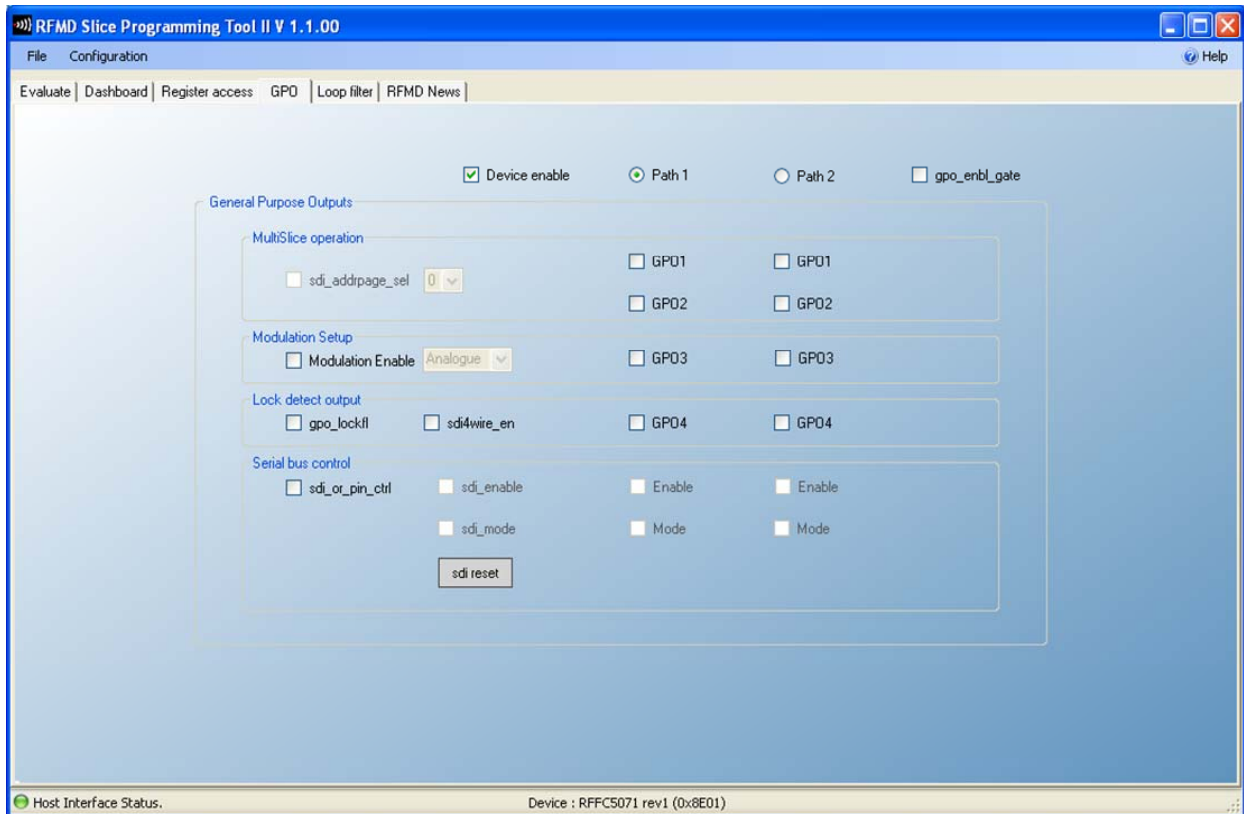The GPO tab controls the general purpose outputs available on the device.

Figure 16.   The GPO tab

All GPOs have an alternative function depending on the status of the bits represented in this tab. If MultiSlice is enabled, then GPO1 and GPO2 become inputs setting the chip address. GPO3 can be set as the modulation control input and/or as serial data output (as an alternative to the multiplexed data stream on the SDFATA pin). GPO4 can be set to be a lock detect indicator.

GPOs that are not available with the current configuration may not be selected. Their current function displays.

It is also possible to control the device via the serial bus by setting the appropriate bit in the registers. In this case the MODE and ENABLE pins become available as GPOs. The MODE and ENABLE pins on the FTDI device are tri-stated for this purpose.

2.5.5 Loop Filter Tab

The Loop Filter tab calculates the values for the passive and active configuration of the loop filter.
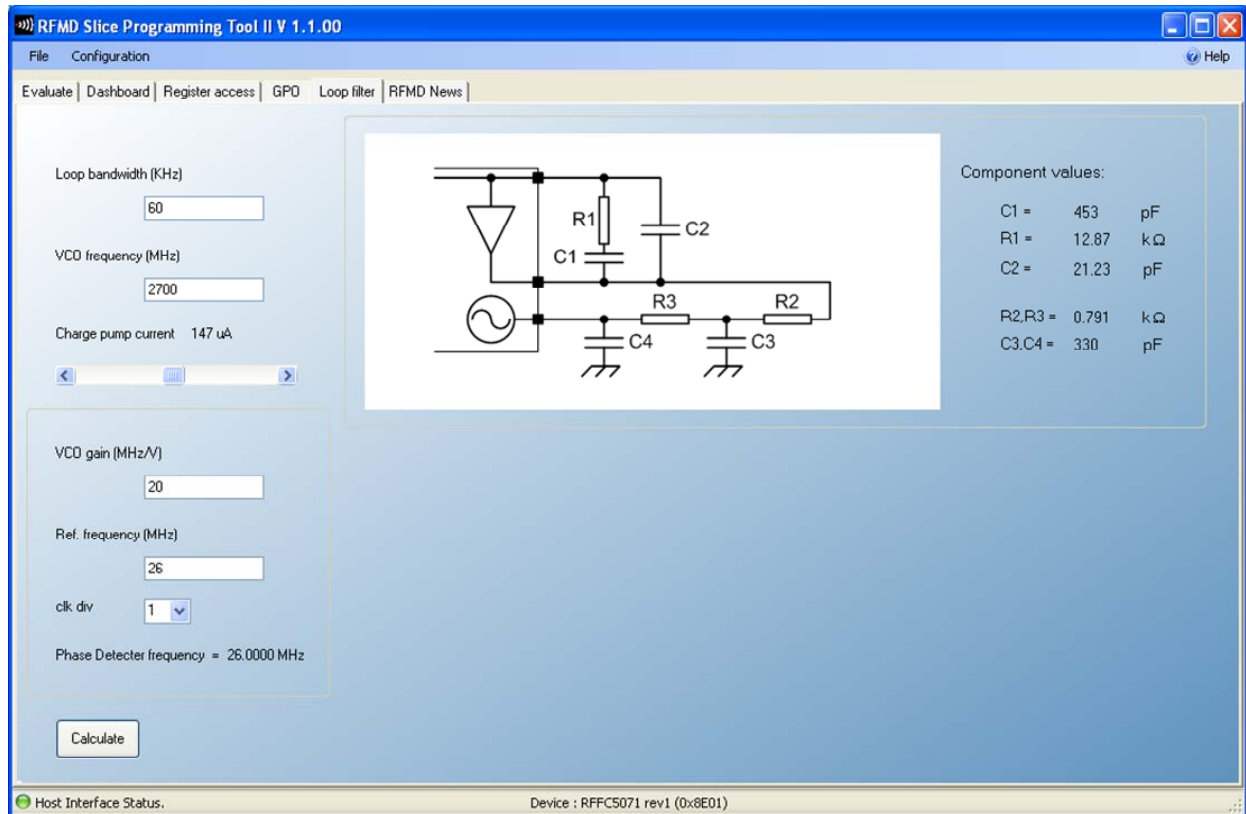

Figure 17. The Loop Filter tab

1. Enter the desired loop filter bandwidth in the Loop Bandwidth box. The VCO frequency, charge pump current, and phase detector frequency display based on the figures used in the Dashboard and/or Evaluate tabs. These can be changed if necessary. The nominal VCO gain of 20MHz displays in the VCO gain box by default, although an alternative value may be entered.
2. Select Calculate button to determine the values of the loop filter components.

2.5.6 RFMD News Tab

The RFMD News tab display information on the part and hyperlinks to the RFMD web site.
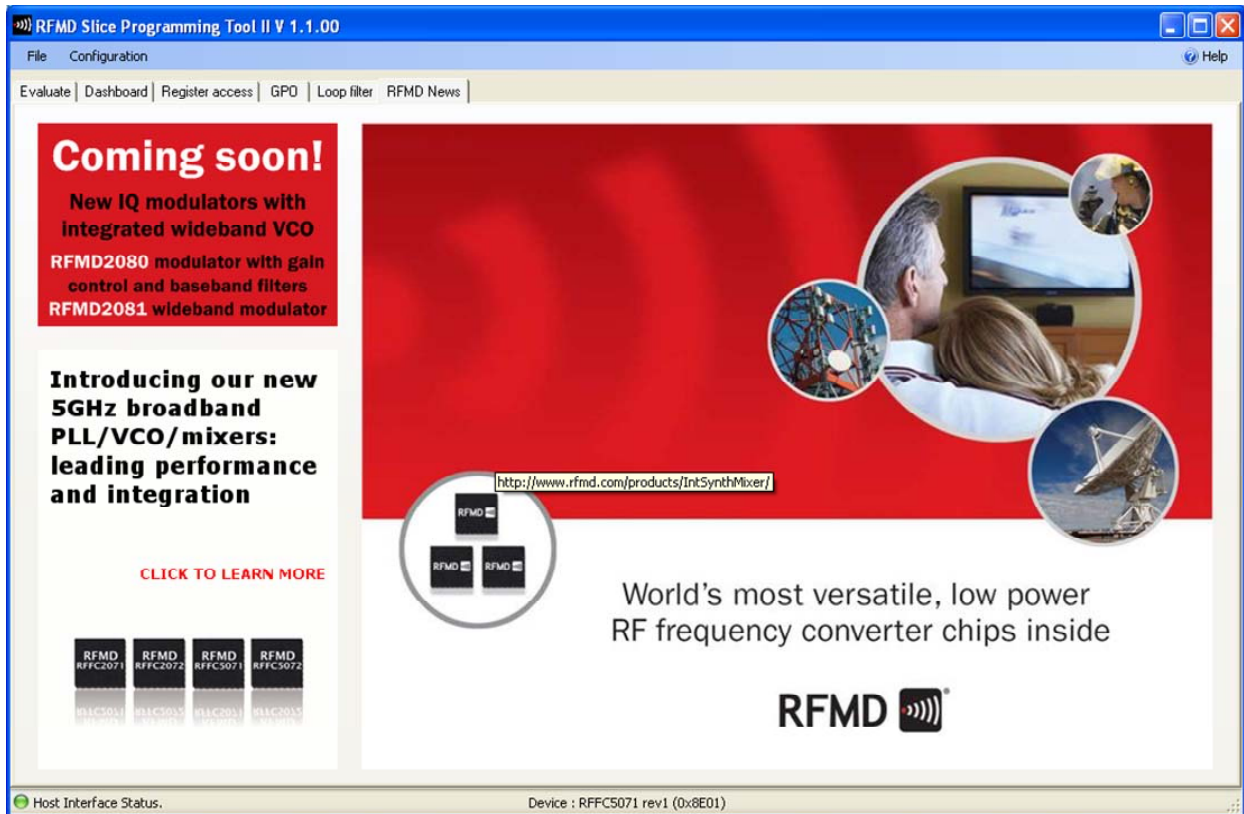

Figure 18.   The RFMD News tab default page

The image above shows the default page, though other timely information (such as updated product information, new product releases, etc.) displays if the computer running the programming tool has an active connection to Internet.
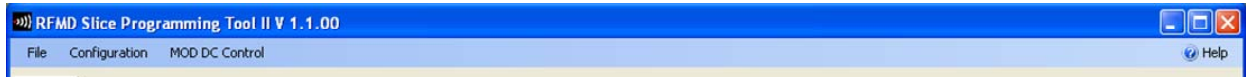
2.6 MENU OPERATIONS

Figure 19. Programming Tool Menus

The File menu provides facilities to:

- load and save the register/chip contents

- print the programming tool display

- exit the programming tool (the same as pressing the Close button)

The Configuration menu provides access to advanced settings for:

- crystal properties

- VCO range

- frequency stop control

- tri-state control

- frequency hop control

The MOD DC Control menu provides facilities to:

- control RFMD2080 settings

The Help menu provides facilities to:

- check for software updates

- display version information

2.6.1 Saving Register Contents

From the File menu the register contents can be saved as shown in the programming tool or as stored in the chip. The file is saved with a .rfreg suffix but is in an Microsoft Excel format. This file may be edited by hand if required, but this should be done carefully to ensure the correct format is maintained so that the programming tool can read it back again.

2.6.2 Loading Register Values

To load a set of register contents from a file, use Load Register Settings from the File menu. Select Update to store the settings in the device.

2.6.3 Crystal Properties

From the File menu, display crystal properties may be displayed via the Crystal Tune Control Panel. This dialog allows adjustment of the internal load capacitance applied to the crystal frequency used in the programming tool to calculate the register contents.
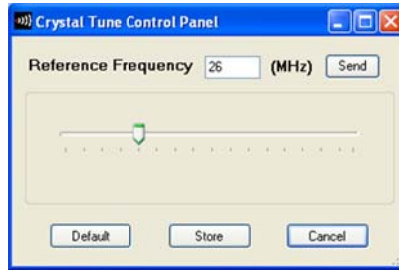
Figure 20.   Crystal Tune Control Panel

The reference frequency is the frequency of the crystal used with the device. The standard Evaluation Board is fitted with a 26MHz TCXO (depending on device variant) but any frequency between 10MHz and 52MHz could be used. The reference frequency selected is displayed in the Evaluation and Dashboard tabs of the programming tool.

The slider adjusts the value of the crystal load capacitance within the device (for use with devices that use an external crystal).

2.6.4 VCO Range Adjust

From the Configuration menu, use this option when a first generation device is attached to allow the user to set the frequency range of the on-chip VCOs.

2.6.5 Frequency Step Control

From the Configuration menu, use this option to configure the GUI to allow the local oscillator frequency to be changed in discrete steps in the Evaluate tab. This is useful when performing measurements that require sweeping the LO frequency.

2.6.6 Tri-State Controls

Use this option in the Configuration menu to set the control lines into a high-impedance state if controlling them manually using external signals is desired.

2.6.7 Frequency Hop Control

This option in the Configuration menu allows for switching control between the two paths on the device to allow settling time measurements to be performed more easily.

2.6.8 MOD DC Control

If an RFMD2080 device is connected to the GUI, this menu allows control of the internal DC offset control DACs and the input low pass filter bandwidth.

2.6.9 Help

The Help menu provides a feature to check for updates to the programming tool and an About RFSlice GUI popup which displays software version information. If a problem is experienced with the software it would be useful if the information contained in this box could be included in any correspondence (to copy an

image of the box to the clipboard for pasting into an e-mail, press Ctrl+Alt+PrintScreen when the About popup window is active).

Figure 21.   About popup displaying software version information

2.7 MULTISLICE OPERATION

The programming tool software has been programmed to detect whether multiple devices are present on the programming bus. The programming tool does this by interrogating the status of two pins on the USB interface module (pins 8 and 10). If only a single device is present on the bus, both pins are set to High or left floating (there are internal pull-ups on the FTDI device).

If multiple devices are present, pins 8 and/or 10 on the FTDI device should be set to Low. In this case, MultiSlice capability enables up to four devices to be individually controlled from the programming tool.

Select MultiSlice Mode in the Evaluate tab to enable this feature in all the devices connected to the serial bus. All devices will then have to be programmed separately according to the state of GPO1 and GPO2.

If it is necessary to regain control of all the devices they should be reset.

3. REFERENCES

1. RFMD company web site (http://www.rfmd.com)

2. RFMD Integrated Synthesizer and Mixer web site (http://rfmd.com/products/IntSynthMixer/)

3. Register Map and Programming Guide
   (http://www.rfmd.com/CS/Documents/IntegratedSynthMixerRegMapProgrammingGuide.pdf)

4. Integrated Synthesizer/Mixer Programming Guide
   (http://www.rfmd.com/CS/Documents/IntegratedSyntMixerProgrammingGuide.pdf)

5. IQ Modulator Programming Guide
   (http://www.rfmd.com/CS/Documents/IQ%20Modulator%20Programming%20Guide.pdf)

4. APPENDIX: PROGRAMMING THE UM232R

The UM232R module is a USB - Serial universal asynchronous receiver/transmitter (UART). When shipped with an evaluation board the UM232R is already programmed. However, if a new device is purchased it needs to be programmed in order to operate with the evaluation board.

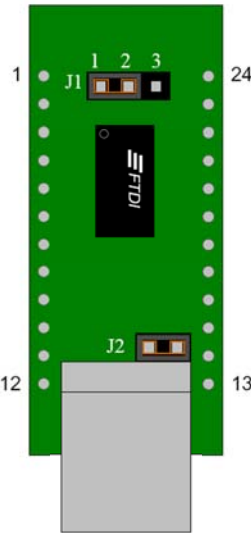For more information on the UM232R module, visit
http://www.ftdichip.com/Products/EvaluationKits/UM232R.htm.

Figure 22.   Layout of the UM232R UART

To program a new UM232R:

1. Ensure that the shorting link on header J1 is fitted on pins 1 and 2 as shown above. This sets the interface voltage level to +3.3V.
2. Leave the shorting link fitted on header J2 in place, this sets the UM232R to be powered from the USB bus.
3. Download the EEPROM programming tool (MProg) from
   http://www.ftdichip.com/Resources/Utilities.htm.

Connect the UM232R to the spare USB port on the PC. A USB type-A to type-B cable is required. When the device is connected a Found New Hardware dialog displays "UM232R USB Adaptor". If so, then the FTDI UM232R drivers are not already installed on the PC. In this case, use the New Hardware Wizard to install the drivers see "

4. Installing the FTDI UM232R USB drivers".
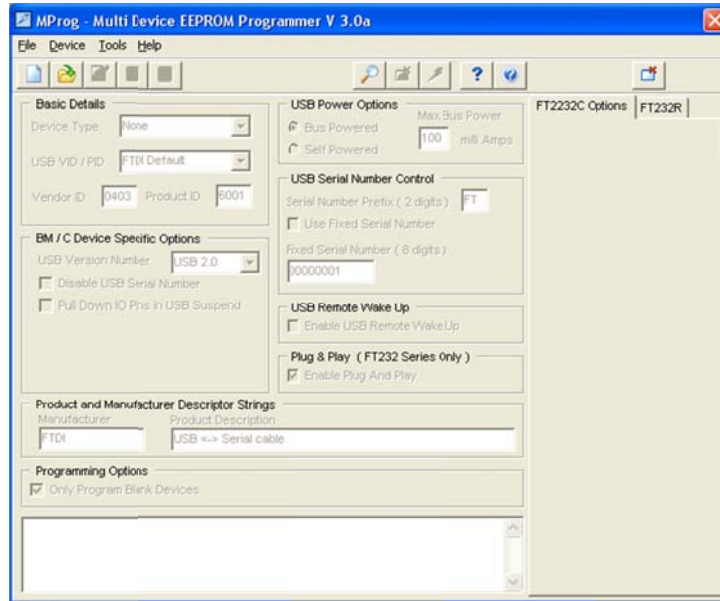5. Run the MProg utility.

Figure 23.   MProg Programmer

6. Select File>Open.
7. Browse to the correct directory and select the .ept file for the RFMD Slice II Programmer.
8. Select Device>Program. The device has been programmed and a serial number displays in the window at the bottom of the programming tool
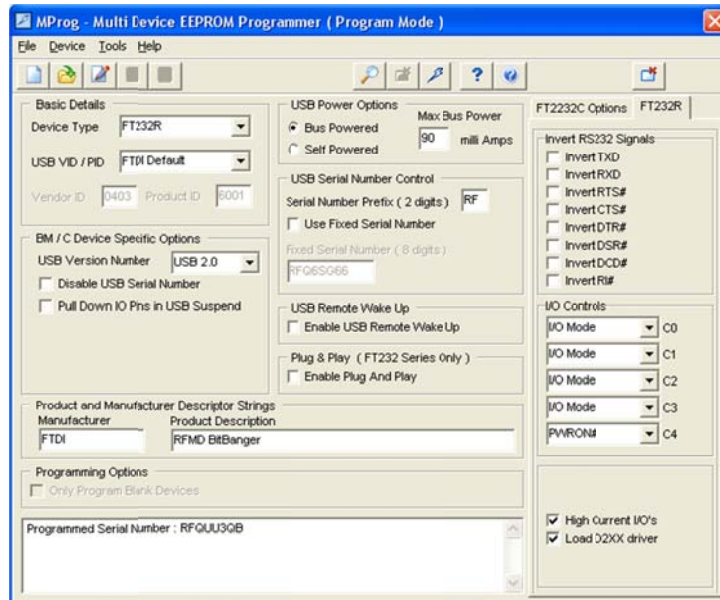

Figure 24.   MProg Programmer, displaying device serial number

9. Confirm operation by disconnecting the USB cable from the UM232R, then reconnecting it. In the bottom right hand side of the PC screen there will be a small window displaying information on the USB hardware which should display "Found New Hardware RFMD Bit Banger".