DS-ML

Micrel RF Development System User's Guide

Supports the follow parts:

MRX-001
MRX-010
MRX-011
MRX-002
MRX-002S
MRX-005
MRX-005S
MRX-007
MRX-008
MRX-009
MRX-009S
MTX-102
MTX-103

Radios, Inc.

Micrel RF Development System User's Guide

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The Micrel RF Development System ("DS-ML") is intended for use by engineers for the purpose of evaluating the feasibility of implementing the Radios, Inc. RF modules in various wireless applications. The user's environment must be limited to use of the development system within an environment which provides for adequate isolation of RF emissions which might be caused by operation of the DS-ML. In field testing, the device must not be operated in a residential area or any area where radio devices might be subject to harmful electrical interference. The development system has not been certified for use by the FCC in accord with Part 15, ETSI I-ETS 300 220 or I-ETS 300 220-1 regulations, or other known standards of operation governing radio emissions. Distribution and sale of the DS-ML is intended solely for use in future development of devices which may be subject to FCC regulation, or other authorities governing radio emission. DS-ML may not be resold by users for any purpose. Accordingly, operation of the DS-ML in the development of future devices is deemed within the discretion of the user and the user shall have all responsibility for any compliance with any FCC regulation or other authority governing radio emissions of such development or use, including without limitation reducing electrical interference to legally acceptable levels. All products developed by user must be approved by the FCC or other authority governing radio emission prior to marketing or sale of such products and user bears all responsibility for obtaining the FCC's prior approval, or approval as needed from any other authority governing radio emissions.

DS-ML is an experimental device, and Radios, Inc. makes no representation with respect to the adequacy of the DS-ML in developing low-power wireless data communications applications or systems, nor for the adequacy of such design or result. Radios, Inc. does not and cannot warrant that the functioning of the DS-ML will be uninterrupted or error-free.

The DS-ML and products based on the technology in the DS-ML operate on shared radio channels. Radio interference can occur in any place at any time, and thus the communications link may not be absolutely reliable. Products using the DS-ML technology must be designed so that a loss of communications due to radio interference or otherwise will not endanger either people or property and will not cause the loss of valuable data. Radios, Inc. assumes no liability for the performance of products which are designed or created using the DS-ML. Radios, Inc.'s products are not suitable for use in life-support applications, biological hazard applications, nuclear control applications, or radioactive areas.

Micrel RF Development System Warranty

Radios, Inc. warrants solely to the purchaser that the hardware components of the Micrel RF Development System (DS-ML) will be free from defects in materials and workmanship under normal use for a period of 90 days from the date of shipment by Radios, Inc. This limited warranty does not extend to any components or circuits which have been subjected to modification, misuse, neglect, accident, or improper installation or application. Radios, Inc.'s entire liability and the purchaser's sole and exclusive remedy for the breach of this Limited Hardware Warranty shall be, at Radios, Inc.'s option, when accompanied by a valid receipt, either (i) repair or replacement of the defective components or (ii) upon return of the defective DS-ML, refund of the purchase price paid for the DS-ML. EXCEPT FOR THE LIMITED HARDWARE WARRANTY SET FORTH ABOVE, RADIOS, INC. AND ITS LICENSORS PROVIDE THE HARDWARE ON AN "AS IS" BASIS, AND WITHOUT WARRANTY OF ANY KIND EITHER EXPRESS, IMPLIED OR STATUTORY, INCLUDING BUT NOT LIMITED TO THE IMPLIED WARRANTIES OF NONINFRINGEMENT, MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. Some states do not allow the exclusion of implied warranties, so the above exclusion may not apply to you. This warranty gives you specific legal rights and you may also have other rights which vary from state to state.

Limitation of liability. IN NO EVENT SHALL RADIOS, INC. OR ITS SUPPLIERS BE LIABLE FOR ANY DAMAGES (WHETHER SPECIAL, INCIDENTAL, CONSEQUENTIAL OR OTHERWISE) IN EXCESS OF THE PRICE ACTUALLY PAID BY YOU TO RADIOS, INC. FOR THE DS-ML, REGARDLESS OF UNDER WHAT LEGAL THEORY, TORT, OR CONTRACT SUCH DAMAGES MAY BE ALLEGED (INCLUDING, WITHOUT LIMITATION, ANY CLAIMS, DAMAGES, OR LIABILITIES FOR LOSS OF BUSINESS PROFITS, BUSINESS INTERRUPTION, LOSS OF BUSINESS INFORMATION, OR FOR INJURY TO PERSON OR PROPERTY) ARISING OUT OF THE USE OR INABILITY TO USE THE DS-ML, EVEN IF RADIOS, INC. HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES. BECAUSE SOME STATES DO NOT ALLOW THE EXCLUSION OR LIMITATION OF LIABILITY FOR CONSEQUENTIAL OR INCIDENTAL DAMAGES, THE ABOVE LIMITATION MAY NOT APPLY TO YOU.

1. Micrel RF Development System Introduction

1.1 General Description

The Micrel RF Development System comprises the hardware, firmware and software resources commonly used by wireless designers in the design and development of wireless applications. The Micrel RF Development System (DS-ML) offers a comprehensive test suite that allows the developer/designer to vary a number of electrical firmware, software and antenna parameters to facilitate the optimal architecture and topology for the given application being developed.

1.2 Intended User

The Micrel RF Development System ("DS-ML") is intended for use solely by engineers for the purpose of evaluating the feasibility of implementing the Radios, Inc. RF modules in various wireless applications. The user's evaluation must be limited to use of the development system within a environment which provides for adequate isolation of RF emissions which might be caused by operation of the DS-ML. In field testing, the device must not be operated in a residential area or any area where radio devices might be subject to harmful electrical interference. This Kit has not been certified for use by the FCC in accord with Part 15 ETSI I-ETS 300 220 or I-ETS 300 220-1 regulations or other known standards of operation governing radio emissions.

FIGURE 1

Labels (clockwise/around figure): Power LEDs, ON/OFF Switch, 9V Battery Holder Compartment (opposite side), Antenna Jack, Alternate Antenna Port, Breadboard Header, Breadboard Area, Relay Terminals, USB Port, RS232 Port, Jumper Bus, Module Antenna Pin, Module Socket, Module Header, Microprocessors (MCUs), MCU Programming Headers, MCU LEDs, Momentary Button, MCU DIP Switches, Piezo Element
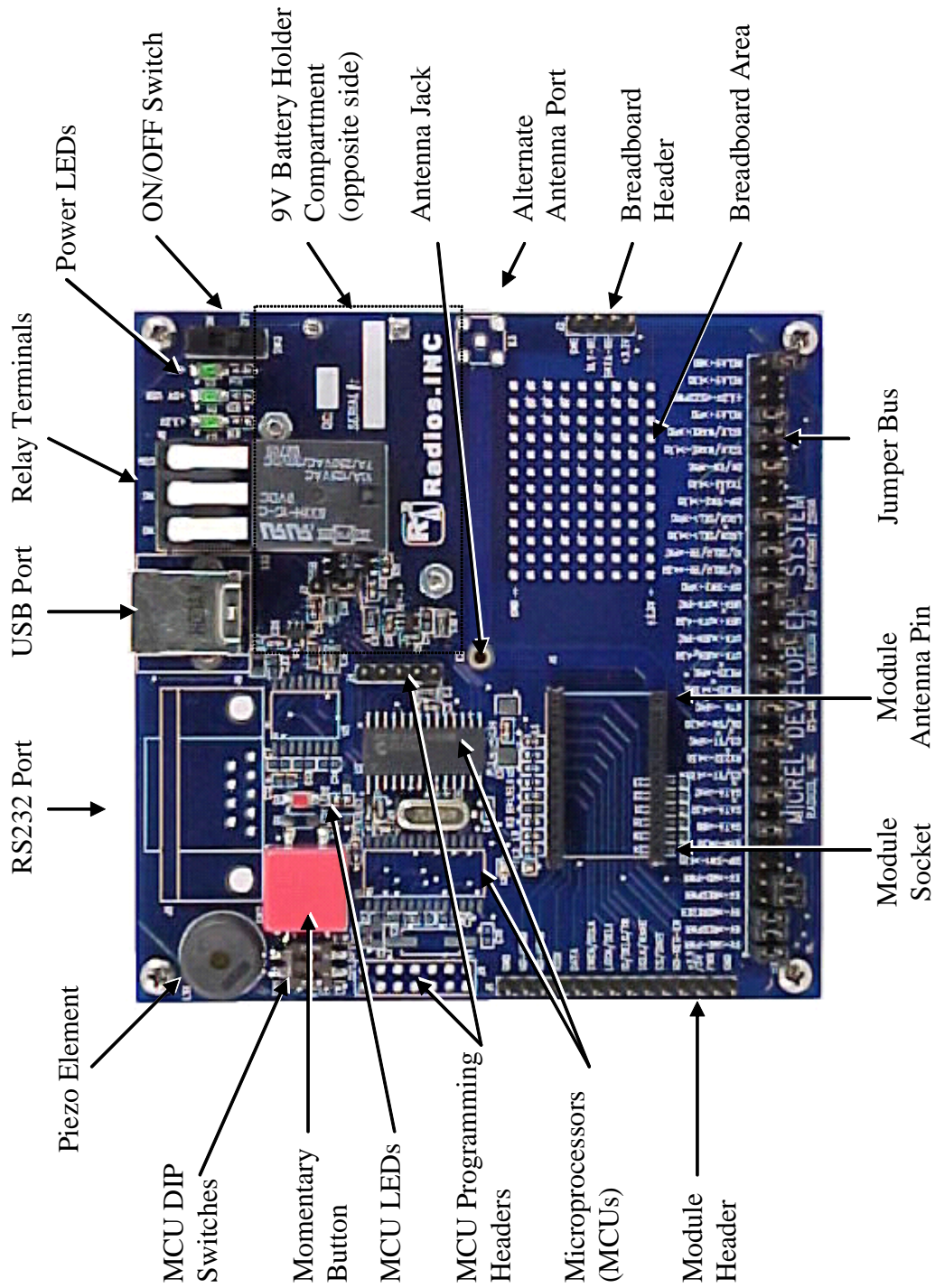
2.2 Getting Started

Required Equipment:

DS-ML (Micrel RFDevelopment System)

- One/Two DS-ML development boards (Figure 1)
- One/Two antennas
- One/Two 9 volt batteries
- DS-ML user's manual

* DS-ML Windows software

* One/Two computers each with one available 9 pin, serial communication port
   or universal serial bus port and Windows 98 or later installed.

* One/Two serial cables - male to female, DB9

* One/Two USB cables

*Note 1: For RS-232/USB Windows-based Software Testing Only

Setup:

1. Select a location that lends itself to wireless testing, i.e., line-of-sight with as few metal objects and RF pathway obstructions as practical.

2. Ensure that jumper settings match that required for desired test (see page 10 for jumper settings). Units are shipped with the radios interfaced with the PIC microcontroller. <u>The default configuration is for communication via the USB port.</u> (Note 2) Both dipswitches should be set to the OFF position.

3. Install 9 volt battery in holder underneath each development board.

4. Install one monopole antenna per unit into PCB mounted jack indicated by "Antenna Jack" in Figure 1.

Note 2: If the user is using the serial port, the jumpers need to be configured accordingly. See page 10 for USB/Serial port jumper settings.

Setup (cont.):

5. Turn ON/OFF switch to the "ON" position.

6. If using PIC, connect USB port on computer to USB port on the DS-ML using USB cable. If using MSP430, connect serial port on computer to serial (RS232) port on the DS-ML using serial cable.

7. Install Micrel RF Development System software if not already installed on computer(s) being used.

8. Select the appropriate USB or Comm setting from the Port menu in software to indicate your connection. Choose USB if using USB cable or RS232 and the appropriate Comm port if using serial cable. This option will need to be reselected EVERY time the USB/Serial cable is disconnected and reconnected.

9. In software, select the module being used from the Module menu.

10. Insert desired module into socket indicated by "Module Socket" in Figure 1 by lining up antenna pin on desired module with the antenna pin on the DS-ML.

11. In software, set the parameters in the Settings and Baud Rate boxes on screen to fit your need. Note: the baud rates, preamble, headers and checksum settings need to match between the transmitter and receiver.

12. If the DS-ML is connected through USB and using a receiver module, click the "Start Wireless Communication" button to start receiving data. To stop receiving data, click the "Stop Wireless Communication" button. If the DS-ML is connected through the serial port, it will begin receiving automatically.

13. If you are using a transmitter module, enter the data you want to transmit in the text box marked "Transmit" and click the "Send" button. To transmit that data continuously once every second, check the "Auto" checkbox below the "Send" button. To stop the automatic transmit mode, uncheck the "Auto" checkbox. The "Send" button is not needed to auto-transmit. When connected via the USB port, the user can send a maximum of 28 characters per transmission, including preamble, header, data and checksum. When connected via the Comm port, the user can send a maximum of 10 characters per transmission, including preamble, header, data and checksum. If additional characters are transmitted, the transmission will be terminated until the number of characters has been reduced.

Setup (cont.):

14. When finished with your test, disconnect the USB/serial cable from the computer and turn off the power to the DS-ML.

Additional Notes:
If the user is using the power from the PC through the USB to power the PIC microcontroller, configure the PIC power jumper to use the 5 volt USB source (jumper over middle pin and top pin labeled USB). The 9 volt battery is still needed to source power to other circuitry on the DS-ML. If the user is using the power from the 9 volt battery through the 5 volt regulator to power the PIC microcontroller, configure the PIC power jumper to use the 5 volt regulator source (jumper over middle pin and bottom pin labeled REG).

2.3. Interchanging Modules

When interchanging modules on the DS-ML, care must be taken to avoid input/output conflicts. First turn off the power to the DS-ML and carefully remove the module from the "Module Socket". See Figure 1. Verify the jumpers are set according to user's needs and turn on power to the DS-ML. Reconnect the USB or Comm port, by selecting the appropriate USB or Comm setting from the Port menu in software. In software, select the module being used from the Module menu and insert the desired module into the "Module Socket". Interchanging modules without following the preceding instructions, could damage the module as well as the DS-ML.

2.4. Programming the Microcontrollers

Both microcontrollers can be reprogrammed via their respective programming headers. The programming header for the MSP340 microcontroller is a standard JTAG interface. The PIC microcontroller can be reprogrammed using the 5 pin header in the middle of the DS-ML. The PIC programming header is a standard SPI interface with the following pins: MCLR, VPP, GND, DATA, CLK. Reprogramming the DS-ML microcontrollers is not advised and is not supported by Radios, Inc.

3 Assembly and DS-ML Overview

3.1 Assembly of Development System

The Micrel RF Development System comes assembled in a default configuration for immediate evaluation except for battery and antenna installations.

3.2 Jumpers and DIP Settings

The DS-ML units are shipped with the following default jumper settings:
("ON" MEANS THAT JUMPER IS INSERTED, "OFF" MEANS THAT IT IS NOT)
("PIC" MEANS THAT THIS JUMPER IS ONLY NEEDED FOR USING THE PIC/USB, "MSP" MEANS THAT THIS IS ONLY NEEDED FOR THE MSP430/SERIAL PORT)

JUMPER BUS: **MODULE CONFIGURATION SETTINGS**:

9V-> MD-PWR (ON)   UTX-> URX-PIC (OFF)   Set in software
9V-> REGPWR (ON)   URX-> UTX-430 (OFF)
9V-> MDREGEN (ON)   URX-> UTX-PIC (OFF)
5V-> REGPWR (OFF)   DIP-SW2-> PIC (ON,PIC)
5V-> MD-PWR (OFF)   IO/SEL0/TR-> 430 (OFF,MSP)
DIP-SW1-> 430 (OFF,MSP)   IO/SEL0/TR-> PIC (ON,PIC)
BTN-> 430 (OFF,MSP)   LOCK/SEL1-> 430 (OFF,MSP)
DATA-> BB (OFF)   LOCK/SEL1-> PIC (ON,PIC)
DATA-> 430 (OFF,MSP)   DIP-SW2-> 430 (OFF,MSP)
DATA-> PIC (ON,PIC)   TX232-> 430 (OFF,MSP)
CS/ST-> 430 (OFF,MSP)   DK/SW-> PIC (ON,PIC)
RX232 -> 430 (OFF,MSP)   SCLK/WAKE-> 430 (OFF,MSP)
CS/ST-> PIC (ON,PIC)   SCLK/WAKE-> PIC (ON,PIC)
DK/SW-> 430 (OFF,MSP)   RELAY-> PIC (ON,PIC)
BTN-> PIC (ON,PIC)   +3.3V-> 232PWR (OFF,MSP)
PIEZO-> 430 (OFF,MSP)   RELAY-> 430 (OFF,MSP)
PIEZO-> PIC (ON,PIC)   RELAY-> BB (OFF)
UTX-> URX-430 (OFF)

3.3 Power Supply and Regulation

The DS-ML units are powered by a 9 volt alkaline cell and regulatred with a Micrel MIC5235 3.3 volt regulator and/or Micrel MIC5235 5 volt regulator. The DS-ML units have two VCC/VDD sources: 3.3 volts and 5 volts. When DS-ML is employed with the MSP430 microcontroller, their is just one VCC/VDD source, that being 3.3 volts.

Power Supply and Regulation Cont.

On the DS-ML units with the PIC microcontoller, the microcontoller can be powered either from a 9 volt battery or the PC through the USB port. When using the 9 volt battery, the 9 volt battery supplies voltage to two Micrel regulators a MIC5235 5 volt regulator which sources power to the PIC microcontroller. The second regulator is a Micrel MIC5235 3.3 volt regulator. The 3.3V supply powers other required circuitry. The PIC microcontroller can also be powered from the PC through the USB port. Jumpers need to be set accordingly.
Additionally, the module can be powered either directly from the 9 volt battery or the 5 volt regulator. Jumpers need to be set accordingly.

Jumper Settings:

9V->MD-PWR	The module is powered from the 9 volt battery
9V->REGPWR	The 3.3 volt regulator is powered from the 9 volt battery
9V->MDREGEN	The module regulator enable pin is powered from the 9 volt battery
5V->REGPWR	The 3.3 volt regulator is powered from the PC through the USB port
5V->MD-PWR	The module is powered from the PC through the USB port

Note: The 9V->MDREGEN jumper needs to be ON to enable the module regulator. Additionally, either the 9 volt battery or the USB port can power the module. Only one of the jumpers can be ON at one time. Similarly, either the 9 volt battery or the USB port can power the 3.3 volt regulator. Only one of the jumpers can be ON at one time.

3.4 Microcontroller (MCU) Section

All DS-ML's are supplied with either a PIC18F2455, an MSP430F123, or both on-board 4 MHz, flash-based, microcontrollers (MCU). Each microcontroller can be reprogrammed repeatedly with an inexpensive programmer. The MCU's come pre-programmed with sample code which allows the user to transmit and receive simple asyncronous protocol with its corresponding DS-ML unit. The sample code can be modified in an ASCII editor and reprogrammed according to the requirements of the user's application. Both MCU's are connected to the module's data output, wake-up and power down features, as well as, the DS-ML's push button, LEDs, dip switches, piezo element and relay.

The MCU's come pre-programmed with embedded firmware and software which supports simple, asyncronous communication between both DS-ML development boards. The sample code includes a basic method for one-way remote control with accompanying LED and relay activation as well as a warbling beep routine to drive the on-board piezo element.

3.5 Antenna Options and Interfaces

The DS-ML's antenna input can be matched to a number of external antennas. A simple 1/4 wave monopole is supplied with the development unit(s).

The DS-ML allows for two antenna polarizations and several different antenna types such as monopole whip, helical, helically loaded whips and others. There are two antenna feed ports: horizontal SMA and direct PCB mount via the on-board jack. The units a shipped with one or two monopole whip antenna which are inserted directly into the antenna jack. (Figure 1)

3.6 RS-232 Interface

The Windows-based software supplied with the DS-ML package permits the users to communicate PC to PC where both DS-ML units are connected via their RS232 port and the associated jumpers are appropriately placed.

3.7 USB Interface

The Windows-based software supplied with the DS-ML package permits the users to communicate PC to PC where both DS-ML units are connected via their USB port and the associated jumpers are appropriately placed.

3.8 Breadboard Area

The development board offers a prototype area with several 0.100" spaced vias. There are VCC and GND rails provided at the top and bottom of this section.

3.9 Module Section

This is where the module chosen for evaluation is inserted. Attention should be given to reference pin 1 correctly.

4 Operation Instructions and Guidelines

4.1 Theory of Operation

The DS-ML system employs one RF module per unit. Transmission and reception of wireless data is controlled in one of four ways: by microprocessor, RS232, USB (PC), or external hardware mounted in the prototyping area.

The development boards ship with microprocessor control as their default setting. After applying power, an asyncronous remote control packet can be initiated by the depression of SW2 (the red momentary button). The data packet is a simple three-byte word preceded by a two byte preamble to place the comparator and AGC threshold of the radio at an optimal bias for synchronization with the first byte of data.

As the radio module demodulates the received data from the transmitter, the IC's data output is sent to either the MCU, RS232 or breadboard for processing. If the MCU is interfaced to the module, the sample firmware will acknowledge a valid data packet with a beep, blink of an LED once and finally toggle the on-board relay. If both DS-ML boards are jumpered to the RS232 interface and connected to a PC with the DS-ML development software via a serial cable, the module's data output will be shown in the software "received data" display screen.

The units come with two monopole antennas which employ the ground plane of the DS-ML board itself as a reference. The socket the antenna uses will also accept other antennas with diameters between 0.048"-0.064". Located on the edge of the side of the units (Figure 1, "Antenna Jack") is an SMA edge connector footprint intended for future installation of an SMA connector in the event the user desires to connect an analyzer or generator to the DS-ML or module.

4.2 I/O Interface

The DS-ML boards are provided with one RS232 port, one USB port, one relay output and one SMA edge connector footprint.

4.3 LED, Piezo and Button Functions

The development system is shipped with the MSP430 microprocessor jumpered such that a depression of the yellow push button on the left side of the DS-ML will prompt the transmission of one data packet. LED1 will also light to indicate that a transmission did indeed occur. The piezo element in turn is prompted to warble as an indication of a valid reception of one data packet. The MSP430 microprocessor can be modified to monitor and control the dip switches, the push button and the piezo various ways. The PIC microprocessor can only control dip switch two, the push button and the piezo. LED1 is connected to the MSP430 microprocessor and LED2 is connected to the PIC microprocessor.

4.4 Microcontroller Protocol

The microcontroller is preprogrammed with a simple asynchronous protocol intended to serve as a starting point for those unfamiliar with wireless data transmission. It consists of a three-byte word preceded by a two-byte preamble to place the comparator threshold of the module in an optimal bias for reception of the first byte of data. The protocol in hexadecimal is as follows: FF, 00, AA, AA, AA.

4.5 RS232 Interface and Windows Software

Installation:

Insert DS-ML CD into PC and navigate to "DS-ML Windows Software (Installation Files)\setup.exe". Follow all prompts, and repeat process for other PC to be used in test.

The RS232 port (Figure 1, "RS232 Port") and USB port (Figure 1, "USB Port") are located to the rear of both units. After installing the DS-ML development software and determining which serial communication port or universal serial bus is free for use, connect either a nine-pin serial cable or USB cable between the DS-ML PC's respective port(s). One DS-ML unit can use the RS232 port while the other is connected to the USB port or visaversa .

To open the DS-ML software, go to the Windows *start menu*, and after going into *programs,* scroll down to *Micrel RF Development System.* Before starting your testing, it is necessary to designate a communications port from the scroll-down menu labelled "Port" to the right of the "File" menu. Next a module must be assigned in the next menu tab to the right.

After selecting the Port and the module, the user settings the settings according to their preferences. Only the options available for the module selected will be enabled for use. If Sel0 or Sel1 are checked, that sets Sel0 or Sel1 to a logical level "1". If they are unchecked, that sets Sel0 or Sel1 to a logical level "0". The user can also select if they want the module in sweep or fixed mode. They are to see the individual datasheet of the module for the specifics of Sel0, Sel1, sweep and fix modes. Lastly, the user can select the baud rate of the wireless communication. Only the baud rates allowed by the module will be enabled. Each module has a bandwidth it can handle. It is possible for one unit to be in sweep mode while the other is in fixed mode. The user has to make sure that the baud rate they chose can be handled with both sweep or fixed modes. If user desired to experiment with different baud rates, care must be taken that the DS-ML receiver IC bandwidth settings match the data rates used in the DS-ML software. The baud rate has to be the same between both units. Additionally, the lights will turn from red to green when Sel0 or Sel1 is at a logical level "1" and from green to red when Sel0 or Sel1 is at logical level "0". The user can save their settings by using the Save feature under the File Menu.

The preamble section in the lower left hand corner of the DS-ML software window contains two user-definable bytes that can be modified to experiment with comparator bias levels which are necessary to optimize for best reception of the first data byte of the transmitted data packet.

The three header bytes can be used for redundancy or as address bytes. They will, along with the pre-amble bytes, be transmitted with every packet. It is necessary that the header bytes match each other in both DS-ML software windows.

The software also facilitates a checksum feature which is activated by selection of the "Checksum" radial box. The final feature of the program is an auto-transmit switch which causes the last entered data packet to be re-transmitted continuously.

After all of the above settings have been determined, set in both DS-ML software windows, testing may begin by simply typing any text into the lower window label "Transmit Data." Thereafter, each depression of the "Send" button will cause the current data in the "Transmit Data" window to be transmitted once. The "Auto" check box allows the packet to transmitted repeatedly, once per second until the check box has been cleared.

The receive section in the middle of the DS-ML software window contains the received data transmitted from the other DS-ML unit. Data will be displayed in ASCII format. The "Clear RX" button will clear the contents of the receive section.

The application notes section allows the user to take notes about the testing they have done or what ever information they want to keep there. This then can be saved using the Save feature under the File menu.

The Help menu refer's them to the user guide and the About menu gives the part number, version and name of the development system.

5 Developing Applications

5.1 A Radios, Inc. RF Module Overview

The Radios, Inc. RF modules are made for OOK (ON-OFF Keyed) for remote wireless applications, employing Micrel RF technology. All RF and IF tuning is accomplished automatically within the module, which eliminates manual tuning and reduces production costs. Receiver functions are completely integrated. The result is a highly reliable yet extremely low cost solution for high volume wireless applications. Because the module is a true single-chip radio receiver, it is extremely easy to apply, minimizing design and production costs, and improving time to market.

The receiver modules provide two fundamental modes of operation, FIXED and SWP. In FIXED mode, the device functions like a conventional superheterodyne receiver, with an (internal) local oscillator fixed at a single frequency based on an external reference crystal or clock. As with any conventional superheterodyne receiver, the transmit frequency must be accurately controlled, generally with a crystal or SAW (Surface Acoustic Wave) resonator. In SWP mode, the modules sweep the (internal) local oscillator at rates greater than the baseband data rate. This effectively "broadens" the RF bandwidth of the receiver to a value equivalent to conventional super-regenerative receivers. Thus the module can operate with less expensive LC transmitters without additional components or tuning, even though the receiver topology is still superheterodyne. In this mode the reference crystal can be replaced with a less expensive $\pm 0.5\%$ ceramic resonator.

All post-detection (demodulator) data filtering is provided on the module, so no external filters need to be designed. Any one of four filter bandwidths may be selected externally by the user. Bandwidths range in binary steps, from 0.625kHz to 5kHz (SWP mode) or 1.25kHz to 10kHz (FIXED mode). The user only needs to program the appropriate filter selection based on data rate and code modulation format.

5.2 Data Slicing Level

When developing with the MRX-*** modules, extraction of the DC value of the demodulated signal for purposes of logic-level data slicing is accomplished with an on-board capacitor and the on-chip switched-cap "resistor" R SC. The the optimal values for any given application can be determined and manufactured to suit by Radios, Inc. Optimization of these values is necessary for maximize range and performance.

5.3 AGC Function

The MRX-*** series modules feature automatic gain control (AGC) to increase input dynamic range. Radios, Inc. can optimized this function for an application for optimal performance. AGC attack and decay time-constants must be correct for optimal range.

5.4 Antenna Design Considerations

Three types of antennas are normally associated with DS-ML applications, (1) quarter-wave monopole, (2) helical (coil), and (3) pcb loop. Of these antenna types, the quarter-wave monopole is preferred, giving the best range performance. Typical SR and SH receivers employing quarter-wave monopole antennas generally provide about 100 meters open field range. The Radios, Inc. RF modules are designed to be connected to a quarter-wave monopole antenna at its input ANT pin, with no further coupling network, and provide this similar range. Of course, the monopole can be a free-standing "wire," or a metal trace built directly into the pcb. The antenna need not be a quarter-wavelength long, but shorter lengths will reduce range. Although the other two antenna types, helical and pcb loop, are less efficient antennas than the monopole, they provide cost and/or ergonomic advantages. The pcb loop antenna is a very inexpensive structure to produce, being built into the pcb. The only requirement is that there be enough "room " on the pcb to build a sufficiently effective antenna. This antenna has the further advantage that it can be hidden from the end- user. The primary disadvantage is that this is usually the least efficient of the three antenna types being discussed, with a typical range of 30 meters. Loop antennas are more commonly found in transmitters than receivers. Where the antenna must be hidden, but still be rather efficient, a good choice is the helical antenna. The structure is simply a "coil " of wire, inexpensive, and easy to fabricate. Typical range for this type of antenna is 60 meters. (Both helical and pcb loop antennas are commonly found in transmitter designs, which usually requires a small unit with the antenna hidden from the user.) Another aspect of antenna selection, aside from its effectiveness at "picking-up " signal from the "ether," is its directionality. Every type of antenna has its own signature of energy distribution in the 3-dimensional space that surrounds it. This signature is generally composed of "peaks" and "nulls"; if the transmit antenna "peak" is pointed at the receiving antenna's "peak," then range is maximized. However, optimizing this for a particular application or installation is generally not practical. All one can do in these cases is choose the antenna that meets the other constraints, like cost and form-factor, then test to determine if the system provides adequate range in all the required directions and orientations. Unfortunately, much of this work is empirical.

The ANT input is internally AC-coupled, so no external biasing is required. The input circuit impedance is very high (i.e. a FET gate), shunted by approximately 2pF of parasitic capacitance, giving an input AC-impedance of about 200 Ω at 400MHz. Specialized 50 Ω antennas may also be connected directly to the module. The antenna should be connected as closely as possible to the IC pin, minimizing parasitic inductance between the antenna pad and the pin. (Use a >25mil trace,<200mil long, if possible). The antenna can be located away from pin 1 of the device, but this requires using a transmission line from the antenna to the IC input pin and an impedance matching coupling circuit. We do not recommend such an approach for users who lack the necessary RF expertise and test equipment to design transmission line matching networks.

Suitable antennas are crucial to the success the application. Here are several key points to consider in designing antennas for your application:

Where possible, the antenna should be placed on the outside of the product. Also, try to place the antenna on the top of the product. If the product is "body worn", try to get the antenna away for the body as far as practical.

Regulatory agencies prefer antennas that are permanently fixed to the product. Antennas can be supplied with a cable, provided a non-standard connector is used to discourage antenna substitution (these connectors are often referred to as "Part 15" connectors).

An antenna can not be placed inside a metal case, as the case will shield it. Also, some plastics (and coatings) significantly attenuate RF signals and these materials should not be used for product cases, if the antenna is going to be inside the case. The antenna designs used in the kit are included in the Drawings section of the manual. Many other antenna designs are possible, but efficient antenna development requires access to antenna test equipment such as a vector network analyzer, calibrated test antenna, antenna range, etc. Unless you have access to this type of equipment, the use of an antenna consultant is recommended. A patch or slot antenna can be used in some applications where an external antenna would be subject to damage. These types of antennas usually have to be designed on a case-by-case basis.

5.5 Bandwidth and Data Rate

Modules manufactured to a specific bandwidth or data rate can be requested from Radio, Inc.

5.6 Noise Management

Noise sources are found in all places and at all times. So the real question regarding noise generation and management is not IF but: how much, what frequency and at what amplitude. Radios which operate under FCC "Part 15" guidelines are subject to noise like any other receiver. Some noise sources commonly encountered by wireless developers are microprocessors, motors or fans, high frequency logic circuits among others. When there exist sufficient speed regarding the rise time and fall time of microprocessor clocks, harmonics can be found around critical frequencies of the receiver. If the option exists, the designer should choose a microprocessor that has the slowest rise and fall time possible for the given application to avoid problematic harmonics relative to the receiver. Swithing power supplies, brush-type motors and other radio unfriendly devices should be avoided around the receive circuitry. Adequate bypass capacitors, chokes, series resistors and shielding can be helpful in managing such problems.

6 Low-power Radios and Regulatory Compliance

6.1 Electromagnetic Compliance

All low-power radio utilizing a frequency 9 Khz or about is subject to electromagnetic compliance and conformance. Often these devices use less than 1 mW or 0 dBm of power, operate shorter distances (1 to 1000 feet) and are simple in design.These devices are unlicensed meaning that they may be used without the end user having to apply for any other type of FCC authorization. In that the frequencies these devices use are shared by millions, one has to take occupied bandwidth inference into account when determining if the desired application is suitable for this regulatory area.

Normally part 15 or low-power radios are used for short-range low-cost applications where human life or safety are not considerations. Among some of these are remote controls for automotive and home alarms, garage door openers and simple contact closers amoung others. Data and telemetry is also another area where Part 15 devices are employed. DS-ML is intended to support the design of these types of low-power wireless applications. Most low-power wireless systems operate with few interference problems. However, these systems operate on shared radio channels, so interference can occur at any place and at any time.

6.2 A Regulatory Overview for The United States

Although the Radios, Inc. RF modules normally do not exceed the FCC regulations for unintentional radiation, the wireless developer should be aware of the requirements for the transmitter being used.

Non-licensed transmitters operate on a variety of frequencies. They must share these frequencies with licensed transmitters and are prohibited from causing interference to licensed transmitters.
The Federal Communications Commission (FCC) has rules to limit the potential for harmful interference to licensed transmitters by low-power, non-licensed transmitters. In its regulations, the FCC takes into account that different types of products that incorporate low-power transmitters have different potentials for causing harmful interference. As a result, the FCC's regulations are most restrictive on products that are most likely to cause harmful interference, and less restrictive on those that are least likely to cause interference.

This overview is intended to provide a general understanding of the FCC's regulations and policies applying to products using low-power transmitters. It reflects the current text and interpretations of the FCC's regulations. More detailed information is contained in the regulations themselves, which can be found in Part 15 of Title 47 of the Code of Federal Regulations.

Manufacturers and parties selling low-power, non-licensed transmitters, or products containing low-power, non-licensed transmitters, are strongly encouraged to review the FCC's regulations closely. Recognizing that new uses of low-power transmitters often generate questions that are not directly addressed in the regulations, we welcome inquiries or requests for specific interpretations. Occasionally, the FCC proposes changes to its regulations, generally to address industry concerns and/or as new uses of low-power transmission equipment appear.

The terms "low-power transmitter," "low-power, non-licensed transmitter," and "Part 15 transmitter" all refer to the same thing: a low-power, non-licensed transmitter that complies with the regulations in Part 15 of the FCC rules. Part 15 transmitters use very little power, most of them less than a milliwatt. They are "non-licensed" because their operators are not required to obtain a license from the FCC to use them.

Although an operator does not have to obtain a license to use a Part 15 transmitter, the transmitter itself is required to have an FCC authorization before it can be legally marketed in the United States. This authorization requirement helps ensure that Part 15 transmitters comply with the Commission's technical standards and, thus, are capable of being operated with little potential for causing interference to authorized radio communications.

If a Part 15 transmitter does cause interference to authorized radio communications, even if the transmitter complies with all of the technical standards and equipment authorization requirements in the FCC rules, then its operator will be required to cease operation, at least until the interference problem is corrected.

Part 15 transmitters receive no regulatory protection from interference.

Changing the antenna on a transmitter can significantly increase, or decrease, the strength of the signal that is ultimately transmitted. Except for cable locating equipment, the standards in Part 15 are not based solely on output power but also take into account the antenna characteristics. Thus, a low power transmitter that complies with the technical standards in Part 15 with a particular antenna attached can exceed the Part 15 standards if a different antenna is attached. Should this happen it could pose a serious interference problem to authorized radio communications such as emergency, broadcast and air-traffic control communications.

In order to prevent such interference problems, each Part 15 transmitter must be designed to ensure that no type of antenna can be used with it other than the one used to demonstrate compliance with the technical standards. This means that Part 15 transmitters must have permanently attached antennas, or detachable antennas with unique connectors. A "unique connector" is one that is not of a standard type found in electronic supply stores.

It is recognized that suppliers of Part 15 transmitters often want their customers to be able to replace an antenna if it should break. With this in mind, Part 15 allows transmitters to be designed so that the user can replace a broken antenna. When this is done, the replacement antenna must be electrically identical to the antenna that was used to obtain FCC authorization for the transmitter. The replacement antenna also must include the unique connector described above to ensure it is used with the proper transmitter.

Hobbyists, inventors and other parties that design and build Part 15 transmitters with no intention of ever marketing them may construct and operate up to five such transmitters for their own personal use without having to obtain FCC equipment authorization. If possible, these transmitters should be tested for compliance with the Commission's rules. If such testing is not practicable, their designers and builders are required to employ good engineering practices in order to ensure compliance with the Part 15 standards.

Home-built transmitters, like all Part 15 transmitters, are not allowed to cause interference to licensed radio communications and must accept any interference that they receive. If a home-built Part 15 transmitter does cause interference to licensed radio communications, the Commission will require its operator to cease operation until the interference problem is corrected. Furthermore, if the Commission determines that the operator of such a transmitter has not attempted to ensure compliance with the Part 15 technical standards by employing good engineering practices then that operator may be fined up to $10,000 for each violation and $75,000 for a repeat or continuing violation.

Operating a prototype of a product that is ultimately intended for market is not considered "personal use." Thus, a party that designs and builds a transmitter with plans to mass produce and market a future version of it must obtain an experimental license from the FCC in order to operate the transmitter for any purpose other than testing for compliance with the Part 15 technical standards.

A Part 15 transmitter must be tested and authorized before it may be marketed. There are two ways to obtain authorization: certification and verification.

The *certification* procedure requires that tests be performed to measure the levels of radio frequency energy that are radiated by the device into the open air or conducted by the device onto the power lines. A description of the measurement facilities of the laboratory where these tests are performed must be on file with the Commission's laboratory or must accompany the certification application. After these tests have been performed, a report must be produced showing the test procedure, the test results, and some additional information about the device including design drawings. Certified transmitters also are required to have two labels attached: an FCC ID label and a compliance label. The FCC ID label identifies the FCC equipment authorization file that is associated with the transmitter, and serves as an indication to consumers that the transmitter has been authorized by the FCC. The compliance label indicates to consumers that the transmitter was authorized under Part 15 of the FCC rules and that it may not cause, nor is it protected from, harmful interference. The FCC ID. The FCC ID must be permanently marked (etched, engraved, indelibly printed, etc.) either directly on the transmitter, or on a tag that is permanently affixed (riveted, welded, glued, etc.) to it. The FCC ID label must be readily visible to the purchaser at the time of purchase.

The FCC ID is a string of 4 to 17 characters. It may contain any combination of capital letters, numbers, or the dash/hyphen character. Characters 4 through 17 may be designated, as desired, by the applicant. The first three characters, however, are the "grantee code," a code assigned by the FCC to each particular applicant (grantee). Any application filed with the FCC must have an FCC ID that begins with an assigned grantee code.

The Grantee Code. To obtain a code, new applicants must send in a letter stating the applicant's name and address and requesting a grantee code. This letter must be accompanied by a completed "Fee Advice Form" (FCC Form 159), and a $45 processing fee.

The Compliance Label. The applicant for a grant of certification is responsible for having the compliance label produced and for having it affixed to each device that is marketed or imported. The wording for the compliance label is in Part 15, and may be included on the same label as the FCC ID, if desired. The compliance label and FCC ID label may not be attached to any devices until a grant of certification has been obtained for the devices.

Once the report demonstrating compliance with the technical standards has been completed, and the compliance label and FCC ID label have been designed, the party wishing to get the transmitter certified (it can be anyone) must file a copy of the report, an "Application for Equipment Authorization" (FCC Form 731) and an $845 application fee, with the FCC.

After the application is submitted, the FCC's lab will review the report and may or may not request a sample of the transmitter to test. If the application is complete and accurate, and any tests performed by the FCC's lab confirm that the transmitter is compliant, the FCC will then issue a grant of certification for the transmitter. Marketing of the transmitter may begin after the applicant has received a copy of this grant.

Typically, 90% of the applications for certification that the FCC receives are processed within 30 calendar days. This time frame may increase due to incomplete applications and pre-grant sampling, if determined to be necessary.

The *verification* procedure requires that tests be performed on the transmitter to be authorized using a laboratory that has calibrated its test site or, if the transmitter is incapable of being tested at a laboratory, at the installation site. These tests measure the levels of radio frequency energy that are radiated by the transmitter into the open air or conducted by the transmitter onto the power lines. After these tests are performed, a report must be produced showing the test procedure, the test results, and some additional information about the transmitter including design drawings.

Once the report is completed, the manufacturer (or importer for an imported device) is required to keep a copy of it on file as evidence that the transmitter meets the technical standards in Part 15. The manufacturer (importer) must be able to produce this report on short notice should the FCC ever request it.

The manufacturer (or importer) is responsible for having the compliance label produced, and for having it affixed to each transmitter that is marketed or imported. Verified transmitters must be uniquely identified with a brand name and/or model number that cannot be confused with other, electrically different transmitters on the market. However, they may not be labelled with an FCC ID or in a manner that could be confused with an FCC ID.

Once the report showing compliance is in the manufacturer's (or importer's) files and the compliance label has been attached to the transmitter, marketing of the transmitter may begin. *There is no filing with the FCC required for verified equipment.*

Any equipment that connects to the public switched telephone network, such as a cordless telephone, is also subject to regulations in Part 68 of the FCC Rules and must be registered by the FCC prior to marketing. The rules in Part 68 are designed to protect against harm to the telephone network.

7. Schematic

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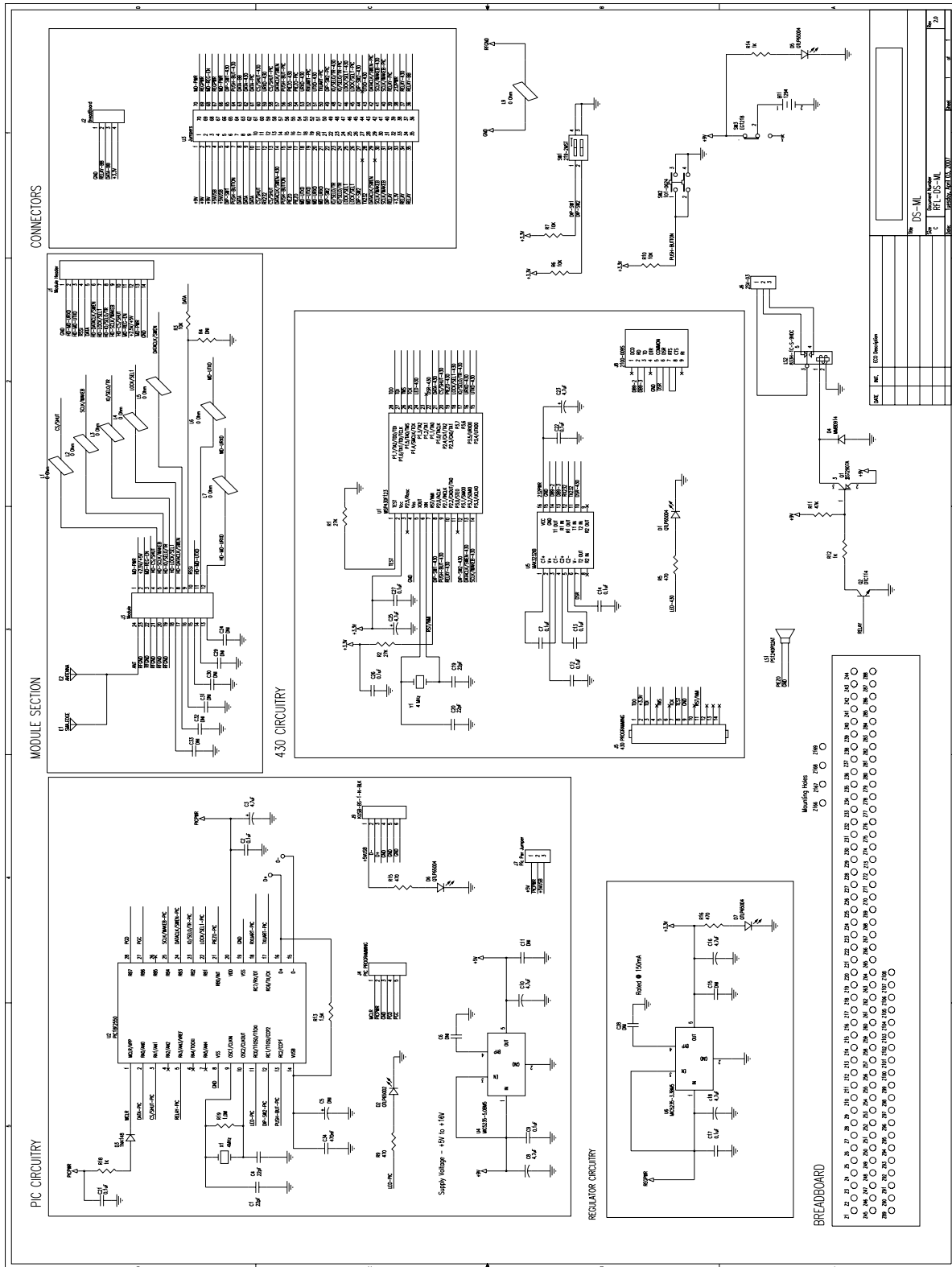
8. FAQ's

9. Support

Radios, Inc.
1408 Center Avenue
Oostburg, WI 53070
920-564-6622
Information@radiosinc.com