



The easy Radio Intelligent Controller (eRIC) radio transceiver module is based on the Texas Instruments CC430F5137 System-on-Chip device to provide an intelligent radio sub-system that combines a high performance RF transceiver, RF band pass filters (BPF), an MSP430 microcontroller, 32Kb flash memory, non-volatile flash storage, temperature sensor, and a low drop voltage regulator. The device operates on the International licence exempt Industrial, Scientific and Medical (ISM) radio bands.

eRIC thus extends the proven easyRadio product line by offering a low cost RF transceiver intended for high volume applications. The compact form factor, surface mount packaging and external antenna connector simplify product design and manufacture and provide for flexible placement of the module within an end product.

Features

- Default 'easyRadio' Protocol Embedded
- ISM Frequency Bands
- Radio Approvals
- Small 15x20x2.2mm Surface Mount Device (SMD)
- Low power operation capable
- eROS Operating System & Application partitions
- Configurable & programmable User I/O
- AES 128 bit data encryption
- Built in Temperature Sensor

Benefits

- Simple serial data in/data out user interface and configuration
- 433 & 868MHz (UK & Europe), 315 & 915MHz (USA)
- Meets ETSI (Europe) & FCC Certified (USA) requirements
- Simplifies product design and manufacture
- Battery powered applications
- Can eliminate need for external application processor
- Minimises external hardware requirements for custom applications
- Secure communications
- Environment monitor

easyRadio Operating System (eROS)

eRIC's processor memory is partitioned and embedded with a protected version of the easyRadio Operating System (eROS) that handles all the complex radio functions and thus eliminates the need for the user to program multiple control registers and understand their interaction. The other partition provides an optional user accessible application code area.

Radio parameters such as frequency, channel, output power and data rate are passed by the application code and radio data is sent and received in the background by simply calling predefined functions.

Also provided is a simple to use API that replaces low level chip specific code with intuitive pin commands that allow the multiple general purpose I/O pins and internal function blocks to be configured and interfaced to external hardware. These built in functions make customisation easy for the novice and powerful for advanced programmers. This architecture can eliminate the need for a separate application microcontroller and thus minimises cost and power consumption for simple 'sense and control' RF nodes such as might be employed within the 'Internet of Things'.

By default (factory settings) the application code area is pre-programmed with a subset of the familiar easyRadio command and communication software that allows key operating parameters such as operating frequency, RF power output and host communication settings to be (optionally) pre-configured using the 'easyRadio Companion' software or to be dynamically changed using simple serial commands sent from the host processor. This allows multiple eRIC devices to communicate free from interference with each other and other local RF devices.

In the default application mode, data is sent to and received from host processors or devices using 3.3V logic level serial data (inverted) with packet sizes up to 250 bytes.



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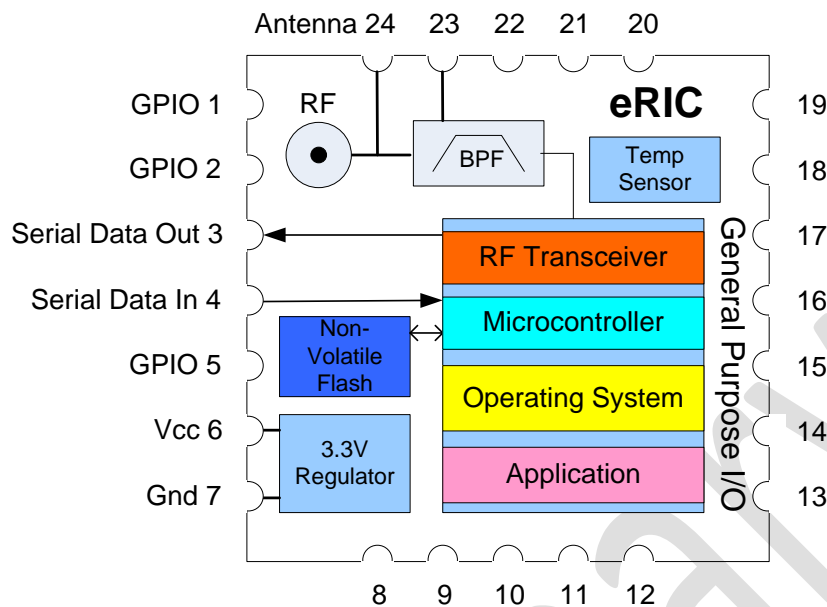


Figure 1 eRIC Transceiver Block Diagram

Pin/Pad Description

| Pad No | Name | Description | Notes |
|---------|--------|--|---|
| 1 | GPIO | General purpose digital I/O | Optional A-D Input |
| 2 | GPIO | General purpose digital I/O | Optional A-D Input |
| 3 | SDO | Rx Serial Data Out (Default) | Digital output - Connect to host serial input |
| 4 | SDI | Tx Serial Data In (Default) | Digital input - Connect to host serial output |
| 5 | GPIO | General purpose digital I/O | Optional A-D Input |
| 6 | Vcc | Operating Supply Voltage | +2.4V to +6V. Supply should be 'clean', noise and ripple free |
| 7 | Gnd | Power Ground | 0V |
| 8 | JTAG | JTAG pins | Reserved Use – do not connect |
| 9 | Reset | Reset & JTAG use | Restricted Use – Internal pull-up. Connect to Gnd for Reset |
| 10 | GPIO | General purpose digital I/O | |
| 11, 12 | GPIO | Bootloader & General purpose digital I/O | When connected together invokes bootloader function on reset |
| 13 | | General purpose digital I/O | |
| 14 - 21 | GPIO | General purpose digital I/O | Mappable secondary function |
| 22 | GPIO | General purpose digital I/O | Optional A-D Input. Mappable secondary function |
| 23 | RF Gnd | RF Ground – 0V | Connect to antenna ground and local ground plane. Internally connected to Power Ground 0V |
| 24 | RF | 50R RF Input/Output | Connect to suitable antenna via 50R PCB trace or use the alternative UFL connector |

Notes

GPIO Pins/pads are configured (by default) on power up or Reset as Inputs with internal weak pull ups.. Exercise caution when connecting to any external circuitry..

Pins/pad 1-7 are physically (pin/pad sequence) and electrically compatible with easyRadio eRA400/900 Transceivers. The eRA 'Busy' and 'Ready' handshake and 'Carrier Detect' functions are NOT implemented in the current firmware.

Interrupt function available on Pins/pad 1, 2, 3, 4, 5, 22

Mappable functions are UART, SPI, I2C, TimerA, TimerB, Compare/Capture I/O

See eROS Developers Manual for further details and descriptions of these functions.



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**Absolute Maximum Ratings**

| | |
|----------------------------------|--------------------|
| Operating Temperature Range | -40° C to +85° C |
| Storage Temperature Range | -40° C to +85° C |
| Supply Voltage - Vcc | -0.3 to +6.0 Volts |
| All Other Pins/Pads w.r.t 0V Gnd | -0.3 to +3.3 Volts |
| Antenna | 50V p-p @ < 10MHz |

Performance Data: Supply +3.6 Volt ± 5%, Temperature 20° C

| DC Parameters | Pin | Min | Typical | Max | Units | Notes |
|--------------------------------|-----------------------------|------|-------------|-------|-------|---|
| Supply Voltage (Vcc) | 6 | 2.4 | 3.6 | 6.0 | Volts | |
| Internal Regulator (Vreg) | | 2.95 | 3.3 | 3.65 | Volts | |
| Transmit supply current | 6 | | 32 | 33 | mA | +10dBm RF power output |
| Receive supply current | 6 | | 15 | | mA | Continuous mode @ 250kbps |
| Sleep Mode current | 6 | | 0.8 | | uA | TBA |
| Initial Power Up Time | | | 5 | 50 | ms | See Note |
| Logic Levels | | | | | | |
| Data Output Logic 1 | All | | 3.1 | | Volts | 10k load to 0V Gnd |
| Data Output Logic 0 | | | 0.1 | | Volts | 10k load to internal +Vreg supply |
| Data Output Current | | 6 | | 15 | mA | Under software control Hi/Lo drive |
| Data Input Logic 1 | | 2.0 | | 3.6 | Volts | |
| Data Input Logic 0 | | 0 | | 0.2 | Volts | |
| Input Pull-ups/Downs | | | 100 | | kΩ | Under software control To internal +Vreg or 0V Gnd |
| RF Parameters | | | | | | |
| Antenna Impedance | 24 | | 50 | | Ohms | Via UFL connector or pads |
| Operating Frequency | | 402 | 434.00 | 470 | MHz | See Configuration Command set |
| | | 868 | 869.85 | 870 | MHz | |
| | | 902 | 915 | 928 | MHz | |
| Modulation | FSK Wideband MSK at 500kbps | | | | | |
| Transmitter | | | | | | |
| RF Power Output 434MHz | 24 | -30 | Set by user | +12 | dBm | 50Ω load – 434MHz |
| RF Power Output 869MHz | 24 | -30 | Set by user | +5 | dBm | 50Ω load – 869MHz |
| Frequency Accuracy | | | ±10 | ±15 | ppm | Overall |
| FSK Deviation (Min) | | | ±5.2 | | kHz | 1.2kbps 58kHz filter bandwidth |
| FSK Deviation (Max) | | | ±127 | | kHz | 250kbps, 540kHz Filter bandwidth |
| Harmonics & Spurious Emissions | 24 | | -47 | < -36 | dBm | Meets EN 300 220-3 |
| Over Air Data Rate | | 1.2 | 38.4 | 500 | Kbps | Configurable |
| Receiver | | | | | | |
| Receive Sensitivity 433MHz | 24 | | -111 | | dBm | At 1.2kbps Data rate |
| 868/900MHz | 24 | | -109 | | dBm | At 1.2kbps Data rate |
| 433MHz | 24 | | -91 | | dBm | At 500kbps Data rate |
| 868/900MHz | 24 | | -81 | | dBm | At 500kbps Data rate |
| Host Serial Data Rate | 3, 4 | 2.4 | 19.2 | 115.2 | Kbps | Host interface |
| Mechanical | | | | | | |
| Size | 15 x 20 x 2.2 | | | | mm | |
| Pin/Pad Pitch | 2.54 | | | | mm | Standard 0.1 Inch |
| Weight | 1.5 | | | | grams | |

*All Specifications are subject to change without notice



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Notes

When power is first applied to the module the processor retrieves 'calibration' data for the RF section that compensates for temperature and power supply voltage variations. The transceiver will then be ready to transmit or receive (default) and would normally be left in this state, ready to receive data.

The internal Vreg is not brought out to a specific pin/pad. Should there be need to connect external pull up resistors then connection should be made to a spare GPIO pin/pad configured as a 'High' Output.

Power Supply

The supply used to power the transceiver should be 'clean' and free from ripple and noise (<20mV p-p total). It is suggested that 100nF ceramic capacitors be used to de-couple the supply close to the power pins of the transceiver. The use of 'switch mode' power supplies should generally be avoided as they can generate both conducted and radiated high frequency noise that can be very difficult to eliminate. This noise may considerably reduce the performance of any radio device that is connected or adjacent to such a supply.

Antennas

The eRIC transceiver can be used with the various common types of antenna that match the 50Ω RF Input/Output such as a monopole (whip), a tuned helical antenna, a PCB loop antenna or a ceramic 'chip' antenna.

Monopole antennas are resonant with a length corresponding to one quarter of the electrical wavelength ($\lambda/4$). They are very easy to implement and can simply be a 'piece of wire' or PCB track which at 434MHz should be 16.4cms in length. This should be kept straight, in 'free space' and well away from all other circuitry, conducting objects and metalwork and should preferably be connected directly to the Antenna pin (24) of the eRIC transceiver.

If the antenna needs to be remote it should be connected via a 50Ω coaxial feeder cable or transmission line. A 50Ω transmission line can be constructed on FR4 board material by using a 3mm wide PCB track over a ground plane and this should be kept as short as possible.

The eRIC transceiver is also fitted with UFL (U.FL) RF Connector wired in parallel with pin 23 (RF Gnd) and pin 24 (RF In/Out). LPRS can supply suitable antennas fitted with matching connectors and low loss cable assemblies.

Helical antennas are also resonant and generally chosen for their more compact dimensions. They are more difficult to optimise than monopole antennas and are critical with regard to any surrounding conducting objects that can easily 'de-tune' them. They operate most efficiently when there is a substantial ground plane for them to radiate against.

PCB loop antennas are the most compact antennas but are less effective than the other types. They are also more difficult to design and must be carefully 'tuned' for best performance.

Chip antennas are attractive as they are compact and if used in accordance with the manufacturers specifications can provide very good performance.

The Internet can provide much useful information on the design of Short Range Device (SRD) Antennas.





Mechanical

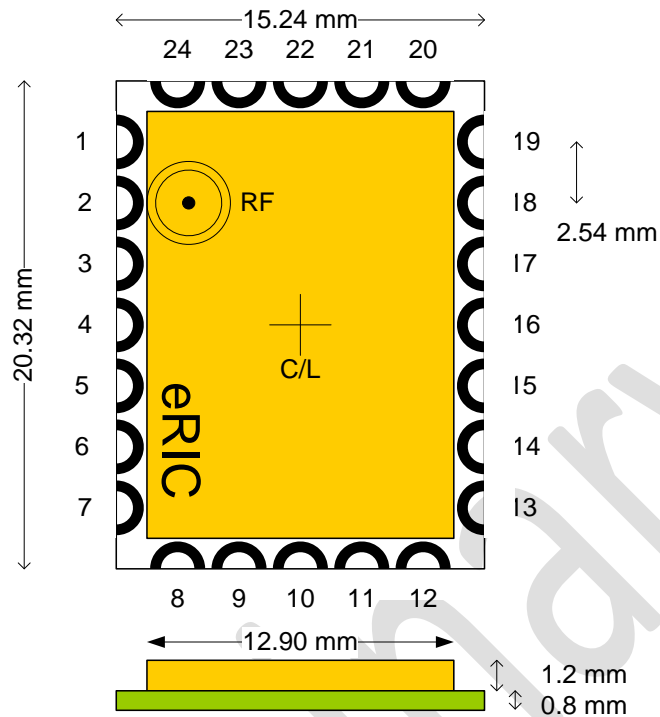


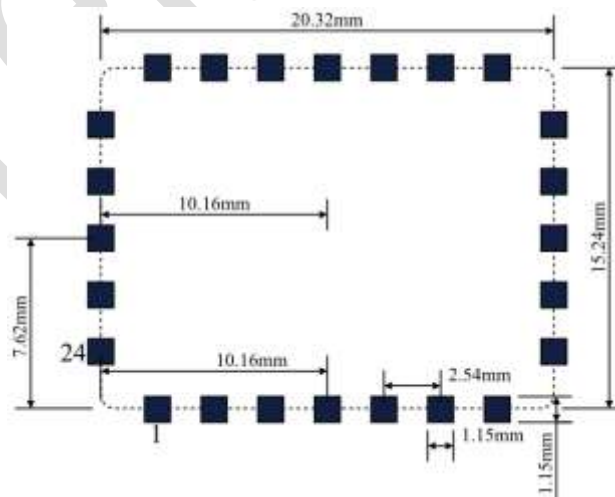
Figure 2 Mechanical Drawing

PCB Layout Notes

Pitch of the castellated connection pads is 2.54mm. Pads 4 & 16 and 10 & 22 are on centre line (C/L) of module

It is recommended that the module is mounted on a double sided PCB and that the area below the module be flooded with additional copper ground plane. This should be connected to pad 23 (RF Ground) and pad 7 (Power Gnd).

The recommended pad layout is shown below. Pads should be solid with no hole.



eRIC is designed for reflow soldering. Please contact LPRS Technical Department for further details and the suggested thermal profiles.

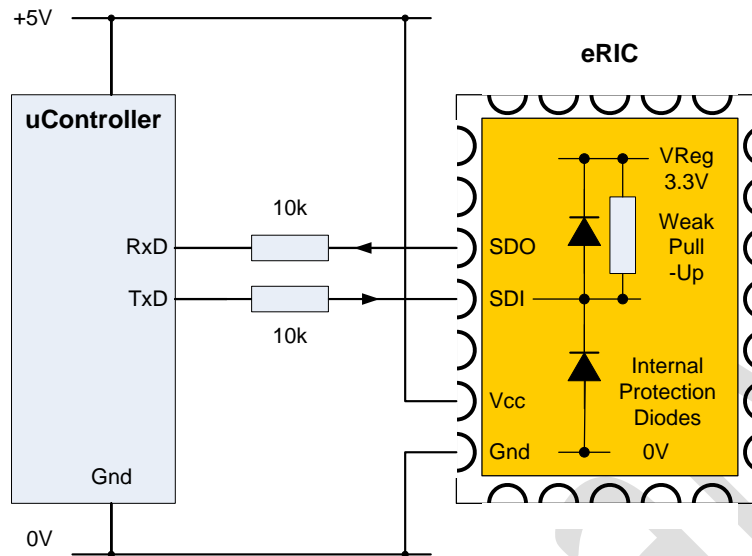


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Interface to Microcontroller

**Figure 3 Connection to Host UART and I/O Protection**

The transceiver module is powered internally by an on board 3.3V low drop voltage regulator. Any eRIC pin/pad configured as an input should not be connected directly to a voltage greater than 3.3V or less than -0.3V otherwise damage may occur to the module due to excess current flowing through the IC internal protection diodes. To prevent such damage this current should be limited by the use of a suitable (10k) series resistor (as shown above).

eRIC output pins can only provide a maximum high voltage of 3.3V (Vreg) and whilst not strictly necessary to use a series resistor in series with outputs it may afford protection under some fault conditions.

The serial data input (or any other pin) must NOT be directly connected to any RS232 level ($\pm 15V$) devices.

Serial data is inverted i.e. Start Bit is logic low. This allows direct connection to a microcontroller UART (Inverted data) or to RS232 devices via a voltage level translator device such as a Maxim MAX232, which invert the logic of the RS232 signals. Data is sent and received in standard serial 'RS232' format (logic level only) and there is no restriction on the characters (Hex 00 – FF) that may be sent or received.

The host should provide serial data input and output lines. Optional 'handshaking' lines could be used (under custom software control) to control the flow of data between the host and eRIC.



Serial Data Timing

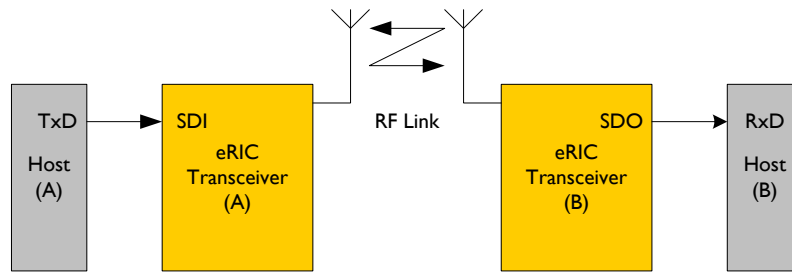


Figure 4 System Block Diagram

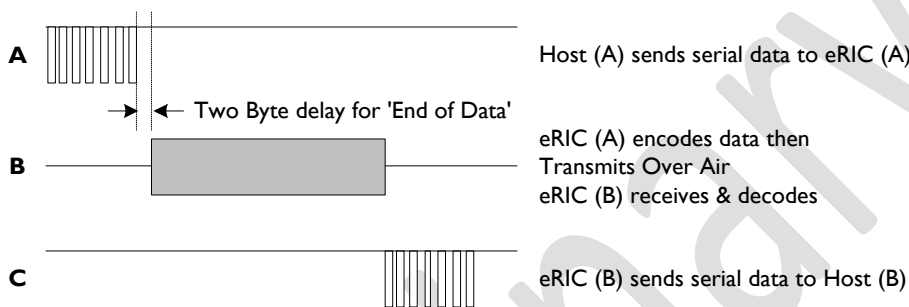


Figure 5 Timing Diagram

| Parameter | Values | Notes |
|-----------------------|---|--|
| Host Serial Data Rate | 1200, 2400, 4800, 9600, 19200, 38400, 31250 (MIDI), 76800 & 115200 baud | Configurable – Default = 19200 baud |
| Host Character Format | 1 Start bit, 8 Data bits, No Parity, 1 Stop bit | 10 bits @ 104uS/bit = 0.52mS/character at 19200 baud |
| 'End of Data' Delay | 2 x baud Byte duration | Twice character time |
| RF Transmit Duration | Depends on RF Data rate | See drawing. Between 2 & 4 bytes of Preamble and other internal data are automatically added to every packet |
| Buffer Size | 1-250 bytes maximum | |

Notes

The serial data internal buffer size is limited to a maximum of 250 bytes. Data will be lost if more than 250 bytes are sent in any one transmission. RF transmission begins automatically when the buffer is full or when 'End of Data' (no data for twice the character time) is detected.

- A. Host (A) sends serial data to eRIC (A). The data must be continuously streamed (no breaks) at the selected host baud rate and is loaded into an internal transmit buffer.
- B. After detecting either the 'End of Data' gap or the 'Buffer Full' condition the controller enables the RF transmitter circuitry of the transceiver and sends the data within the buffer together with preamble and other internal data across the RF link. Any eRIC transceiver operating in receive mode and within range that 'hear' the transmission will receive and decode the data, check for data integrity and place it into their receive buffers.
- C. Data within the receive buffer of eRIC (B) will be sent to Host (B) at the selected baud rate.

Host (A) must allow time for the complete 'Over Air' transmission and for the receiving Host (B) to unload (and process) the data before sending new data. (See Figure 5). There is no automatic 'RF handshaking' provided by the eRIC transceivers. Radio transmission and reception is bi-directional (half duplex) i.e. transmit OR receive (but not simultaneously) and there is no automatic confirmation of the satisfactory reception of the data.

The user application should therefore, either send the data repetitively to provide some redundancy or devise a scheme of acknowledgements (Acks) and re-trials to increase the security and reliability of the transmitted data should need be.



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**easyRadio eRIC Configuration Command Set (Using Preloaded Module Application code)**

Key operating parameters of eRIC can be changed and configured by sending the 'text' (ASCII character) commands detailed below. These commands can be executed using 'easyRadio Companion' software, any 'Terminal' software operating on a PC or from the host microcontroller.

The commands should be sent exactly as shown: i.e. case sensitive with no spaces between characters. Commands are not executed until the Acknowledgement sequence (ACK) is sent to and processed by the module.

To send the commands follow this procedure:

1. Send Command from host: e.g. ER_CMD#U5 (Set UART BAUD to 38400)
2. Wait for the completion of the echo of the Command from the module. e.g. ER_CMD#U5
3. Send the ACK command as the three upper case ASCII characters 'A' 'C' 'K' in sequence with no spaces

Commands ending with '?' (see below) do not require an ACK.

| Host Serial Communication Settings | | | | | | |
|------------------------------------|---|---|---|---------|-------|------|
| Command | UART Data Rate | ✓ | Indicates Factory Default setting | | | Note |
| ER_CMD#U1 | 2400 | | | | | |
| ER_CMD#U2 | 4800 | | | | | |
| ER_CMD#U3 | 9600 | | | | | |
| ER_CMD#U4 | 19200 | ✓ | | | | |
| ER_CMD#U5 | 38400 | | | | | |
| ER_CMD#U8 | 115200 | | | | | |
| ER_CMD#U? | Get UART Value | | The module replies with the current UART value Eg: ER_CMD#U2 - No 'ACK' is required | | | |
| Transmit RF Power Settings | | | | | | |
| | | | eRIC400 | eRIC900 | Units | |
| ER_CMD#P0 | Minimum | | 1.0 | -1.0 | dBm | |
| ER_CMD#P1 | | | 2.5 | 0.0 | dBm | |
| ER_CMD#P2 | | | 3.5 | 1.0 | dBm | |
| ER_CMD#P3 | | | 5.0 | 2.0 | dBm | |
| ER_CMD#P4 | | | 6.0 | 3.0 | dBm | |
| ER_CMD#P5 | | | 6.5 | 4.0 | dBm | |
| ER_CMD#P6 | | | 7.5 | 5.0 | dBm | |
| ER_CMD#P7 | | | 8.0 | 6.0 | dBm | |
| ER_CMD#P8 | | | 9.0 | 6.5 | dBm | |
| ER_CMD#P9 | Maximum | ✓ | 10.0 | 7.0 | dBm | |
| ER_CMD#p0-9 | Temporary RF Power output setting | | Using lowercase 'p' allows temporary RF Power output adjustment without modifying the value for the Power On Reset (POR) value stored in EEPROM. (Not implemented in current firmware version). | | | I |
| ER_CMD#P? | Get RF Power output value | | The module replies with the current power output value Eg: ER_CMD#P9 No ACK is required | | | |
| RF Channel Settings | | | | | | |
| ER_CMD#Cx | Where x = Channel Number in decimal. Only channels (0-9) implemented at present | | E.g. For Channel 5 – 434.500MHz: ER_CMD#C5 or ER_CMD#C05 (leading zero) or ER_CMD#C005 Uppercase 'C' stores value in EEPROM | | | |
| ER_CMD#C0 | | ✓ | Sets frequency to 434.000MHz | | | |
| ER_CMD#C1-8 | | | Intermediate values at 100kHz steps | | | |
| ER_CMD#C9 | | | Sets frequency to 434.900MHz | | | |
| ER_CMD#C? | Get Channel Value | | The module replies with the current channel setting Eg: ER_CMD#C9 - No ACK is required. | | | |
| Over-Air Data Rate | | | | | | |
| ER_CMD#B0 | | | 1200 bps | | | |
| ER_CMD#B1 | | | 2400 bps | | | |
| ER_CMD#B2 | | | 4800 bps | | | |
| ER_CMD#B3 | | | 9600 bps | | | |
| ER_CMD#B4 | | | 19200 bps | | | |



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| | | | | |
|----------------------|-----------------------|---|---|--|
| ER_CMD#B5 | | ✓ | 38400 bps | |
| ER_CMD#B6 | | | 76800 bps | |
| ER_CMD#B7 | | | 100000 bps | |
| ER_CMD#B8 | | | 250000 bps | |
| ER_CMD#B9 | | | 500000 bps | |
| Miscellaneous | | | | |
| ER_CMD#R0 | Reset Module (POR) | | Reset module and retrieve all 'Power On Reset' values | |
| Test Modes | | | | |
| ER_CMD#T0 | Upper FSK | | Transmit continuous upper FSK Carrier | |
| ER_CMD#T1 | | | Transmit continuous modulated Carrier at selected over air data rate. | |
| ER_CMD#T2 | Lower FSK | | Transmit continuous lower FSK Carrier | |
| ER_CMD#T3 | Get Firmware Revision | | Returns firmware revision string: e.g. eRIC400xxxx | |
| ER_CMD#T4 | RAW data | | Demodulated received data | |
| ER_CMD#T6 | Carrier Off | | End continuous transmit modes | |
| ER_CMD#T7 | Get Temperature | | Returns internal chip temperature in Degrees C. e.g. 20.5C | |

Notes

- 1) easyRadio 'lower case' commands are currently not implemented.

Product Order Codes

| Name | Description | Frequency | Order Code |
|--------------|--|------------|------------|
| eRIC400 | UK/European Transceiver Module (Can Marked '4') | 433MHz | eRIC4 |
| eRIC900 | Europe/US Transceiver Module (Can Marked '9') | 868/915MHz | eRIC9 |
| eRIC Dev Kit | eRIC Development Kit including two eRIC400 modules | 433MHz | eRIC4-DK |
| eRIC Dev Kit | eRIC Development Kit including two eRIC900 modules | 868/915MHz | eRIC9-DK |

Document History

| Issue | Date | Notes/Comments |
|--------------------------|------------------|---|
| Preliminary 0.1 | July 2013 | Preliminary Internal Draft |
| Preliminary 0.2 | July 2013 | Preliminary |
| Preliminary 0.30 to 0.35 | July/August 2013 | Additions, amendments and minor corrections |
| Preliminary 0.36 | September 2013 | This version |

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