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	**Benefits**
• Default 'easyRadio' Protocol Embedded	Simple serial data in/data out user interface and configuration
• ISM Frequency Bands	433 & 868MHz (UK & Europe), 315 & 915MHz (USA)
• Radio Approvals	Meets ETSI (Europe) & FCC Certified (USA) requirements
• Small 15x20x2.2mm Surface Mount Device (SMD)	Simplifies product design and manufacture
• Low power operation capable	Battery powered applications
• eROS Operating System & Application partitions	Can eliminate need for external application processor
• Configurable & programmable User I/O	Minimises external hardware requirements for custom applications
• AES 128 bit data encryption	Secure communications
• Built in Temperature Sensor	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.

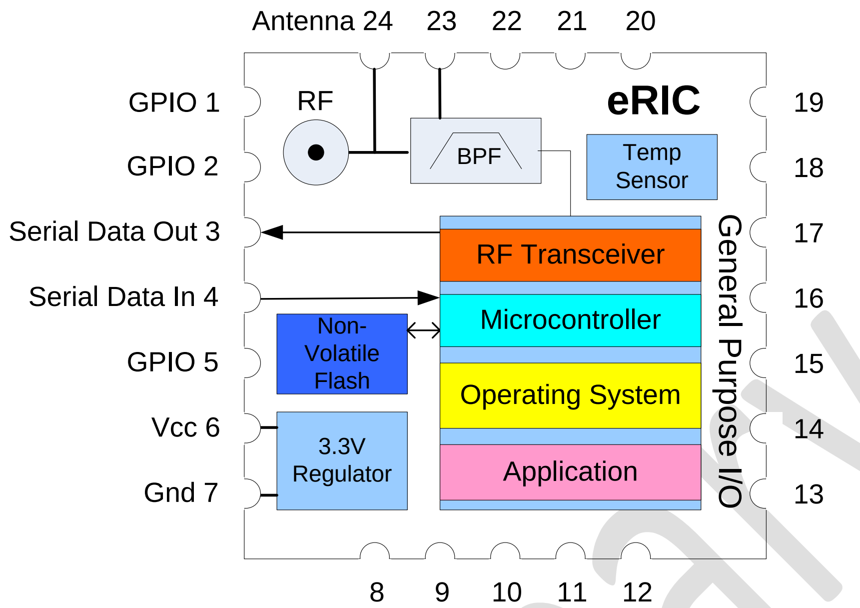

Figure 1 eRIC Transceiver Block Diagram

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

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

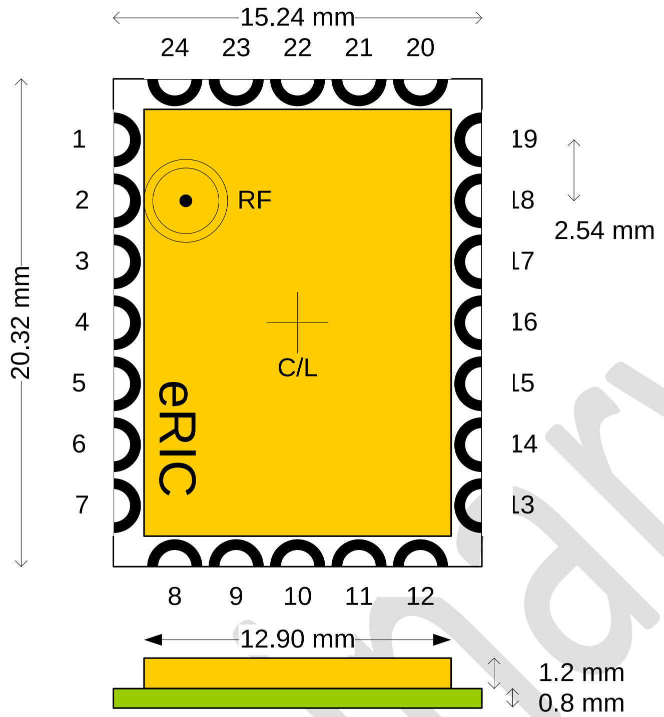


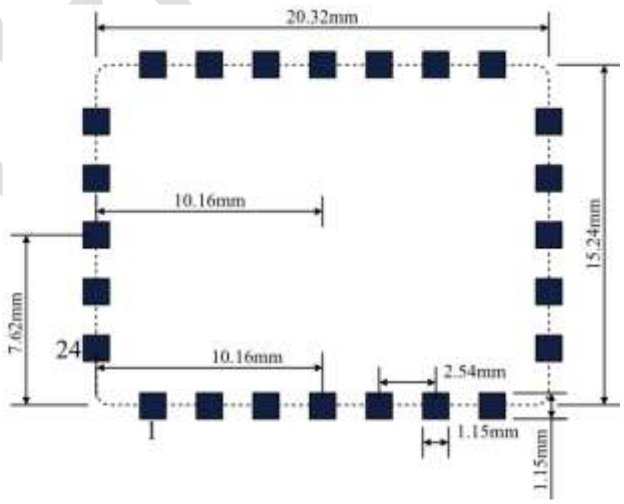
Figure 2 Mechanical Drawing

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

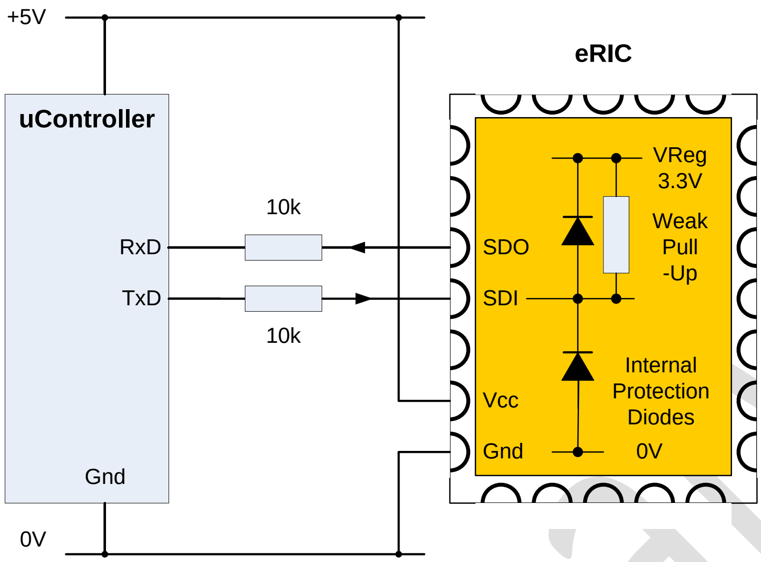

Figure 3 Connection to Host UART and I/O Protection

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 (±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

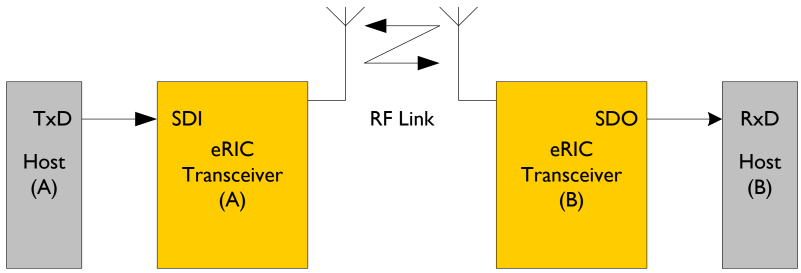

Figure 4 System Block Diagram

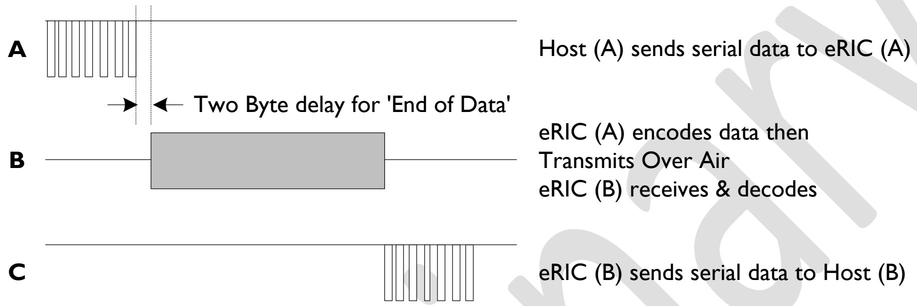

Figure 5 Timing Diagram

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-tries 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 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).			1
ER_CMD#P?	Get RF Power output value		The module replies with the current power output value E.g. 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 E.g: 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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