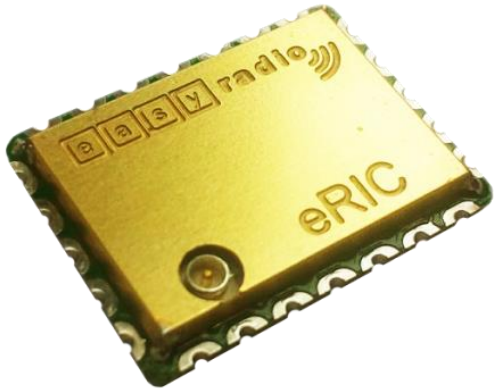
The easy Radio Intelligent Controller (eRIC) radio transceiver module is based on the Texas Instruments CC430F5137 System-on-Chip device to provide an intelligent radio sub-system that combines a high performance RF transceiver, RF band pass filters (BPF), an MSP430 microcontroller, 32Kb flash memory, 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 Compliance	Meets ETSI (Europe) & FCC Certified (USA) requirements
• Small 15x20x2.2mm Surface Mount Device (SMD)	Simplifies product design and manufacture
• Low power operation modes	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.

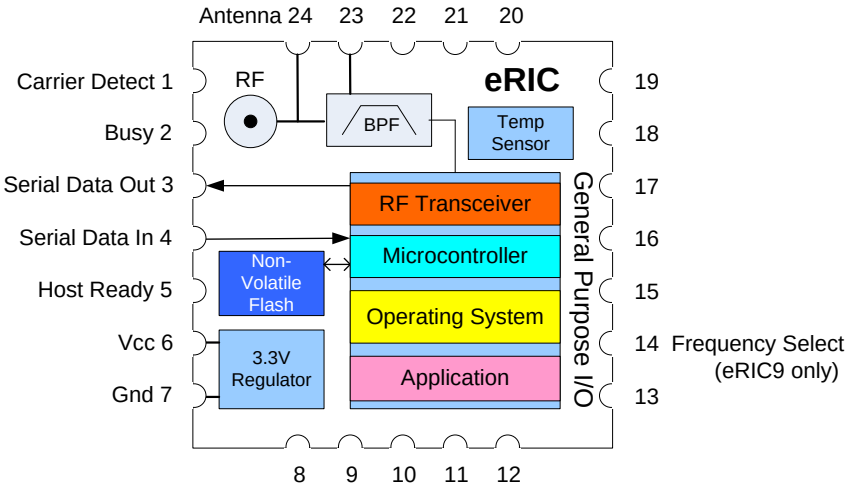


Figure 1 eRIC Transceiver Block Diagram

Pin/Pad Description

Pad No	Name	Description	Notes
1	CD	Carrier Detect Digital output	Indicates presence of any RF carrier within the receiver bandwidth Idle – Low, Carrier Present – High Optional A-D Input
2	Busy	Clear to Send (CTS) function Digital output	Indicates that transceiver is ready to receive serial data from the Host. Low – Transceiver Ready, High – Transceiver not Ready Optional A-D Input
2 (Option)	RF Rx Data	Demodulated receiver data Digital output	Only active when RAW Data mode is enabled
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	Host Ready	Request to Send (RTS) function Digital input	Used to indicate that Host is ready to receive serial data from the Transceiver Low – Host Ready, High – Host Not Ready Weak (35k) pull down enabled. 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 the bootloader function on reset. Do not connect for normal operation.
13	GPIO	General purpose digital I/O	
14	GPIO	General purpose digital I/O	eRIC4 only – see variant below:
	Input	Frequency Select EU/US	eRIC9 only. Pin High - 869.75 MHz, Pin Low - 915.00MHz Internal pull-up enabled
15 - 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 downs. Therefore, 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.
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 the eROS Developers Manual for further details and description of these functions.

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		1.8		uA	TBA
Initial Power Up Time			5	50	mS	
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		389	434.00	470	MHz	See Configuration Command set
		779	869.75	902	MHz	
		902	915.00	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	+7	dBm	50Ω load – 869MHz
RF Power Output 915MHz	24	-30	Set by user	-3	dBm	50Ω load – 915MHz
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 Over Air data rate
868/915MHz	24		-109		dBm	At 1.2kbps Over Air data rate
434MHz	24		-91		dBm	At 500kbps Over Air data rate
868/915MHz	24		-81		dBm	At 500kbps Over Air 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 manufacturer's specifications can provide very good performance.

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

Please Note: To meet US FCC requirements the modules must be used with the specified antennas (TBA) that were used for testing.

Mechanical

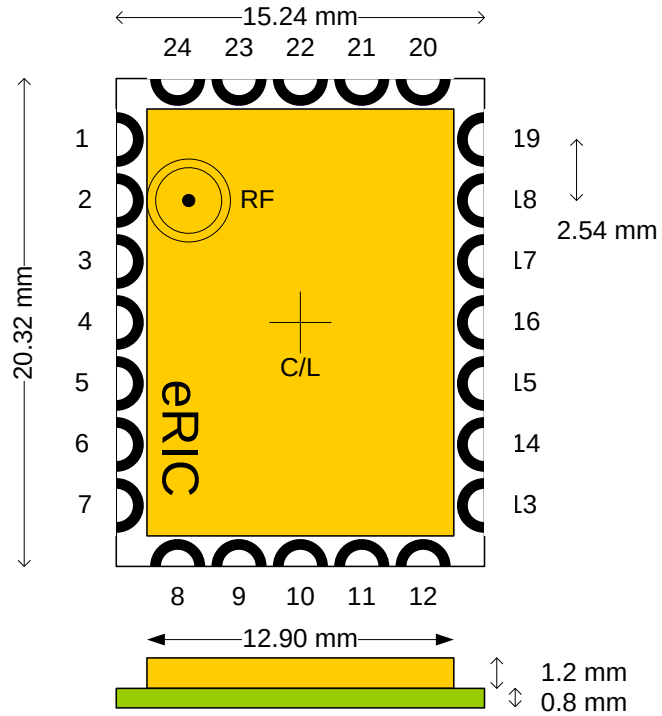


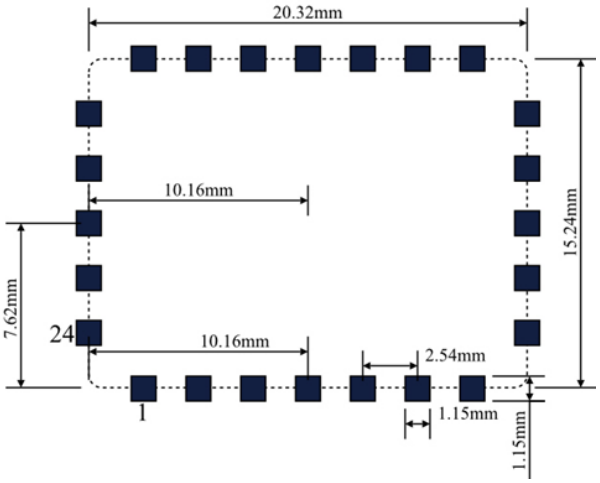
Figure 2 Mechanical Drawing

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.

Interface to Microcontroller

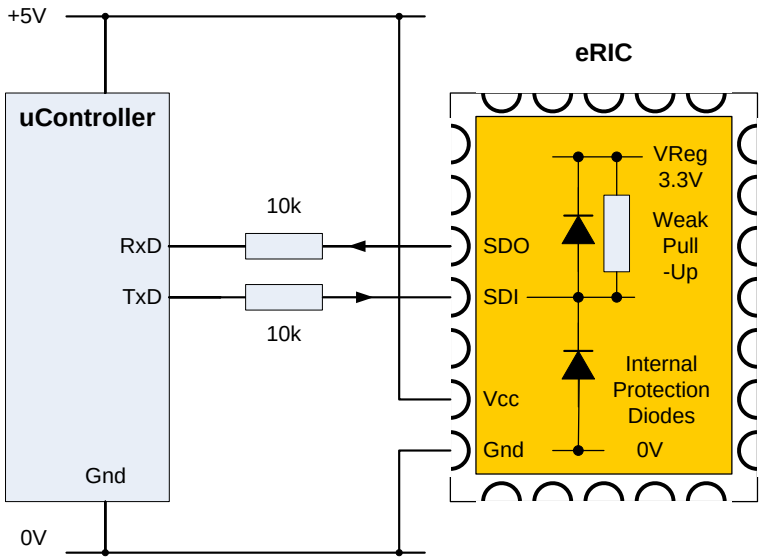


Figure 3 Connection to Host UART and I/O Protection

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 typical) 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. The optional 'handshaking' lines can be used to control the flow of data between the host and eRIC. If handshaking is not being used then Pin5 (Host Ready) should either be left floating (internal pull down) or held low.

Serial Data Timing

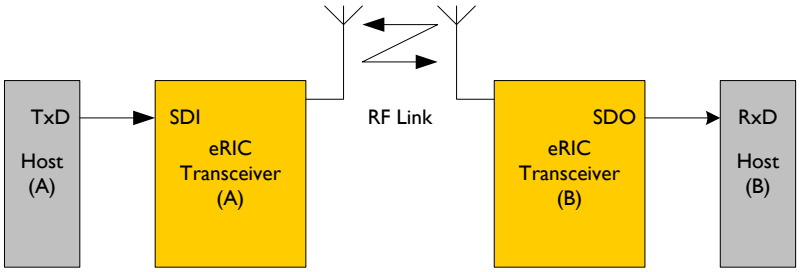


Figure 4 System Block Diagram

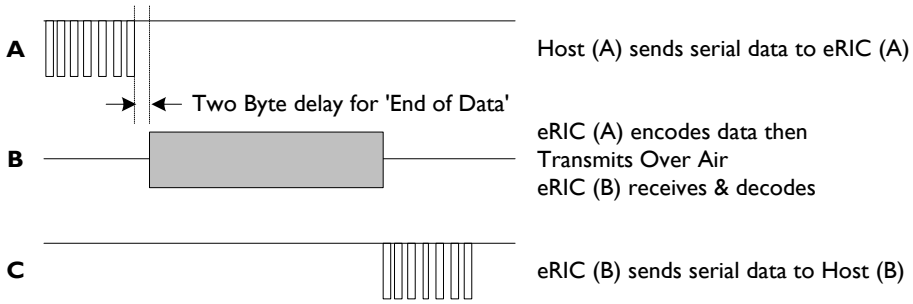


Figure 5 Timing Diagram

Parameter	Values	Notes
Host Serial Data Rate	2400, 4800, 9600, 19200, 38400 & 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 over air RF data rate Default - 38400 bps	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 'hears' 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.

easyRadio eRIC Configuration Command Set

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 (ACK) sequence 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

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		Returns the current UART value E.g. ER_CMD#U2 - No 'ACK' is required					
Transmit RF Power Settings								
			eRIC4 433MHz	**eRIC9** 869.75 – 870MHz	**eRIC9** 902 – 928 MHz	**eRIC9** Other frequencies	**Units**	
ER_CMD#P0	Minimum Power		0	-2	-12	0	dBm	
ER_CMD#P1			1	-1	-11	1	dBm	
ER_CMD#P2			2	0	-10	2	dBm	
ER_CMD#P3			3	1	-9	3	dBm	
ER_CMD#P4			4	2	-8	4	dBm	
ER_CMD#P5			5	3	-7	5	dBm	
ER_CMD#P6			6	4	-6	6	dBm	
ER_CMD#P7			7	5	-5	7	dBm	
ER_CMD#P8			8	6	-4	8	dBm	
ER_CMD#P9	Maximum Power	✓	9	7	-3	9	dBm	
ER_CMD#P?	Get RF Power output value		Returns the current RF 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 For Channel 5 – 870.250MHz For Channel 5 – 915.500MHz					
ER_CMD#C0		✓	Sets base frequency to: 434.000MHz, 869.75MHz, 915.000MHz					
ER_CMD#C1-8			Set intermediate frequency values at 100kHz steps					
ER_CMD#C9			Sets frequency to 434.900MHz (434.000 + 900KHz)					
ER_CMD#C?	Get Channel Value		Returns the current channel setting E.g. ER_CMD#C9 - No ACK is required					
RF Frequency Settings								
ER_CMD#F xxxxxxxx	Set Absolute Frequency		Sets the absolute frequency to xxxxxxxx in Hex E.g. ER_CMD#F1B4C8680 sets the radio frequency to 458000000Hz.					
ER_CMD#F?	Get current Frequency value		Returns the current frequency value as 8 bytes of Hex E.g. ER_CMD#F? Returns 1B4C8680 which is 458MHz					
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					
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	
ER_CMD#B?	Get the Over-Air data rate value		Returns the current Over-Air data rate value as command setting value E.g. ER_CMD#B5 - not the integer bps value No ACK is required	
Radio Receive - Power Saving				
	On Time		Typical Average Receiver Current	
ER_CMD#D0	100%	✓	16mA	V1.1
ER_CMD#D1	12.50%		2mA	V1.1
ER_CMD#D2	6.25%		1mA	V1.1
ER_CMD#D3	3.33%		500uA	V1.1
ER_CMD#D4	1.56%		250uA	V1.1
ER_CMD#D5	0.78%		125uA	V1.1
ER_CMD#D6	0.39%		63uA	V1.1
ER_CMD#D7	0.20%		32uA	V1.1
Radio Transmit - Power Saving				
ER_CMD#d0		✓	This setting must be used in conjunction with the receive power saving setting: ER_CMD#dx >= ER_CMD#Dx E.g. If the receiver is set by command ER_CMD#D4, the communication would fail if transmitter is set with command less than ER_CMD#d4. It will only work if the transmitter is set with command ER_CMD#d4 or above	V1.1
Group ID Settings				
ER_CMD#L7 xxxx	Enable Group ID (2 bytes)		E.g. ER_CMD#L74578 sets the group ID as 0x4578	V1.1
ER_CMD#L7 0000	Disable Group ID			V1.1
ER_CMD#L7?	Get Group ID value		Returns the 4 byte Group ID number in Hex	V1.1
EEPROM Settings				
ER_CMD#L8?	Get the Serial Number of the module		Returns the 4 byte module Serial Number in Hex E.g. 40000056	V1.1
ER_CMD#L4 xxxx	Writes data to EEPROM at location xx		E.g. ER_CMD#L4FE2A - Write the data 0x2A at EEPROM address 0xFE Where xxxx is the address followed by the data in hexadecimal	V1.1
ER_CMD#L4 xx?	Returns the EEPROM data located at address xx		E.g. ER_CMD#L4FE? Returns data as 0x2A Where xx is the EEPROM address in hexadecimal from 0-FF EEPROM is only 256Bytes and ranges from 0x00-0xFF	V1.1
Miscellaneous				
ER_CMD#R0	Reset Radio		Reset all the radio settings and retrieve all the (Default) radio settings P9, C0, D0, d0, U5, B5, L70000	
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 in ASCII e.g. eRIC400xxxx	
ER_CMD#T4	RAW Data mode		Output the demodulated received data on Pin 2	
ER_CMD#T5	Packet Mode		Set the radio into normal packet data mode	V1.1
ER_CMD#T6	Carrier Off		End continuous transmit modes	
ER_CMD#T7	Get Temperature		Returns internal chip temperature in decimal Degrees C. e.g. 20.5°C	
ER_CMD#T8	Last Packet RSSI		Returns the Received Signal Strength Indication of the last packet in dBm with sign (only in Packet Mode) e.g. -74dBm	V1.1
ER_CMD#T9	Get live RSSI		Returns the live RSSI value in dBm with sign e.g. -102dBm	

Notes

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 to 0.2	July 2013	Preliminary internal draft
Preliminary 0.30 to 0.36	July/August 2013	Additions, amendments and minor corrections
V1.0	January 2014	First release
V1.1	June 2014	This version

Download your Software

easyRadio Companion V3.18 (Windows OS)

http://www.lprs.co.uk/assets/media/ER%20Companion%203_18%20setup.zip

eRIC Flash Programmer V1.1 setup. (Windows OS)

http://www.lprs.co.uk/assets/media/downloads/eRIC%20Flash%20Programmer%20V1_1%20Setup.zip

eROS4

http://www.lprs.co.uk/assets/media/downloads/eRIC_Bootloader_eROS%20V4.0.zip

eRIC4easyRadioV1.1 hex file

http://www.lprs.co.uk/assets/media/downloads/eRIC4easyRadioV1.1.zip

eRIC9easyRadioV1.1 Hex file

http://www.lprs.co.uk/assets/media/downloads/eRIC9easyRadioV1.1.zip

For all files and supporting documents please go to:

http://www.lprs.co.uk/resource-centre/downloads.html

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