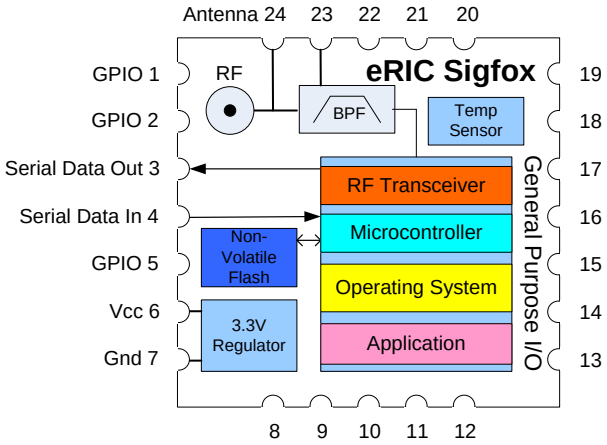
Product image for illustration purposes only



Block Diagram

Features
Ultra Narrow band modulation
Serial Data Input and Output
Pin compatible with all eRIC series RF modules
uFL RF connector for remote antennas
Built in on-chip temperature sensor
Supply voltage measurements
Operating temperature range -40°C to 85°C

Applications
Up-link and down-link for Sigfox networks
Where required range is above 1km or transceiver is in poor RF location
Suburban security alarms - void buildings, caravan or car storage sites, warehouses
Rural security, farm buildings/equipment, livestock monitoring, remote irrigation pumps
Data collection and monitoring over a wide physical area

Receiver
Carrier frequency 869.525 MHz
Data-rate up to 600 bps
Sensitivity -126 dBm @ 600bps, GFSK
Line of Sight (LoS) range - 1km – 3km plus

Transmitter
High efficiency Power Amplifier
Carrier frequency 868.13 MHz
Data-rate 100 bps PSK
RF Power output: up to +14dBm
Power level programmable in 1dBm steps from 0dBm to +14dBm

Power Consumption
Power Supply range 2.5V – 5.0V
Ultra-low power consumption:
Standby mode current: 0.5 mA
Sleep mode current: 1.3 µA
Deep sleep mode current: 100 nA
Continuous radio Rx mode: 10 mA
Continuous radio Tx mode: 49 mA @ 14 dBm
Charge required to send a Sigfox packet at 14 dBm output power: 0.28C

General Purpose Input/Output (GPIO)
4 x GPIO pins with selectable voltage measure functionality
2 x GPIO pins with selectable Sigma Delta DAC output functionality
2 x GPIO pins with selectable output clock
3 x GPIO pins selectable as SPI master interface

The eRIC Sigfox® AT RF transceiver module provides an ultra-low power module solution for nodes connected to the Sigfox network. The module is a complete sub-system that combines a high performance low power RF transceiver, a microcontroller and a voltage regulator. The form factor and pin out is compatible with other LPRS eRIC family modules allowing a drop-in replacement to upgrade or change the radio technology of host devices.

The module is delivered ready for use and contains the necessary firmware to transmit and receive data from the Sigfox network in Europe and the UK. It connects to the customer host product via a logic level RS232 UART operating at 9600 bps. AT commands are used to configure the radio parameters and send up-link and down-link frames to the network.

The module uses Ultra-Narrow Band (UNB) RF modulation to achieve excellent range and provide rugged and reliable connections to SigFox® base stations and networks.

Key operating parameters can be changed and configured by sending simple 'text' (ASCII character) AT modem commands to the module via the on-board UART.

Pin Description

Pad No	Description	SIGFOX Function	Type	Notes
1	GPIO4	PCO/SEL	I/0/PU	GPIO, selectable DAC functionality, selectable clock functionality
2	CPU Activity Indicator	PB0/TX1	O	LED drive via external current limit resistor
3	UART Tx	PB4/TXO	O	Serial Data Out to host
4	UART Rx	PB5/RXO	I/PU	Serial Data In from host
5	Radio Activity Indicator	PB1/RX1	O	LED drive via external current limit resistor
6	Power Input		P	Positive power supply pin. +2.5 to +5.5 Volts. This should be a 'clean' noise free supply with less than 25mV of ripple
7	Gnd		P	Power Gnd 0 V
8	JTAG	DBG_En	N	Reserved use - Do Not Connect
9	Reset	RST_N	I/PU	Internal Pull-up
10	Transmit Activity Indicator	DBG_CLK	O	LED drive via external current limit resistor
11	No Connection			NC
12	Receive Activity Indicator	DBG/DATA	O	LED drive via external current limit resistor
13	GPIO0	PA0/ADC0	I/0/A/PU	GPIO, selectable ADC functionality, selectable DAC functionality, selectable clock functionality
14	GPIO1	PA1/ADC1	I/0/A/PU	GPIO, selectable ADC functionality
15	GPIO2	PA2	I/0/A/PU	GPIO, selectable ADC functionality
16	GPIO3	PA5	I/0/A/PU	GPIO, selectable ADC functionality
17	GPIO8	PC4	I/0/PU	GPIO
18	GPIO7	PC3/MISO	I/0/PU	GPIO, SPI MISO
19	GPIO6	PC2/MOSI	I/0/PU	GPIO, SPI MOSI
20	No Connection			NC
21	GPIO5	PC1/SCK		GPIO, SPI SCK
22	GPIO9	PB3	I/0/PU	GPIO, Wakeup from Deep sleep
23	RF Ground		P	RF Gnd. Connect to antenna ground (coaxial cable screen braid) and local ground plane. Internally connected to other Ground pins.
24	Antenna	Antenna	A	50Ω RF input/output. Connect to suitable antenna.

Key:			
A	Analog signal	I/O	Digital input/output signal
I	Digital input signal	N	Not to be connected
O	Digital output signal	P	Power or ground
PU	Pull-up	PD	Pull-down

Pin	**Possible GPIO modes**
GPIO0	0,I,Z,U,A,T
GPIO1, 2, 3	0,I,Z,U,A
GPIO4	0,I,Z,U,T
GPIO5, 6, 7, 8, 9	0,I,Z,U

Pin is configured as:			
O	Output driver	U	Input with pull-up
I	No Connect	A	Analogue input
Z	High impedance input	T	Driven by Clock or DAC

Notes

The module operates internally from an on-board 3.3 Volt low dropout voltage regulator. The logic levels of the GPIO input/output pins are therefore between 0 Volt and 3.3 Volts.

Digital outputs will drive external logic operating at 3.3 Volts.

Digital inputs are 5V tolerant with the exception of GPIO3 which must NOT be driven above the VDD_IO voltage.

All digital inputs are Schmitt trigger inputs, digital input and output levels are LVCMOS/LVTTL compatible.

All GPIO pins start up as input with pull-up.

For explanations on how to use the GPIO pins, see the AT Commands.

eRIC-Sigfox AT uses the UART (pins UARTTX, UARTRX) to communicate with a host and uses a bit rate of 9600 baud, no parity, 8 data bits and 1 stop bit only.

The UARTRX pin starts up as input with pull-up.

The UART serial inputs and outputs are intended for connection to a microcontroller UART or other similar low voltage logic device. Do not connect any of the inputs or outputs directly to an RS232 port. The transceiver module may be permanently damaged by the voltages (+/-12V) present on RS232 signal lines.

Mechanical

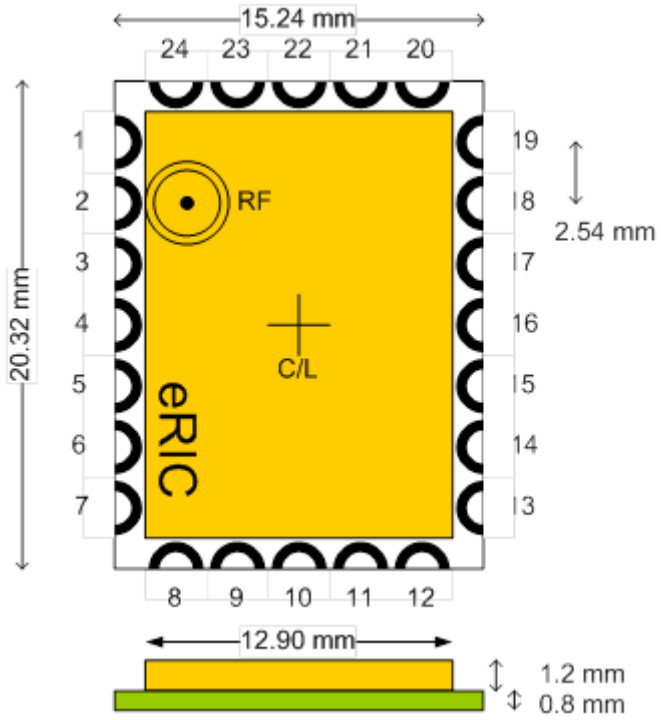


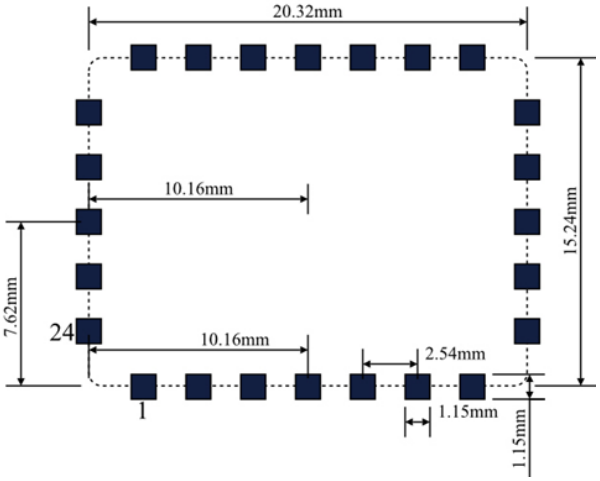
Figure 2 Mechanical Drawing

PCB Layout Notes

Pitch of the castellated connection pads is 2.54mm. Pads 4 & 16 and 10 & 22 are on the 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 modules are designed for reflow soldering. Please contact LPRS Technical Department for further details and the suggested thermal profiles.

Absolute Maximum Ratings

Operating Temperature Range	-40° C to +85° C
Storage Temperature Range	-40° C to +85° C
Vcc	- 0.3 to + 5.5 Volts
All Other Pins (N.B.)	- 0.3 to +5.5 Volts
Pin Input Current	10mA
Pin Output current	40mA
Total Supply Current	200mA
Total Power Consumption	800mW
Antenna Pin	+10dBm Should be protected to prevent damage from ESD
Electrostatic handling	+/- 2000V Human Body Model

Stresses above those listed under Absolute Maximum Ratings may cause permanent damage to the device. This is a stress rating only; functional operation of the device at these or any other conditions above those listed in the operational sections of this specification is not implied.
Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

Performance Data: Supply +5.0 Volt ± 5%, Temperature 20° C

DC Parameters	Pin	Min	Typ	Max	Units	Notes
Operational ambient temperature		-40	27	85	°C	
I/O and voltage regulator supply voltage			3.3		V	TBA
I/O voltage ramp for reset activation		0.1			V/ms	Ramp starts at VDD_IO≤0.1V
I/O voltage ramp for reset activation		3.3			V/ms	Ramp starts at 0.1V<VDD_IO<0.7V
						If VDD_IO ramps cannot be guaranteed, an external reset circuit is recommended. See the AX8052 Application Note: Power On Reset
Deep sleep mode current			100		nA	AT$P=2
Sleep mode current			1.3		µA	AT$P=1
Standby mode current			0.5		mA	Internal 20 MHz oscillator, voltage conditioning and supervisory circuitry running
Current consumption continuous RX			10		mA	AT$SR=1,1,-1
Charge to send a Sigfox out of band message, 0dBm			0.12		C	AT$S0
Charge to send a bit, 0dBm			0.08		C	AT$SB=0
Charge to send a bit with downlink receive, 0dBm			0.27		C	AT$SB=0,1
Charge to send the longest possible Sigfox frame (12 byte) , 0dBm			0.14		C	AT$SF=00112233445566778899aabb
Charge to send the longest possible Sigfox frame (12 byte) with downlink receive, 0dBm			0.27		C	AT$SF=00112233445566778899aabb,1

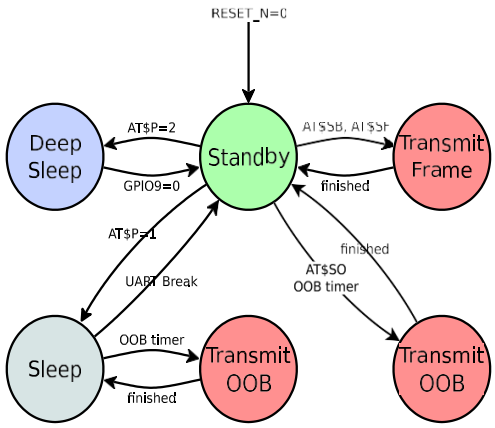
Charge to send a Sigfox out of band message, 14dBm			0.28		C	AT$S0
Charge to send a bit, 14dBm			0.20		C	AT$SB=0
Charge to send a bit with downlink receive, 14dBm			0.35		C	AT$SB=0,1
Charge to send the longest possible Sigfox frame (12 byte) , 14dBm			0.39		C	AT$SF=00112233445566778899aabb
Charge to send the longest possible Sigfox frame (12 byte) with downlink receive, 14dBm			0.46		C	AT$SF=00112233445566778899aabb,1
Modulated Transmitter Current			19.0		mA	Pout=0 dBm; average
Modulated Transmitter Current			49.0		mA	Pout=14 dBm; average
Digital Inputs	**Pin**	**Min**	**Typ**	**Max**	**Unit**	**Notes**
Schmitt trigger low to high threshold point			1.55		V	VDD_IO = 3.3V
Schmitt trigger high to low threshold point			1.25		V	
Input voltage, low				0.8	V	
Input voltage, high		2.0			V	
Input voltage range, GPIO[3:0]		-0.5		VDD_IO	V	Not 5V tolerant
Input voltage range, GPIO[9:4], UARTRX		-0.5		5.5	V	
Input leakage current		-10		10	µA	
Programmable Pull-Up Resistance			65		k	
Digital Outputs	**Pin**	**Min**	**Typ**	**Max**	**Unit**	**Notes**
Output Current, high Ports GPIO[9:0], UARTTX, TXLED, RXLED, TXLED, CPULED		8			mA	V_{OH}= 2.4V
Output Current, low GPIO[9:0], UARTTX, TXLED, RXLED, TXLED, CPULED		8			mA	V_{OL}= 0.4V
Tri-state output leakage current		-10		10	µA	
Transmitter	**Pin**	**Min**	**Typ**	**Max**	**Unit**	**Notes**
						Conditions for transmitter specifications unless otherwise specified with the antenna network from AX-Sigfox Application Note: Sigfox Compliant Reference Design and at 868.130 MHz
Signal Bit Rate (SBR)			100		bps	
Lowest Transmitter output power			0		dBm	AT$CW=868130000,1,0
Highest Transmitter output power			+14			AT$CW=868130000,1,14
Programming step size output power			1		dB	The output power of the AX-Sigfox can be programmed in 1 dB steps from 0 dBm – 14 dBm. Current consumption values are given for a matching network that is optimized for 14 dBm output. 0 dBm transmission with typically 10 mA can be achieved with other networks that are optimized for 0 dBm operation
Transmitter power variation vs. temperature			+/- 0.5		dB	-40 °C to +85 °C
Transmitter power variation vs. VDD_IO			+/- 0.5		dB	1.8 to 3.6 V
Emission @ 2nd harmonic			-51		dBc	
Emission @ 3rd harmonic			-63			
Emission @ 4th harmonic			-84			
Receiver	**Pin**	**Min**	**Typ**	**Max**	**Unit**	**Notes**
						Conditions for transmitter specifications unless otherwise specified with the antenna network from AX-Sigfox Application Note: Sigfox Compliant Reference Design and at 869.525 MHz.
Signal bit rate			600		bps	
			-126		dBm	AT$SB=x,1, AT$SF=x,1, AT$SR PER < 0.1
Blocking at +/- 10MHz offset			78		dB	Channel/Blocker @ PER = 0.1, wanted signal level is +3 dB above the typical sensitivity, the blocker signal is CW
ADC & Temperature Sensor	**Pin**	**Min**	**Typ**	**Max**	**Unit**	**Notes**
ADC resolution			10		Bits	

ADC reference voltage		0.95	1	1.05	V	
Input capacitance				2.5	pF	
Differential nonlinearity			+/- 1		LSB	
Integral non linearity			+/- 1		LSB	
Offset			3		LSB	
Gain error			0.8		%	
ADC in Differential Mode						
Absolute voltages & common mode voltage in differential mode at each input		0		VDD_IO	V	
Full swing input for differential signals		-500		500	mV	Gain x1
		-50		50	mV	Gain x10
ADC in Single Ended Mode						
Mid code input voltage in single ended mode			0.5		V	
Input voltage in single ended mode		0		VDD_IO	V	
Full swing input for single ended signals		0		1	V	Gain x1
Temperature Sensor	**Pin**	**Min**	**Typ**	**Max**	**Unit**	**Notes**
Temperature range		-40		85	°C	AT$T?
Temperature error		-2		+2	°C	AT$T?
Mechanical			**Typ**			**Notes**
Size			15 x 20 x 2.2		mm	
Pin Pitch			2.54		mm	Standard 0.1 Inches
Weight			1.5		grams	

AT Command Interface

The eRIC-Sigfox uses the UART (pins UARTTX, UARTRX) to communicate with a host and uses a bitrate of 9600 baud, no parity, 8 data bits and one stop bit.

Power Modes State Diagram



Standby Mode

After Power-Up and after finishing a SIGFOX transmission, eRIC-Sigfox enters Standby mode.
In Standby mode, eRIC-Sigfox listens on the UART for commands from the host.
Also, Out of Band (OOB) frames are transmitted whenever the OOB timer fires.

Sleep

To conserve power, the eRIC-Sigfox can be put into Sleep or turned off (Deep Sleep) completely.

The command AT$P=1 is used to put the eRIC-Sigfox into Sleep mode. In this mode, only the wakeup timer for out-of-band messages is still running. To wake the eRIC-Sigfox up from Sleep mode toggle the serial UARTRX pin, e.g. by sending a break (break is an RS232 framing violation, at least 10 bit durations low). When an Out of Band (OOB) message is due, eRIC-Sigfox automatically wakes up to transmit the message, and then returns to Sleepmode.

Deep Sleep

In Deep Sleep mode, the eRIC-Sigfox is completely turned off and only draws negligible leakage current. Deep Sleep mode can be activated with AT$P=2.
To wake-up from Deep Sleep mode, GPIO9 is pulled to GND.

When using Deep Sleep mode, keep two things in mind:
Everything is turned off, timers are not running at all and all settings will be lost (use AT$WR to save settings to flash before entering Deep Sleep mode). Out-of-band messages will therefore not be sent. The pins states are frozen in Deep Sleep mode. The user must ensure that this will not result in condition which would draw a lot of current.

Numerical Syntax

hexdigit	::=	[0-9A-Fa-f]
hexnum	::=	“0x” hexdigit+
decnum	::=	“0” | [1-9] [0-9]*
octnum	::=	“0” [0-7]+
binnum	::=	“0b” [01]+
bit	::=	[01]
optnum	::=	“-1”
frame	::=	(hexdigit hexdigit)+
uint	::=	hexnum | decnum | octnum | binnum
uint_opt	::=	uint | optnum

Command Syntax

A command starts with ‘AT’ (everything is case sensitive!), continues with the actual command followed by parameters (if any) and ends with any kind of whitespace (space, tab, newline etc.)

If incorrect syntax is detected (“parsing error”) all input is ignored up until the next whitespace character.

Also note that any number can be entered in any format (Hexadecimal, Decimal, Octal and binary) by adding the corresponding prefix ('0x', '0', '0b'). The only exception is the 'Send Frame' command (AT$SF) which expects a list of hexadecimal digits without any prefix.

Return Codes

A successful command execution is indicated by sending 'OK'. If a command returns a value (e.g. by querying a register) only the value is returned.

Examples

Bold text is sent to **eRIC-Sigfox**.

AT$I=0

AT Command Interface

Here, we execute command 'I' to query some general information.

AT$SF=aabb1234
OK

This sends a Sigfox frame containing { 0x00 : 0x11 : 0x22 : 0x33 : 0x44 }, then waits for a downlink response telegram, which in this example contains { 0xAA : 0xBB : 0xCC : 0xDD}.

AT$SF=0011223344,1
OK
RX=AA BB CC DD

This sends a Sigfox frame containing { 0xAA : 0xBB : 0x12 : 0x34 } without waiting for a response telegram.

AT$CB=0xAA,1
OK

Name	Range	Description	Default
Pattern	0-255, -1	Byte to send. Use '-1' for a (pseudo-) random pattern	
Mode	0, 1	Enable or disable pattern test mode.	

Commands

Command	Name	Description
AT	Dummy command	Just returns 'OK' and does nothing else. Can be used to check communication
AT$SB=*bit[,bit]*	Send bit	Send a bit status (0 or 1). Optional bit flag indicates if **AX-Sigfox** should receive a downlink frame
AT$SF=*frame[,bit]*	Send frame	Send payload data, 1 to 12 bytes. Optional bit flag indicates if **AX-Sigfox** should receive a downlink frame
AT$SO	Manually send out of band message	Send the out-of-band message
ATS*uint*?	Get register	Query a specific configuration register's value. See Chapter "Registers" for a list of registers
ATSuint=*uint*	Set register	Change a configuration register
AT$IF=*uint*	Set TX frequency	Set the output carrier macro channel for Sigfox frames
AT$IF?	Get TX frequency	Get the currently chosen TX frequency
AT$DR=*uint*	Set RX frequency	Set the reception carrier macro channel for Sigfox frames
AT$DR?	Get RX frequency	Get the currently chosen RX frequency
Command	**Name**	**Description**
AT$CW= *uint,bit [,uint_opt]*	Continuous Wave	To run emission tests for Sigfox certification it is necessary to send a continuous wave, i.e. just the base frequency without any modulation. Parameters:
		Name / **Range** / **Description** / **Default**
		Frequency / 800000000 – 999999999, 0 / Continuous wave frequency in Hz. Use 868130000 for Sigfox or 0 to keep previous frequency /
		Mode / 0, 1 / Enable or disable carrier wave. /
		Power / 0-14 / dBm of signal / 14
AT$CB= *uint_opt,bit*	Test mode: TX constant byte	For emission testing it is useful to send a specific bit pattern. The first parameter specifies the byte to send. Use '-1' for a (pseudo-) random pattern. Parameters:

		Name	Range	Description	Default
		Pattern	0-255, -1	Byte to send. Use '-1' for a (pseudo-) random pattern	
		Mode	0, 1	Enable or disable pattern test mode	
AT$T?	Get Temperature	Measure internal temperature and return it in 1/10th of a degree Celsius.			
AT$V?	Get Voltages	Return current voltage and voltage measured during the last transmission in mV			

Command	Name	Description
		Display various product information:
AT$I=*uint*	Information	0 Software Name & Version Example Response: AX-Sigfox 1.0.6-ETSI
		1 Contact Details Example Response: technical@lprs.co.uk
		2 Silicon revision lower byte Example Response: 8F
		3 Silicon revision upper byte Example Response: 00
		4 Major Firmware Version Example Response: 1
		5 Minor Firmware Version Example Response: 0
		6 Firmware Revision Example Response: 3
		7 Firmware Variant (Frequency Band etc. (EU/US)) Example Response: ETSI
		8 Firmware VCS Version Example Response: v1.0.2-36
		9 SIGFOX Library Version Example Response: DL0-1.4
		10 Device ID Example Response: 00012345
		11 PAC Example Response: 0123456789ABCDEF
AT$P=*uint*	Set Power Mode	To conserve power, the AX-Sigfox can be put to sleep manually. Depending on power mode, you will be responsible for waking up the AX-Sigfox again! 0: Software reset (settings will be reset to values in flash) 1: sleep (send a break to wake up) 2: Deep sleep (toggle GPIO9 or RESET_N pin to wake up; the AX-Sigfox is not running and all settings will be reset!)
AT$WR	Save config	Write all settings to flash (RX/TX frequencies, registers) so that they survive reset/deep sleep or loss of power. Use AT$P=0to reset the AX-Sigfox and load settings from flash.

Command	Name	Description
AT:Pn?	Get GPIO pin	Return the setting of the GPIO pin *n*; *n* can range from 0 to 9. A character string is returned describing the mode of the pin, followed by the actual value. If the pin is configured as analog pin, then the voltage (range 0...1 V) is returned. The mode characters have the following meaning:

Mode	Description
0	Pin drives low
1	Pin drives high
Z	Pin is high impedance input
U	Pin is input with pull-up
A	Pin is analog input (GPIO pin 0...3 only)
T	Pin is driven by clock or DAC (GPIO pin 0 and 4 only)

The default mode after exiting reset is U on all GPIO pins

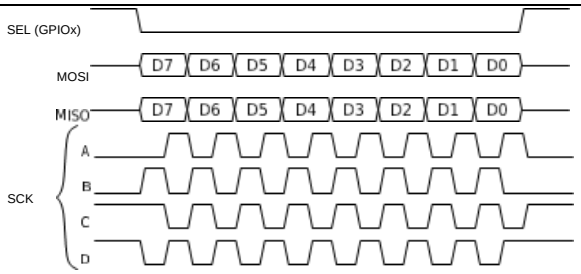
Command	Name	Description
AT:P*n*=?	Get GPIO pin range	Print a list of possible modes for a pin. The table below lists the response.

Pin	Modes
P0	0,1,Z,U,A,T
P1	0,1,Z,U,A
P2	0,1,Z,U,A
P3	0,1,Z,U,A
P4	0,1,Z,U,T
P5	0,1,Z,U
P6	0,1,Z,U
P7	0,1,Z,U
P8	0,1,Z,U
P9	0,1,Z,U

AT:P*n*=*mode*	Set GPIO pin	Set the GPIO pin mode.

		For a list of the modes see the command AT:P*n*?
AT:ADC P*n*[-P*n*[(1V|10V)]]?	Get GPIO pin analogue voltage	Measure the voltage applied to a GPIO pin. The command also allows measurement of the voltage difference across two GPIO pins. In differential mode, the full scale range may also be specified as 1 V or 10 V. Note however that the pin input voltages must not exceed the range 0..VDD_IO. The command returns the result as fraction of the full scale range (1V if none is specified). The GPIO pins referenced should be initialized to analog mode before issuing this command.
Command	**Name**	**Description**
AT:SPI[(A|B|C|D)] =*bytes*	SPI transaction	This command clocks out bytes on the SPI port. The clock frequency is 312.5kHz. The command returns the bytes read on MISO during output. Optionally the clocking mode may be specified (default is A):

Mode	Clock Inversion	Clock Phase
A	Normal	Normal
B	Normal	Alternate
C	Inverted	Normal
D	Inverted	Alternate



Note that SEL, if needed, is not generated by this command, and must instead be driven using standard GPIO commands (AT:Pn=0|1).

AT:CLK=*freq, reffreq*	Set clock generator	Output a square wave on the pin(s) set to T mode. The frequency of the square wave is (freq/2^{16}) x ref freq. Possible values for ref freq16 are 20000000, 10000000, 5000000, 2500000, 1250000,625000, 312500, 156250. Possible values if freq are 0…65535
AT:CLK=OFF	Turn off clock generator	Switch off the clock generator
AT:CLK?	Get clock generator	Return the settings of the clock generator. Two numbers are returned, freq and reffreq
AT:DAC=*value*	Set ΣΔ DAC	Output a ΣΔ DAC value on the pin(s) set to T mode. Parameter value may be in the range –32768..32767. The average output voltage is: (1/2 +Value/2^{16}) An external low pass filter is needed to get smooth output voltages. The modulation frequency is 20 MHz. A possible low pass filter choice is a simple RC low pass filter with R=10kΩ and C=1µF
AT:DAC=OFF	Turn off ΣΔ DAC	Switch off the DAC
AT:DAC?	Get ΣΔ DAC	Return the DAC value

Registers

Number	Name	Description	Default	Range	Unit
300	Out of band period	**AX-Sigfox** sends periodic static messages to indicate that they are alive. Set to 0 to disable	24	0-24	hours
302	Power level	The RF output power of the transmitter	14	0-14	dBm

Product Order Codes

Name	Description	Order Code
	Sigfox AT RF Transceiver	eRIC-SIGFOX

Please contact the sales office for availability of other variants of the standard product.

Document History

Issue	Date	Revision
1.0	October 2016	Provisional datasheet
1.1	October 2016	AT Command Set details added.

Changes to this Document This data sheet has been updated to reflect changes throughout the range of LPRS modules. Specific changes are recorded in the documentation history above.

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