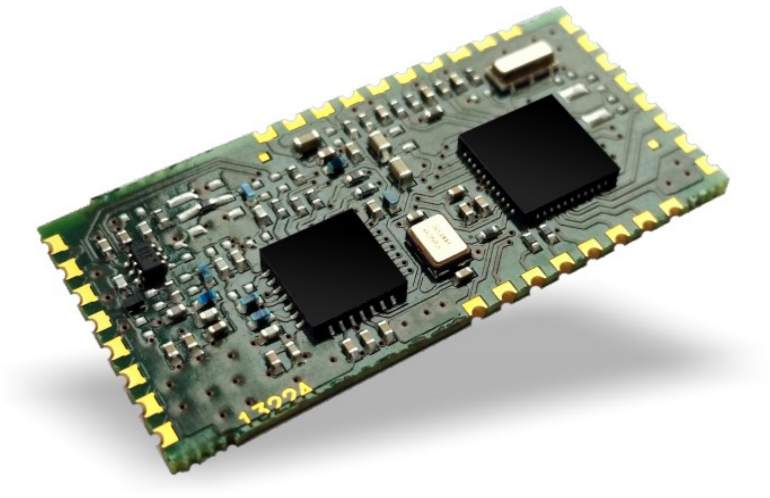


XTR-8LR100 is an half duplex transceiver based on SX1276 chipset patented "**LoRa ™"** modulation technique providing an ultra long range radio communication, high interference immunity, high sensitivity and very low power consumption. Compared to standard modulation techniques, XTR-8LR100 improves up to 20 dB the receiver sensitivity, allowing long distances by using low power in transmission and low consumption, inexpensive power supply circuits and low cost batteries.
Transceiver works in 869,4÷869,65MHz (100mW, ver. 8LR100) and 868÷868,6MHz (25mW) European band with possibility to set the channel width .
XTR-8LR100 is a radio-modem with UART input interface, working on data packages (max. size 255 bytes). It can handle addressing schemes for point-to-multipoint star networks. Main radio parameters might be set up smoothly via command mode procedure.
Operating voltage is 3,3V, current consumption is 17mA in reception, 115mA in transmission (+20dBm ERP) or 35 mA (15 dBm ERP).
Module is available in tape & reel package for SMD assembling.
Size is 37 x 18 x 2,2 mm.

Main features

- **Direct transmission or radiomodem mode**
- **UART interface with store and foreward mode**
- **No encoding or preamble requested**
- **AT command mode for set up of parameters**
- **HyperTerminal* compatible**
- **Channels: 7 max**
- **Small form factor (37x18X2,2 mm)**
- **UART data rate: 9600, 19200, 115200 bps**
- **Emitted power: max 100 mW**
- **Sensitivity from -118 to-144 dBm**
- **Operating voltage: 3,3V**
- **Standard distance: 6000 m**

Applications

- **Home and building automation**
- **Irrigation control**
- **Energy monitoring**
- **Industrial sensors**
- **SCADA**
- **Alarms**
- **Automatic Meter Reading**

Absolute maximum ratings

Operating temperature	-20 °C ÷ +70 °C
Storage temperature	-40 °C ÷ +100 °C
Supply voltage	+3.6V
Input voltage	-1.0 ÷ Vcc + 0.3V
Output voltage	-1.0 ÷ Vcc + 0.3V

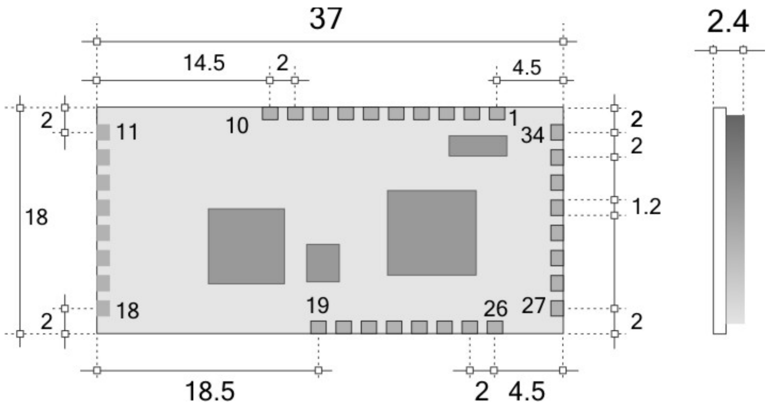
Technical Characteristics

	Min.	Typ.	Max.	Unit
DC Levels				
Supply voltage pin 1,15.	2.4	3.3	3.6	V
Current consumption (rx mode)		17		mA
Current consumption (tx mode @ +20 dBm)	90	110	150	mA
Current consumption (sleep mode)		1	2	µA
High level voltage in input/output	0.7xVcc		Vcc	V
Low level voltage in input/output	0		0.3xVcc	V
RF TX				
Band		869,4÷869,65		MHz
Emitted power	5	10	20	dBm
Modulation		LORA™		
Larghezza canale -3dB		20.8		KHz
Larghezza canale -3dB		62.5		KHz
Larghezza canale -3dB		125		KHz
Spurious emissions < 1GHz			-36	dBm
Spurious emissions > 1GHz			-30	dBm
Power on adjacent channel in TX (note 2)			50	nW
Pin 14 ESD protection on contact (61000-4-2)		8		KV
RF RX				
Sensitivity in RX, 125 KHz band (SF:6-10-12)	-118	-132	-137	dBm
Sensitivity in RX, 62,5 KHz band (SF:6-10-12)	-121	-135	-140	dBm
Sensitivity in RX, 20,8 KHz band (SF:6-10-12)	-127	-140	-144	dBm
RF band		6		MHz
Adjacent channel selectivity (note 3)		50		dB
Adjacent channel saturation (note 4)		≥87		dB
Blocking test at ±2MHz (note 5)	85		90	dB
Blocking test at ±10MHz (note 5)	85		94	dB
Performance				
Spreading Factor	6	10	12	
Coding Rate	4/5		4/8	
UART data rate (note 1)	9600	19200	115200	bps
Package size	1		248	Byte
Outdoor range		15000		m
Channels	1		7	n°
Channel space with 20,8KHz BW		25		kHz
Timing				

PWRDN → RX_NORMAL			1.5	ms
RX_NORMAL → PWRDN			1.5	ms
TX_NORMAL → RX_NORMAL	Vedi : EQ1, EQ2 , EQ3, Fig4			
RX NORMAL → TX_NORMAL	Vedi : EQ1, EQ2 , EQ3, Fig4			
Default value				
Channel		(CN2) 869,5		MHz
Emitted power (tx)		20		dBm
UART data rate (only for data)		115200		Bps
Bandwidth		62,5		KHz
Spreading Factor		8		

Note l: UART data is meant 8,n,1. UART Speed (command S8) is related to data comunication. For command mode communication this set up is not has no effect and it works basically @9600bps
Note2: Test carried out according to method described in ETSI EN 300 220-1 V2.4.1 paragraph 7.6
Note3: Test carried out according to method described in ETSI EN 300 220-1 V2.4.1 paragraph 8.3
Note4: Test carried out according to method described in ETSI EN 300 220-1 V2.4.1 paragraph 8.3.4
Note5: Test carried out according to method described in ETSI EN 300 220-1 V2.4.1 paragraph 8.4

Pin out description



Picture 1: module pin-out and mechanical drowing

PIN-OUT:

1) GND
2) GND
3) GND
4) AN0(NI)
5) AN1(NI)
6) AN2(NI)
7) GND
8) RESET
9) RESERVED
10) +Vcc
11) GND RF
12) GND RF
13) GND RF
14) ANTENNA
15) GND RF
16) GND RF
17) GND RF
18) GND RF
19) RTS
20) CTS
21) RX_UART
22) TX_UART
23) IN4(NI)
24) IN3(NI)
25) IN2(NI)
26) IN1(NI)
27) GND
28) SET_C
29) SET_B
30) SET_A
31) GND
32) OUT2
33) OUT1
34) GND

*NI:not implemented

N° Pin	Nome	Descrizione
1	**GND**	Ground connection
2	**GND**	Ground connection
3	**GND**	Ground connection
4	**AN0**	Analog input (ADC cyclical mode)
5	**AN1**	Analog input (ADC cyclical mode)
6	**AN2**	Analog input (ADC cyclical mode)
7	**GND**	Ground connection
8	**RESET**	Reset of the module
9	**RESERVED**	Not to be connected
10	**+Vcc**	Regulated supply voltage 3,3V-500mA. Connect a capacitor 10-100uF very close to the pin and GND.
11	**GND RF**	Ground connection
12	**GND RF**	Ground connection
13	**GND RF**	Ground connection
14	**ANTENNA**	50 ohm impedance for antenna
15	**GND RF**	Ground connection
16	**GND RF**	Ground connection
17	**GND RF**	Ground connection
18	**GND RF**	Ground connection
19	**RTS**	Request to send. Output goes high when UART buffer is full or during filling/emptying from radio FIFO. Output goes low when ready to receive data from UART port.
20	**CTS**	Clear to send. Input (not implemented)
21	**RX_UART**	UART input in TTL levels, 1 start bit (0V), 8 data bit e 1 stop bit (3V). Input must be driven in high level logic (3V)
22	**TX_UART**	UART output in TTL levels, 1 start bit (0V), 8 data bit e 1 stop bit (3V). Input must be driven in high level logic (3V)
23	**IN4**	Digital input, non implemented yet
24	**IN3**	Digital input, non implemented yet
25	**IN2**	Digital input, non implemented yet
26	**IN1**	Digital input, non implemented yet
27	**GND**	Ground connection
28	**SET_C**	Set operation mode
29	**SET_B**	Set operation mode
30	**SET_A**	Set operation mode
31	**GND**	Ground connection
32	**OUT2**	Digital output. High when transmit or in test mode receives PONG
33	**OUT1**	Digital output. High when transmit or in test mode receives PING
34	**GND**	Ground connection

Tab1: Pin description

LoRa Modulation:

The RF modulator and demodulator uses the spread spectrum radio technique and it's possible to set Chip/Symbol ratio from 128 to 4096, depending on RF sensitivity and flying time desired.
Improvement of sensitivity is outstanding compared to standard FSK modulation technique: 7,5 dB with 128 Chip/Symbol value and 20 dB with 4096 Chip/Symbol value.
Furthermore it is granted a general improvement of interference immunity, adjacent channel immunity and blocking tests compared to FSK demodulator.
The tables here below show how to properly set modulation parameters depending on sensitivity and flying time desired.
In order to be understood, flying time means the radio channel occupation for data package made of a 8 bytes preamble + 8 bytes payload + CRC.

Bandwidth 125KHz		
Spreading Factor	**Sensitivity (dBm)**	**Flying time (ms)**
6	-118	20
7	-123	41
8	-126	82
9	-129	144
10	-131	287
11	-134	495
12	-137	990

Bandwidth 62,5KHz		
Spreading Factor	**Sensitivity (dBm)**	**Flying time (ms)**
6	-121	41
7	-126	82
8	-129	164
9	-132	288
10	-135	577
11	-137	990
12	-140	1980

Bandwidth 20,8KHz		
Spreading Factor	**Sensitivity (dBm)**	**Flying time (ms)**
6	-127	124
7	-130	246
8	-134	492
9	-137	862
10	-140	1730
11	-142	2960
12	-145	5940

As you can see sensitivity increases as far as SF value increases and data rate decreases as far as SF increases and Bandwidth decreases.

Parameters choice have to be made by assessing at first the bandwidth: if more channels are requested it's mandatory to choose 20,8 KHz BW, otherwise, 62,5 or 125 KHz BW.
In this case SF value equals to 8-10 is the best trade-off between RF sensitivity and flying time.
Very often in radio control applications, payload is not more than 8-10 bytes and 0,5 sec is a reasonable time for transmission and feedback (ACK) reception.

Here below the calculation equations of flight times for packet radio with payloads greater than 8Bytes:

$$Tsym = \left(\frac{2^{SF}}{BW} \right) \qquad \textbf{EQ1}$$

Tsym: duration of a symbol in seconds
SF: Spreading Factor from 6 to 12
BW: banda del canale radio in Hz (registro S2)

$$PayloadsymbNb = 8 + \left\{ ceiling \left[\left[\frac{(8 \times nBytePL) - (4 \times SF) + 44}{4 \times (SF - 2)} \right] \right] \times (CR + 4) \right\} \qquad \textbf{EQ2}$$

PayloadsymbNb: Payload symbol quantity
nBytePL: Payload byte quantity
CR: coding rate from 1 to 4 (register S6)

$$Tpachet = (PayloadsymbNb + 12{,}25) \times Tsym \qquad \textbf{EQ3}$$

Tpachet: data packet total timing in seconds
12,25: Simbols quantity used on preamble

From Aurel website you can download an Excel spreadsheet that automatically calculates the flight time radio according to selected parameters.

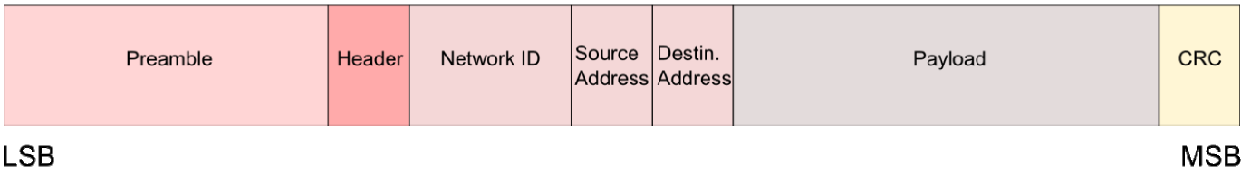
Data packet frame:

XTR-8LR100 is a radio modem working in packet mode and handling addresses for point-to-multipoint networks.
Packet has a 255 bytes max length, where 247 bytes are the payload and 8 the addresses.
It's made up of:

- Preamble: it comprises 8 bytes of variable length depending on data rate, used for synchronization purposes.
- Header: it comprises information related to the payload lengths, Code Rate, and CRC presence of payload 16 bit
- Network_ID: every module has got a 4 bytes network ID, editable via AT command. (It's present only in net modality S10=1)

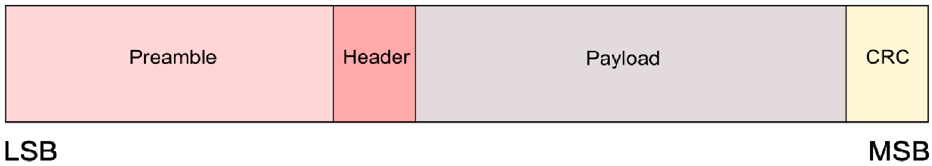
- Sourse Address: Module or Node address from sicht the data packet starts (sender), composed by 2 bytes for a maximum node capability of 65536 nodes each net editable via AT command. (It's present only in net modality **S10=1**)
- Destination Address: 2 bytes destination node address. This address can be changed via AT command. It must be forwarded on serial port before the payload.
  The address 0xFFFF (default) means a broadcasting message: in this case every node joining the network (same network_ID) receives the message (It's present only in net modality **S10=1**)
- Payload: from 1 to 247 bytes. When received, the message is forwarded to UART output only in case Network_ID and Destination address are corresponding, otherwise it's eliminated. In case of transmission, data coming from UART port are included in payload field.
- Payload CRC: checksum 2 Bytes

In normal TX and RX operations, it is mandatory to set up the 2 addresses needed for network functionality in command mode, then move to NORMAL mode and send/receive data (payload) via UART port. To transmit a radio data packet, user must sent on UART the Destination Address before the payload. Data are not yet encryped.



Picture 2: Data radio packet frame in NORMAL Mode with addressing

In NORMAL mode no network (register **S10=0**) fields NETWORK ID, SOURCE ID e DESTINATION ADDRESS will not present on radio protocol and 255 bytes payload will be at disposal



Picture 3: Data radio packet frame in NORMAL Mode no network

Note: By selecting spreading factor 6, the Header field is excluded. The payload must be length 15 Byte. This method is expected to LORA modulation in order to limit flight time and duty-cycle transmission .
Payload of different length of 15 Byte, will be transmitted but rejected by the receiving unit.

Operation modes:

Device works in 7 states operation modes:

1. **SLEEP**
2. **COMMAND MODE**
3. **NORMAL**
4. **TX WAKE UP**
5. **RX WAKE UP**
6. **TX ADC WAKE UP**
7. **TEST MODE**

1. Sleep

When SET_A, SET_B, SET_C inputs are floating or high level, module enters automatically in sleep state: radio and microcontroller chips are in low power state.
It' only allowed the activation of command mode (++++) via UART port.

2. Command Mode

Command mode allows the user to set up operating parameters.
Configuration occurs via AT commands sent to RX_UART (pin.21) with 9600 bps data rate. Likewise return values are received from TX_UART (pin.22).
To enter the command mode, the sleep mode, only possible from sleep mode, you need to send on line RX_UART a sequence of four ASCII characters '+' consecutive (++++).
In order to execute it, it's recommended to use the RS232 or USB port of PC (pay attention to convert phisical levels to 0-3V), connect TX and RX while RTS and CTs are not handled in command mode. Use a program for serial port communication, like Hyperterminal, RealTerm or similar ones, by setting these parameters: data rate: 9600 bps, one start bit, 8 data bit, 1 stop bit, no parity, select CR and LF
Send from PC the sequence ++++. If the return value is **COMMAND-MODE** then communication is ok.
When the device is in command mode, it can't send/receive any data to/from/ RF.
In command mode the UART data rate is fixed at 9600 bps and any change to S8 register can't affect data rate in command mode.
Note: in Command-Mode insert as a command terminal CR(carriage return) and LF(line feed) and transmit each byte with a maximum delay of 2msec from the previous one.

How to quit from COMMAND MODE

After 2 minute from last command sent, module automatically switches to sleep mode. Otherwise, in order to force the exit, send **ATCC** command: if everything is right you'll get a **OK** as confirmation.

AT command list:

Commands allow to write and read registers which set the way the module operates.
Configuration registers reading and writing occurs by sending the sequence **AT** followed by command or register name, according to the standard of PSTN modems.
Below are listed the list of available commands, for their use follow the examples of writing and reading of the registers on the next page. Writing or reading of registers not included in the table will return the answer **NO ACCESS**.

AT	COMMAND	<CR> <LF>
Uppercase characters that come before a command or a register	Commands are codes including one or more characters	Command ends always with <CR> Carriage Return <LF> line feed

<table>
<tr><th>Register</th><th>Name</th><th>Function</th><th colspan="3">Values</th></tr>
<tr><td>S0
r</td><td>HW/FW Version</td><td>It mean the radio module version HW and FW</td><td colspan="3">Byte High = HW Version
Byte Low = FW Version</td></tr>
<tr><td>S1
r/w</td><td>BAND</td><td>Operating band frequency</td><td colspan="3">0= 868 – 868,6MHz (NI, available in other versions)
1= 869,4 – 869,65MHz (default)</td></tr>
<tr><td>S2
r/w</td><td>BANDWIDTH</td><td>RF channel bandwidth</td><td colspan="3">0 = 20,8 KHz
1 = 62,5 KHz (default)
2 = 125 KHz</td></tr>
<tr><td rowspan="8">S3
r/w
(note 2)</td><td rowspan="8">CHANNEL</td><td rowspan="8">Operating radio channel

To apply with limits imposed by EN300 220 normative, channeling is viable only with BW 20,8 KHz; for the others BW (62,5 KHz e 125 KHz) setting of channel is useless and module will work only on default channel</td><td>BW 20,8KHz</td><td>62,5KHz</td><td>125KHz</td></tr>
<tr><td>0= 869,45MHz</td><td>NI</td><td>NI</td></tr>
<tr><td>1= 869,475MHz</td><td>NI</td><td>NI</td></tr>
<tr><td>2= 869,5MHz (default)</td><td>default</td><td>default</td></tr>
<tr><td>3= 869,525MHz</td><td>NI</td><td>NI</td></tr>
<tr><td>4= 869,55MHz</td><td>NI</td><td>NI</td></tr>
<tr><td>5= 869,575MHz</td><td>NI</td><td>NI</td></tr>
<tr><td>6= 869,6MHz</td><td>NI</td><td>NI</td></tr>
<tr><td>S4
r/w</td><td>POWER</td><td>RF power emitted in antenna</td><td colspan="3">0 = +5dBm
1 = +10dBm
2 = +20dBm (default)</td></tr>
<tr><td>S5
r/w</td><td>SPREADING FACTOR</td><td>Spreading factor</td><td colspan="3">6 = 64 (chip/symbol)
7 = 128
8 = 256 (default)
9 = 512
10 = 1024
11 = 2048
12 = 4096</td></tr>
</table>

S6 r/w	**ERROR CODING**	Error recovery	**1** = 4/5 (default) **2** = 4/6 **3** = 4/7 **4** = 4/8
S7 r/w	**RSSI ENABLE**	Adds in rear of payload the RRSI value (2 bytes in 2's complement format)	**0** = No RSSI (default) **1** = RSSI queued to payload
S8 r/w (note 3)	**UART BPS**	UART data rate (speed data communication only)	**0** = 9.600 bps **1** = 19.200 bps **2** = 115.200 bps (default)
S10 r/w	**NETWORK ENABLE**	Adds on top of payload, the ID network and Source address	**0** = No network (default) **1** = network
S11 r/w	**NETWORK ID**	It sets the device network address (4 bytes)	**Min** = 00000001 (default) **Max** = FFFFFFFF
S12 r/w	**SOURCE ADDRESS**	It sets the device ID or sender (2 bytes)start address message	**Min** = 0001 (default) **Max** = FFFF (broadcast)
S20 r/w	**RX CYCLIC TIME**	It sets the wake up time interval from 2 cyclic receptions from 10ms to 6000ms with steps of 1ms	**Min** = 10 ms **Max** = 6.000 ms **Default** = 100 ms (default)
S30 r/w	**ADC TX TIME**	It sets the wake up time interval from 2 cyclic trasmissions Impostazione dell'intervallo di risveglio tra 2 trasmissioni cicliche from 1s to 65536s with steps of 1s. Addressing is activated by default	**Min** = 1 s **Max** = 65.535 s **Default** = 10 s
S90 r	**REGISTERS STATUS**	Registers value restores	**S1** = x (x = value restored) **S2** = x **S3** = x …. **Sn** = x
S91 r/w	**DEFAULT VALUES**	Setted at 1 it stores on register the default values If a register is amended, it returns the value "0", different registers by default.	**0** = Modified values (r) **1** = Default values (r/w)
S92 r/w	**RADIO TEST_MODE**	Ping-Pong radio test mode	**0** = Off **1** = On Tx Master **2** = On Rx Slave

(note 1) NI means not implemented yet. Command execution doesn't have any effect.
(note 2) To apply with limits imposed by EN300 220 normative, channeling is viable only with BW 20,8 KHz; for the others BW (62,5 KHz e 125 KHz) setting of channel is useless and module will work only on default channel
(note 3) UART data rate setting (command S8), refers exclusively to data communication. In command mode this setting has no effect and it will work onlt at 9600 bps.

Command	Name	Feature
WR	**WRITE**	Write registers value to EEPROM
CC	**COMMAND CLOSE**	Command Mode exit
Sx	**REGISTER NAME**	Register ID to be read or write

Tab. 2: command

Return values to commands and operations on registers

Positive return: **OK*<CR><LF>***

Negative return: **ERROR*<CR><LF>***

Forbidden operation: **NO ACCESS*<CR><LF>***

Command mode exit **EXIT*<CR><LF>***

<CR> Carriage Return, ASCII character 13; <LF> Line Feed, ASCII character 10; <bl> ASCII character 32.

Readout of a register

Syntax: **ATSx*<CR><LF>*** [x = 1, ...,99 register to be read]

Return : value stored in the register if the command sintax is correct followed by <CR><LF>.

Register value is given digit after digit as ASCII characters.

Example: ‘16’ is given as the sequence of ASCII characters 0x31,0x36, corresponding to digit ‘1’ and ‘6’. Same procedure must be applied in case of writing a new value in a register.

Writing of a register

Syntax: **ATSx=Y*<CR><LF>*** [x = 2, 3, 4 register to write on, y = value to add]

Return: as described in 'Return values'

All values stored in the registers will be lost when the module is turned off, unless the changes are saved in microcontroller EEPROM memory by means of the specific command ATWR: in this case the saved values will be active even if the module is turned off and then on.

Command to save registers value in EEPROM

Syntax: **ATWR*<CR><LF>***
Return: as described in 'Return values'

Command to quit command mode

Syntax: **ATCC*<CR><LF>***
Return: as described in 'Return values'

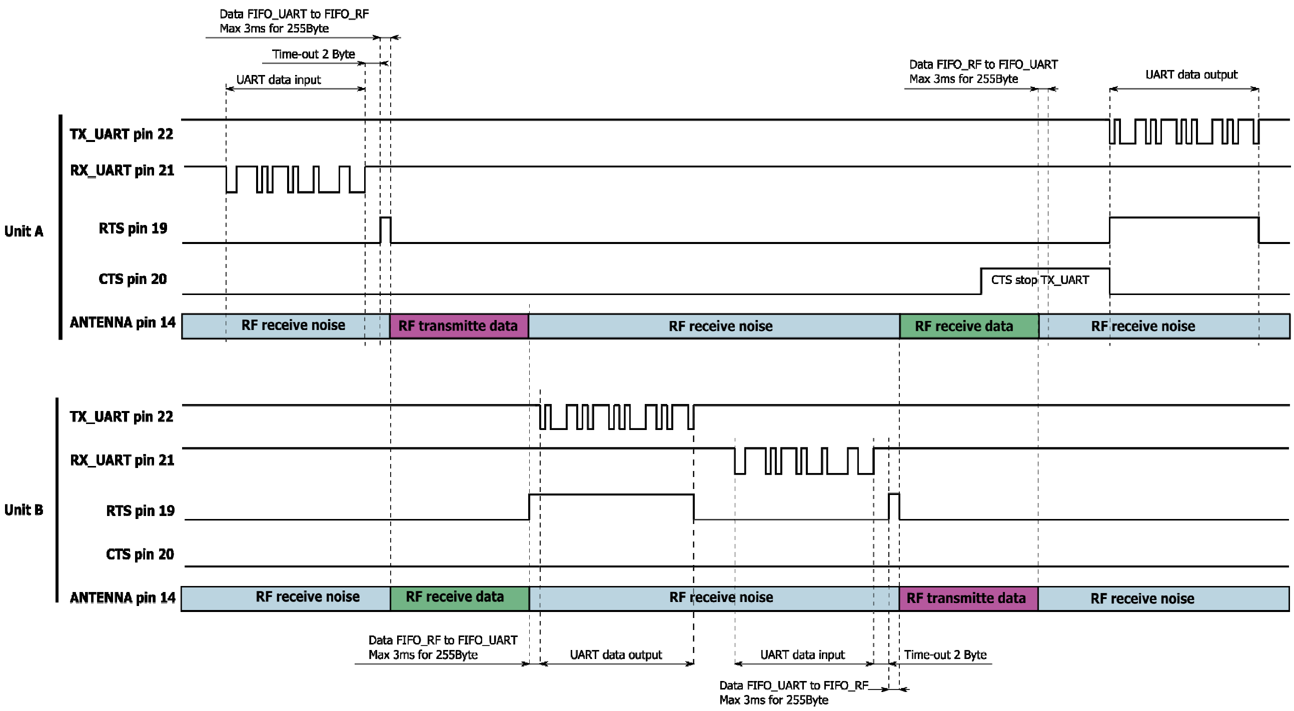
Command mode exit occurs, even without ATCC command, automatically after 2 minuts of idle state, or after the command ATWR

3. NORMAL

Enabled by resetting (closing the jumper) SET_A input and setting (or leaving floating) SET_B and SET_C. Radio chip and microcontroller are ON: transceiver can receive data from RF and/or from UART port. Therefore in this state the transceiver is in receiver mode (OUT2 = high, OUT1 = low) and switches to transmission mode (OUT2 = low, OUT1 = high) only if a packet comes from UART port. When a start bit (low logic level, 0V) and a valid payload packet following (at least 1 byte) is detected on RX_UART (pin.21) input , transceivers moves to transmission mode. The way the *store & Forward* mechanism works is described by couples of sequence operations:

- Store from UART on unit A /Forward to RF buffer on unit A/ RF TX unit A
- RF RX unit B/Forward to UART output on unit B [Fig. 4]

When no data are detected on pin.21 for a time longer than 2 bytes length (considered at data rate in usage), transceiver stops the storing of data coming from UART port until the packet is completely forwarded to RF buffer.
The max packet size is 247 bytes with Network Mode enabled (register **S10 = 1**) and 255 byte with Network Mode disabled (register **S10 = 0**)
Data are sent on air only when the UART storage phase is over. Microcontroller checks the incoming packets from radio receiver and enables forwarding to UART output port only in case of valid packets (corrupted packets are eliminated).
RTS line is helpful to monitor UART buffer status: it's normally low level and goes high when buffer is full or during emptying of UART buffer towards radio buffer, or when data are sent on TX_UART (pin.22)
The following diagram explains how RX, TX and RTS and CTS UART lines work:



Picture 4: Data transmission from unit A → B, and transmission of ACK from unit B → A

As shown in picture 4, the time interval from start where data is present on pin 21 in unit A (RX_UART), to when it forwarded to pin 22 (TX_UART) of unit B, is strictly depending on payload size and UART data rate of both modules. CTS in high logic level forbids to XTR-8LR100 to sent data on pin 22 (TX_UART)

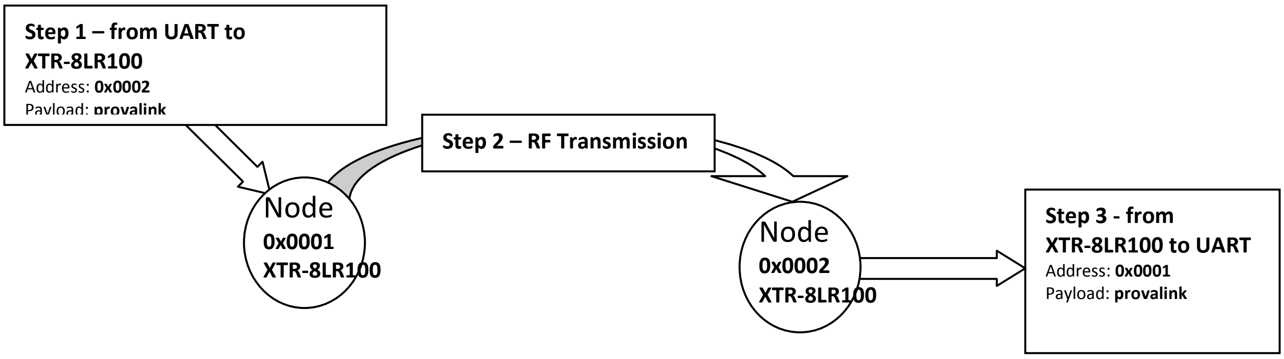
In order to grant a proper functionality of the transceiver, it's not allowed to overlap phases: i.e. if unit A is emptying UART buffer to radio buffer, any data incoming from UART port are lost.
Likewise unit B is not allowed to receive data from RF until the previous packet is still to be transmitted through UART port.
Furthermore consider that UART reception has priority over radio reception : when a byte is received from UART the radio reception in stopped and the device waits until the UART packet is completed. Therefore in that phase eventually radio data are lost.
In order to execute properly the exchange of packet from/to UART port, it's recommended to control the RTS line as go/stop operation signal.

<u>Using the NORMAL mode with addressing:</u>

NORMAL mode allows to work with addressing data packet, so a potential network composed by many devices permit a point-to-point communication, or point-multipoint.
From command-mode network function is achievable with **ATS10=1** register, other registers to be setted are NETWORK ID register S11 and SOURCE ADDRESS S12 (2 bytes) a unique identifier for each device.
A wireless network could be composed by 2 to 65536 devices, SOURCE ADDRESS identifies from which device the message starts, DESTINATION ADDRESS identifies who is the device to which the message is meant. From this condition the device forwards on UART the radio data packet received, but only those who have the same NETWORK ID and DESTINATION ADDRESS. When the device transmits the DESTINATION ADDRESS must be applied ever before the payload.

In case of point –multipont network, it's necessary to set up the DESTINATION ADDRESS on FFFF, then all the related devices with same NETWORK ID will receive the payload preceded by 0xFFFF.
No automatic messages ACK is provided.

As an example here below a communication between device 1 and 2 on network A for a message "provalink"



Picture 5: TX-RX diagram of "provalink" message from node 1 to node 2

Hereinafter are described necessary operations to realize the example on picture 5
From command-mode of device 1, send the following AT command string:

Commands	Answer	Note
++++<CR><LF>	OK<CR><LF>	Command-mode enters
ATS10=1<CR><LF>	OK<CR><LF>	Network mode activates
ATS11=0000000A<CR><LF>	OK<CR><LF>	Assigns network address "A"
ATS12=0001<CR><LF>	OK<CR><LF>	Assigns device address "1"
ATWR<CR><LF>	OK<CR><LF>	Save and exit

Node 1 has been set in NORMAL Mode with addressing, NETWORK ID = A and SOURCE ADDRESS = 1. ATWR stores new settings on eeprom and brings back the device on SLEEP

From command-mode of device 2, send the following AT command string:

Commands	Answer	Note
++++<CR><LF>	OK<CR><LF>	Command-mode enters
ATS10=1<CR><LF>	OK<CR><LF>	Network mode activates
ATS11=0000000A<CR><LF>	OK<CR><LF>	Assigns network address "A"
ATS12=0002<CR><LF>	OK<CR><LF>	Assigns device address "2"
ATWR<CR><LF>	OK<CR><LF>	Save and exit

As per node 1 Commands string is repeated excluding command ATS12 that assigns device address SORUCE ADDRESS = 2
Close SET_A to GND (normal Mode) on both devices and forwards on RX_UART line of device 1 string "\x0 \x2 provalink" (1).
Device 1 sends the message via radio.

Only the device called “2” will forward on its own TX_UART line “01provalink” message
Same as mentioned in the above example, addressing method is obtained placing ahead to the payload, in this case “provalink” the receiver address; listening device 2 receive the payload preceded by the address of the sender "\ x0 \ x1 provalink" (1).

(1): Correct syntax to PC realterm terminal. Network address is write in “hex” and “provalink” message in ASCII. Different programs used from Realterm could require different syntax. For more information related to Realterm using please look at the DEMO BOARD_XTR_8LR100 user manual

4. TX Wake up

Same as the NORMAL mode but with a data packet RF completed by a long preamble settable from command **ATS20=X** (X is value from 10 to 6000 ms) in order to allow the wake up and the receiving from RX WAKE UP mode devices.
This function is viable connecting input SET_B to GND and left open or connected to +V SET_A and SET_C
In Complementary mode to use with the 'Tx Cyclic ie the' Rx Cyclical, the S20 register with the same value is recommended to set.

NOTE: RX WAKE UP and TX WAKE UP do not provide the transmission of ACK automatically. It is possible deploy and ACK from the user side

5. RX Wake up

It comes in RX wake up when connecting inputs SET_A and SET_B to GND and keep open or connected to +V SET_C line. RX wake up is useful for low consumption applications where an auto awakening is required, allowing to choose the on-off loop fit for wanted consumption.
Device is normally in sleep mode with average consumption of 1uA, and command ATS20=X (where X is ms from 10 to 6000 in steps of 1ms) permits to drive the setting. When the time S20 is over, it comes in RX searching for a valid preamble, in order to complete the data packet receiving and repeat the cycle. If RX does not found a valid preamble, it remains on RX for 3 symbols and when they expire, goes back to sleep.
RX ON status time out it is a variable purpose of Spreading Factor (SF) and bandwidth computable as follow:

$$Ton(RX) = 3 \times \left(\frac{2^{SF}}{BW} \right) \qquad \textbf{EQ4}$$

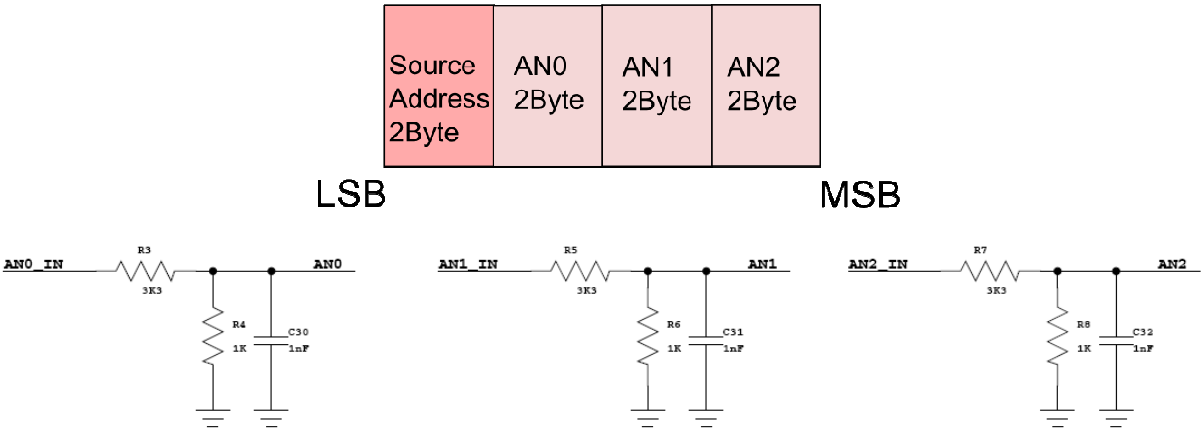
Where:

Ton(RX): Receiver turn on time MAX in seconds
SF: Spreading Factor from 6 to 12 from S5 register
BW: Bandwidth, in (Hz) from S6 register

In order to communicate with RX wake up devices is necessary use XTR-8LR100 in TX wake up mode, programmed with similar working parameters. Only in this case preamble emitted will have adequate length to be intercepted.

6. Tx ADC WAKE UP

Useful for battery powered application who permits to join up to 3 sensors to ADC inputs and and transmit the value at predetermined cycles independently without using interfaces and external intelligence.
This function is possible connecting inputs SET_A and SET_C to GND and keep open or connected to +V SET_B line. Analog inputs used are: AN0 (pin4), AN1 (pin5) e AN3 (pin6) they allows analog signals from 150mV to 4.3V±5% with 12 bit resolution. Device is normally in sleep mode, and it awake with timing fit to command **ATS30=X** (where X is in second from 1 to 65536). It read analog sensors value, transmits the value read of ADC, goes to sleep and repeat the cycle. The device operates only in network mode with broadcast destination address (all FFFF), receiver with same ID network submits on UART ADC values preceded by SOURCE ADDRESS (0xFFF), unique identifier of the source node of the message.



Picture 6: Analog imput electric diagram AN0(pin4), AN1(pin5), AN2(pin6).

7. Test Mode

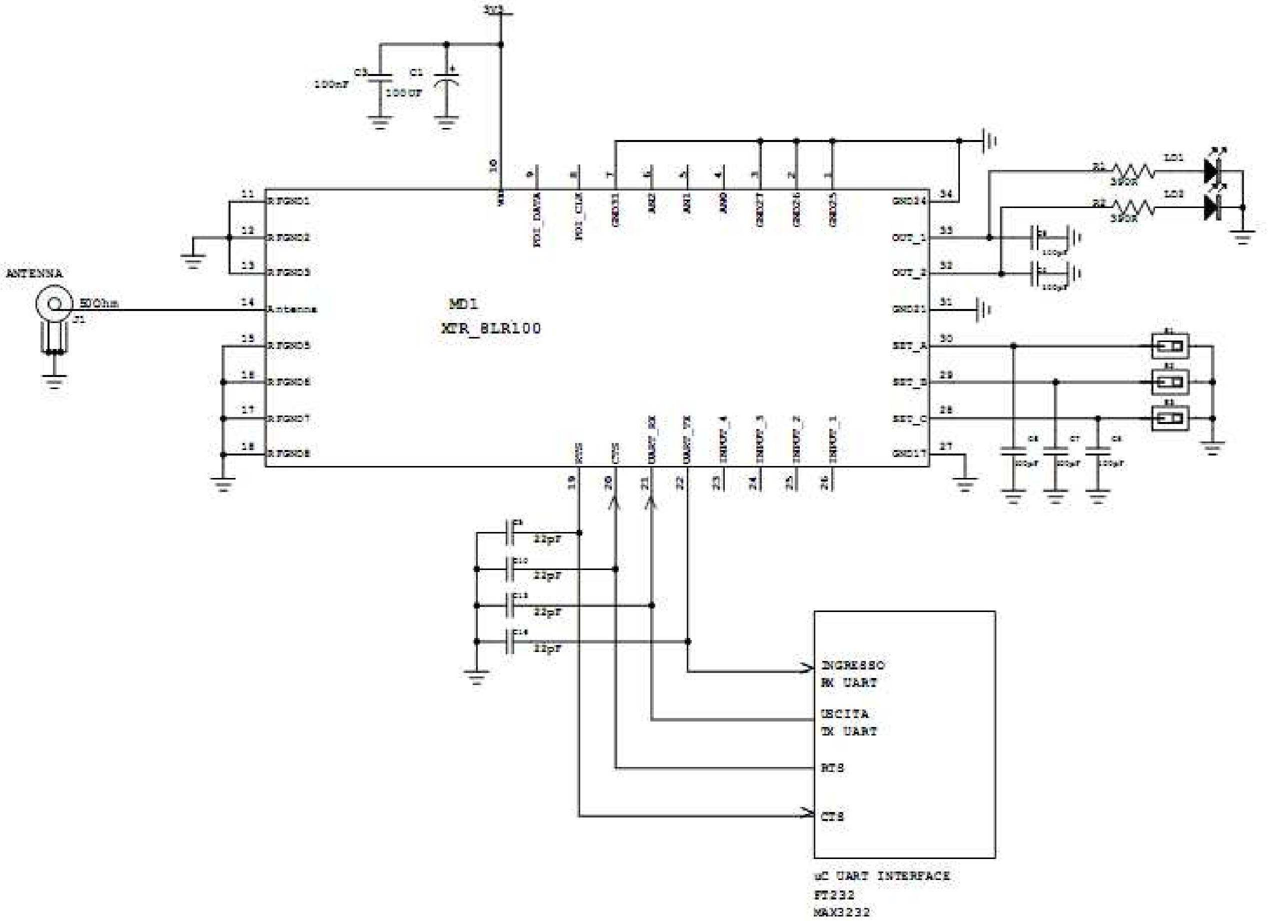
It's an operation mode which allows the user to test seamlessly the radio link performance.
It is triggered by driving input SET_C to low level and setting (or leaving floating) SET_A and SET_B pins.
This mode allows to connect two devices as Master and Slave. The former sends 12 ASCII characters “PING xxxxx\n\r” and in case the latter receives, it will answer with an ACK value of 12 ASCII characters “PONG xxxxx\n\r” (where xxxxx incremental counter sent/received packets, \n line feed, \r cariage return), communication is reported by outputs:
OUT_1 (pin 33) goes high when Master sends or Slave receive a "PING"
OUT_2 (pin 32) goes high when Master receive or Slave sends a "PONG"
The selection between Master/Slave configuration is made through ATS92 command:

0 = disabled feature
1 = module set as Master
2 = module set as Slave

When you have finished test in Test Mode before returning to work in other modes of operation, it is essential to disable the Test with the command ATS92 = 0.

Application schematic:

Module connection in NORMAL mode is very easy. The transmission signals, reception and the radio module settings, are obtained through the communication of asynchronous serial interface input output. Module works always in receive mode. Switching from RX to TX mode is triggered automatically when the first data byte comes to input pin 21 (RX_UART).



Picture 7: Application schematic

DEVICE USAGE

In order to obtain the performances described in the technical specifications and to comply with the operating conditions which characterize the Certification, the transmitter should be mounted on a printed circuit taking into account the following:

Power Supply:

1. XTR-8LR100 must be supplied from very low voltage safety source protected against the short circuits. Maximum voltage variations allowed: 2.4 ÷ 3.6 V. However it is preferable to maintain a stable voltage to a predetermined value in the range of voltage as specified above, using a voltage regulator "Fast transient response"
2. Decoupling, close to the transmitter, with a ceramic capacitor of minimum 100nF.
3. Connect electrolytic capacitor 220uF, low ESR, close to the pin 10 (+Vcc).

Pin interface:

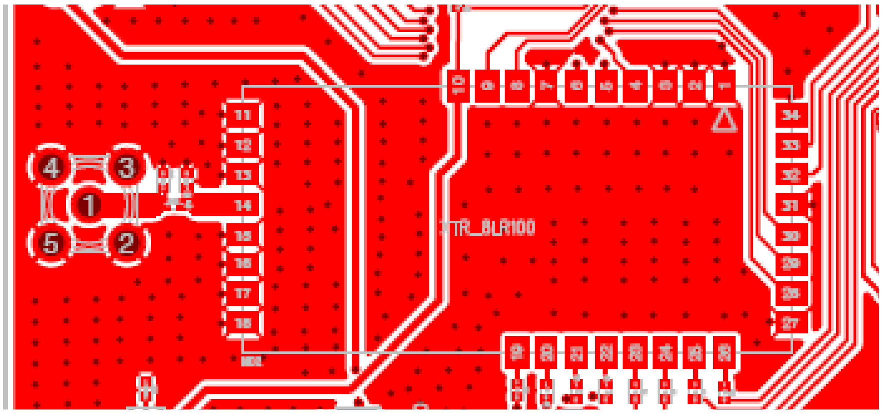
Put a capacity of 22-100pF close to the corresponding pins of signal connection, connected between them and the ground plane. The capacitance value varies according to the pin of the module, so please follow to the electrical schematic of picture 7 and the lay-out of figure 8.

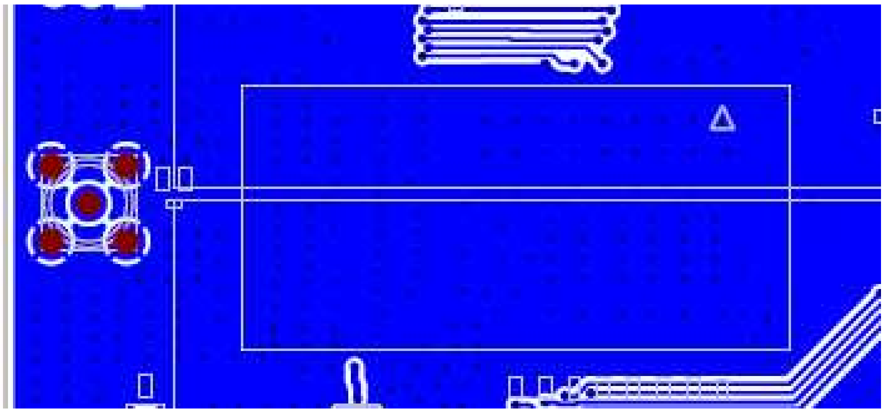
Ground:

The mass must surround at the best the welding area of the module and must also be realized in the lower face in order to obtain the optimal result, with the through holes connecting the two ground planes.

Antenna:

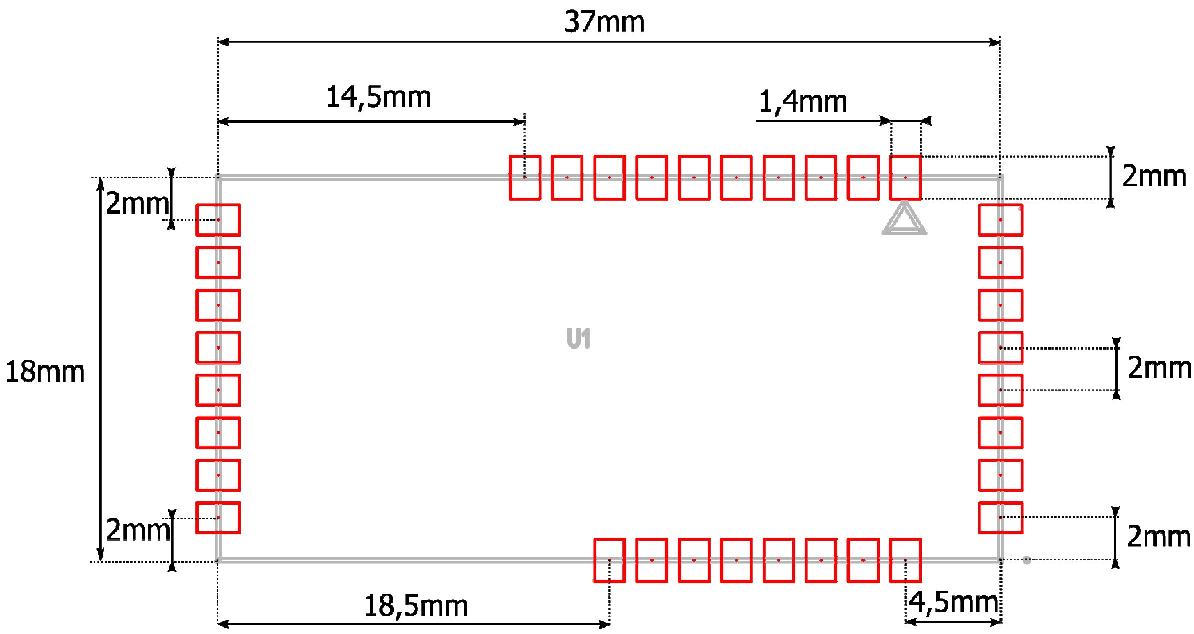
Connect pin 14 (antenna) to the coaxial connector or antenna, with microstrip constant impedance of 50 ohm, width 3.2 mm for PCB with thickness 1.6 mm and 1.6 mm for PCB with thickness 1mm (see Picture 8)
The antenna is a typical rigid copper wire (insulated or not) of 8cm length and cross-section of 0.5 mm² placed vertically to the ground plane. Other placements of antenna (bend, spiral) will work but performance are not predictable.
As an alternative to connect the module to an external antenna, connect an SMA connector into PCB using microstrip 50.
The proposed lay-out below, for example, shows the connections of signals and power supply on the top and a ground plane on the bottom side of the extended PCB that surrounds the radio module. The cross-link antenna impedance 50 ohm is 3.2 mm wide, specifically, calculated for double-sided Fr-4 epoxy glass 1.6 mm thick. The pin 10 of the power supply, it must be connected to the power supply with 2 mm wide track, and a 220uF electrolytic capacitor must be placed nearby.
The pins of the input output signals of the module are connected to ground with the ceramic capacitors from 22 to 100pF, places close by the same.





Picture 8: Example of lay-out, the connection tracks on PCB on the top side and ground plane in the button side

Soldering and assembling layout SMD



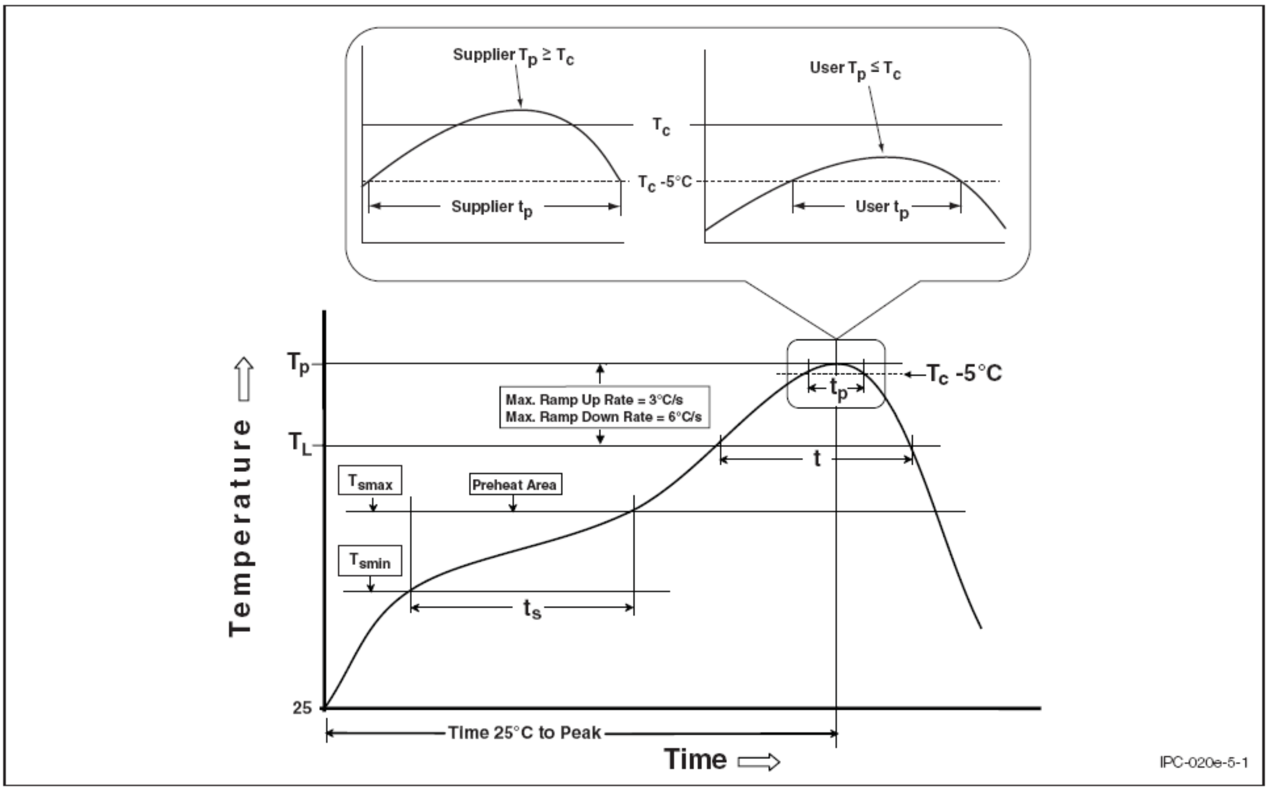
Picture 9: suggested layout for Host board

In order to ensure the correct assembly of the module you are required to apply a production process observing carefully the following recommendations:

- Soldering paste: Use soldering paste as SAC305 (96,5% Sn, 3% Ag, 0,5% Cu), screen printed according the layout of Picture 8, with a thickness> 150um.
- Assembly: the module can be assembled with automatic machine by using a suction cup tool, applied on bigger integrated circuit
- Soldering: the module can be soldered on host board, through a reflow profile for Lead-free components.
  Jedec standard “J-STD-020E”
  Lo standard Jedec “J-STD-020E” defines temperatures and exposure times, is attached below graph and profile table time / temperature recommended for the purpose.
  For host that provide more reflow cycles it is recommended to perform the soldering of the module at the end of the soldering cycle, taking care to limit excessive vibrations during the terminal phase of reflow soldering paste.

Profile Feature	Pb-Free Assembly
Preheat/Soak Temperature Min (T_{smin}) Temperature Max (T_{smax}) Time (t_s) from (T_{smin} to T_{smax})	 150 °C 200 °C 60-140 seconds
Ramp-up rate (T_L to T_p)	2 °C/second max.
Liquidous temperature (T_L) Time (t_L) maintained above T_L	217 °C 60-150 seconds
Peak package body temperature (T_p)	240°
Time (t_p)* within 5 °C of the specified classification temperature (T_c), see Figure 9.	30* seconds
Ramp-down rate (T_p to T_L)	6 °C/second max.
Time 25 °C to peak temperature	5 minutes max.
* Tolerance for peak profile temperature (T_p) is defined as a supplier minimum and a user maximum.	

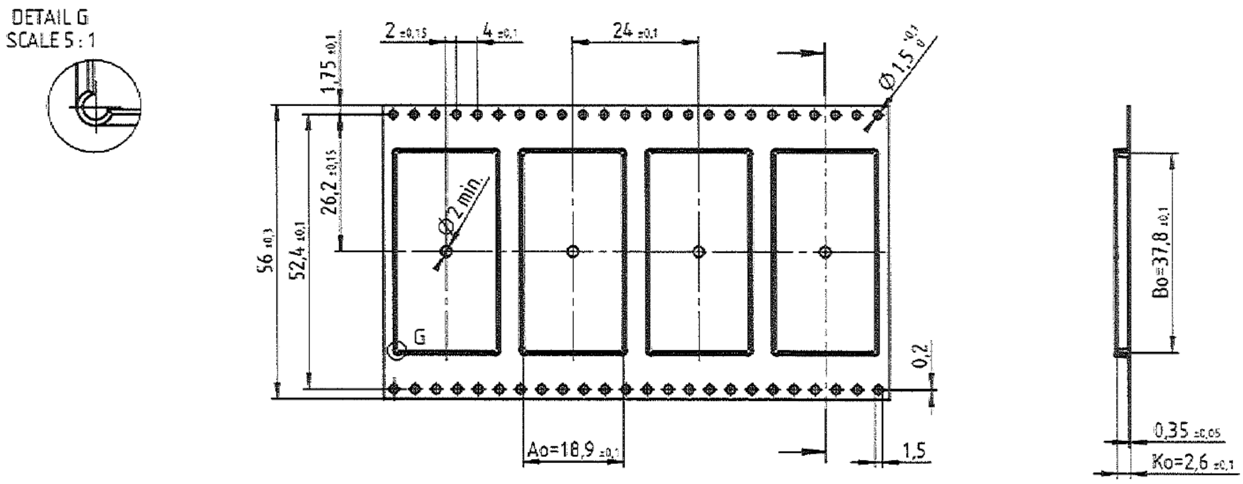
Table 3: Detailed time / temperatures profile for soldering XTR-8LR100



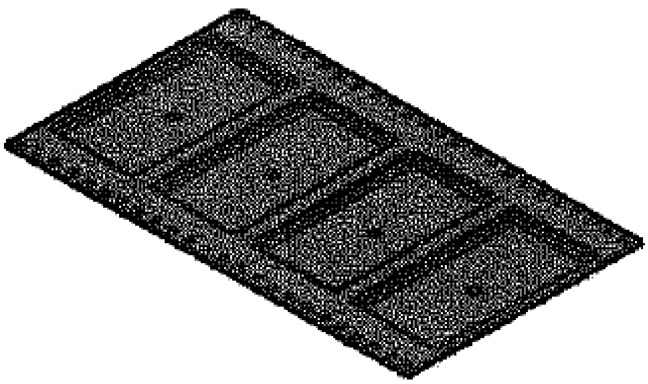
Picture 10: Soldering profile for XTR-8LR100

Specifications Packaging Tape and Reel:

XTR-8LR100 is packed in Tape and Reel composed by an embossed carrier tape and antistatic cover tape. In this way the modules are ESD protected and can be handled by machines for the automatic assembly of SMD components.



Picture 11: Tape and Reel drawing (in mm)



Picture 12: External aspect of the embossed

Reference Rules

XTR-8LR100 transceiver is compliant with the European set of rules **EN 300 220-2** and **EN 301 489-3**. Tests has been performed through transmissions of Pseudo Code Random at 500bps(CEPT 70-03).
The transceiver must be supplied by a very low voltage safety source protected against short circuits.
The usage of the transceiver is foreseen inside enclosures that assure the overcoming of the rule **EN 61000-4-2**, not directly applicable to the module itself.
This device is compliant with EN 62479, connected to the electromagnetic field human exposition, if used with temporal duty cycle not higher than 10% like foreseen in CEPT 70-03 recommendation.

CEPT 70-03

XTR-8LR100 transceiver operates in a harmonized frequency band and therefore, in order to comply with local regulations, the device must be used on the time scale with maximum duty-cycle time 10% (equivalent to 6 to 60 minutes of usage).

Version:

Release date	Revision user manual	Firmware	Changes from the previous revision
	1.0	0100	First release
11/03/2015	2.0	0107	Included fig.3,4,5,6 – AT command, Normal with address, Modality 4,5,6, EQ. Da 1 a 4,
10/07/2015	2.1	0110	Switching time included, correction specifications 8,14,15,16 Introduced paragraph welding, T&R packaging
16/05/2016	2.2	0110	Documented form of reset pin
18/05/2016	2.3	0111	Various fixes
17/10/2016	2.4	0112	Included Note about SF6 on page 7 Fixed bug reception LoRa ™
22/01/2019	2.5	0114	Various fixes

AUR°EL S.p.A. Via Foro dei Tigli, 4 - 47015 Modigliana (FC) – ITALY
Tel.: +39.0546.941124 Fax: +39.0546.941660
http://www.aurelwireless.com - email: rfcomm@aurel.it