



ASR6501 LORA COMMUNICATION SOLUTION TRAINING

ASR IoT Department, 2018.08.21

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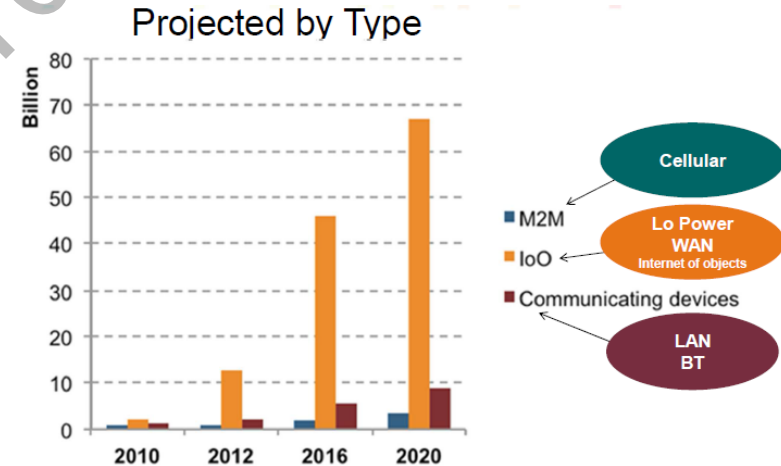
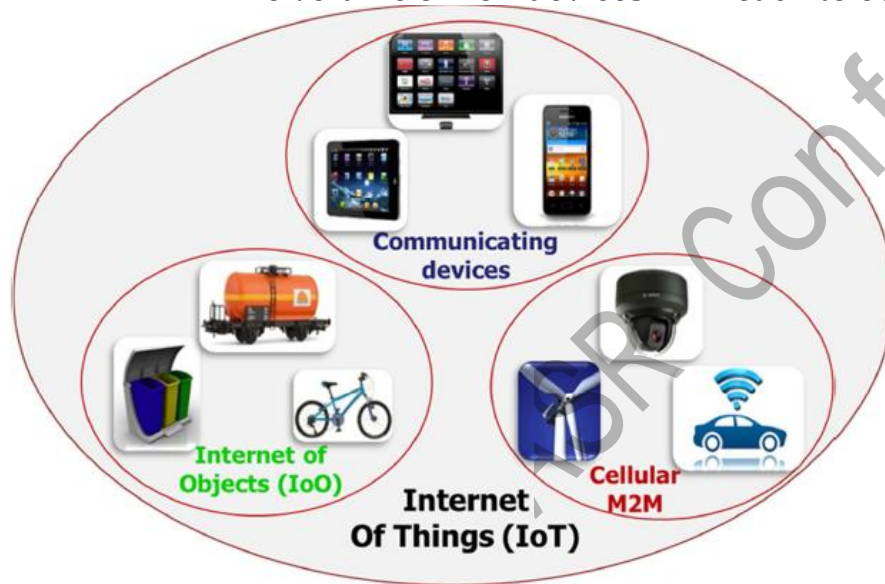
- ❑ LoRa Introduction
- ❑ LoRaWAN Introduction
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- ❑ ASR6501 EVK Introduction

LoRa Introduction

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Internet of Things (IoT)

- IoT segments including Communicating Devices, Internet of Objects (IoO) and Cellular M2M
- The volume of IoT devices will reach to over 65 billions in 2020.



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LoRa Introduction

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□ Internet of Objects (IoO)

- ▣ IoO devices Occupies 80% of volume in IoT connections.
- ▣ IoO devices will face the challenges especially low power and low cost.



Challenges in IoO:

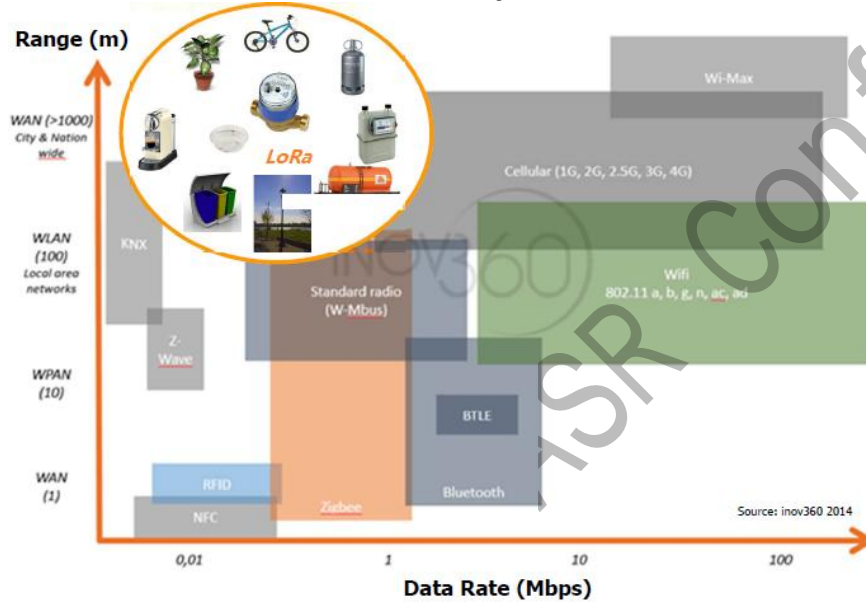
- ✓ Low cost communication
- ✓ Low cost infrastructure
- ✓ Low power technology, supplied with battery
- ✓ Permits mobility
- ✓ Outdoor & Harsh environments
- ✓ Robust communication
- ✓ Scalable system









LoRa Introduction

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LoRa communication network

- LoRa is a standard communication network for LPWAN (Low Power Wide Area Network).
- LoRa is created by Semtech and suitable for low power, long IoT network.



LAN	Lo Power WAN	Cellular
Short Range Communicating Devices	Long Range w/ Battery Internet of Objects	Long Range w/Power Traditional M2M
 	  	  
35% SOM	55% SOM	10% SOM
<ul style="list-style-type: none"> ✓ Well established standards ✓ Good for: <ul style="list-style-type: none"> • Mobile devices • In-home • Short range ❑ Not good: <ul style="list-style-type: none"> • Battery life • Long range 	<ul style="list-style-type: none"> ✓ Emerging PHY solutions / Undecided ✓ Good for: <ul style="list-style-type: none"> • Long range • Long battery • Low cost ❑ Not good: <ul style="list-style-type: none"> • High data-rate 	<ul style="list-style-type: none"> ✓ Well established standards ✓ Good for: <ul style="list-style-type: none"> • Long range • High data-rate • Coverage ❑ Not good: <ul style="list-style-type: none"> • Battery life • Cost

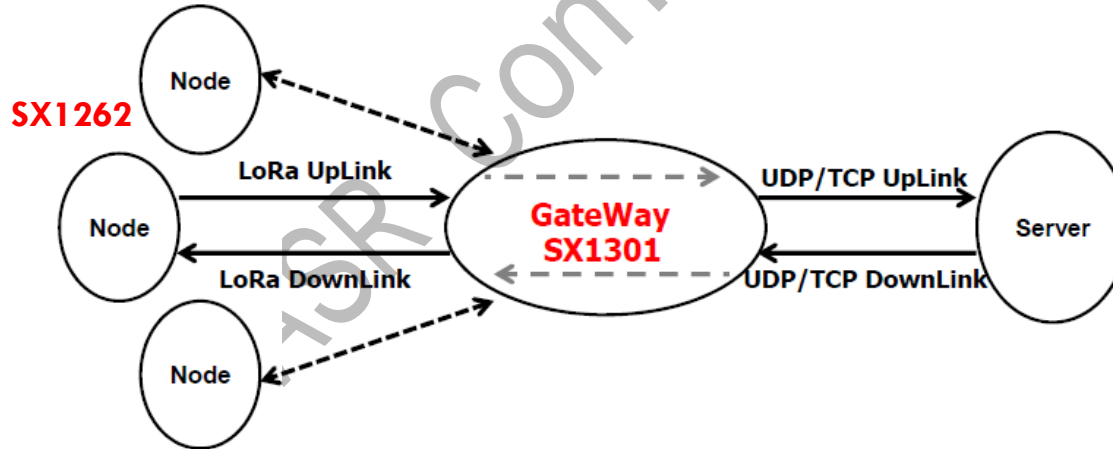
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LoRa Introduction

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LoRa communication network

- LoRa communication network includes Nodes, GateWay (Data concentrator) and Server.
- SX1276/SX1278, SX1261/SX1262 are LoRa Nodes chipsets, Sx1301 is the LoRa GateWay chipset.
- ASR provides ASR6501 chipset to help customers define LoRa Nodes.
- ASR6501 includes a SX1262 and low power MCU as a LoRa system controller.

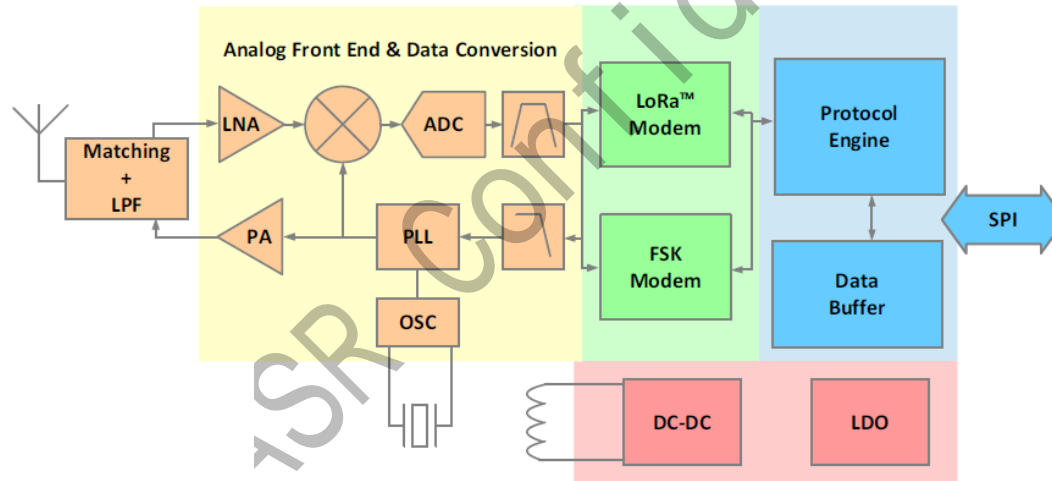


LoRa Introduction

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LoRa features

- SX1262 block diagram. A LoRa transceiver and a LoRa modem is included.
- Need a MCU to control the LoRa data transfer..



SX1261/2 Block Diagram

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LoRa Introduction

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LoRa features

- LoRa features comparison between SX1262 and SX1276 are shown in the following table.
- SX1262 which is used in ASR6501 consumes less power than SX1276.

Symbol	Conditions	SX1262	SX1276
Frequency Range		150~960MHz (All LoRa Channels Supported)	137~1020MHz (Not All LoRa Channels Supported)
Band Width	LoRa Mode	7.8k~500kHz	7.8k~500kHz
Maximum Power		22dBm	20dBm(@PA_Boosted)
Highest Sensitivity	@SF=12, BW=10.4kHz, LoRa	-148dBm	-146dBm
	@SF=12, BW=125kHz, LoRa	-137dBm	-136dBm
Data Rate	LoRa Mode	0.018kbps~62.5kbps	0.018kbps~37.5kbps
	FSK Mode	0.6kbps~300kbps	1.2kbps~300kbps
RX Current	@BW=125kHz	4.6mA	10.3mA
TX Current	@TX_Power=22dBm	107mA	120mA(@20dBm)
	@TX_Power=17dBm	75mA	87mA
DeepSleep Current	Configure not Retained	160nA	
	Configure Retained	600nA	200nA

LoRa Introduction

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□ LoRa modulation -> Why long Range?

- LoRa (Long Range) is a modulation technique that provides significantly longer range than other technologies. The modulation is based on spread-spectrum techniques and a variation of chirp spread spectrum (CSS) with integrated forward error correction (FEC).
- As Shannon's theory, the capacity of signal communication channel (or maximum data rate) is related to SNR and signal BW.
- At a fixed data rate, the larger the BW, the minimum SNR is required. Thus, the higher sensitivity and longer transmitter range will be achieved.

$$C = B * \log_2 \left(1 + \frac{S}{N} \right)$$

Equation 1

Where:

C = channel capacity (bit/s)

B = channel bandwidth (Hz)

S = average received signal power (Watts)

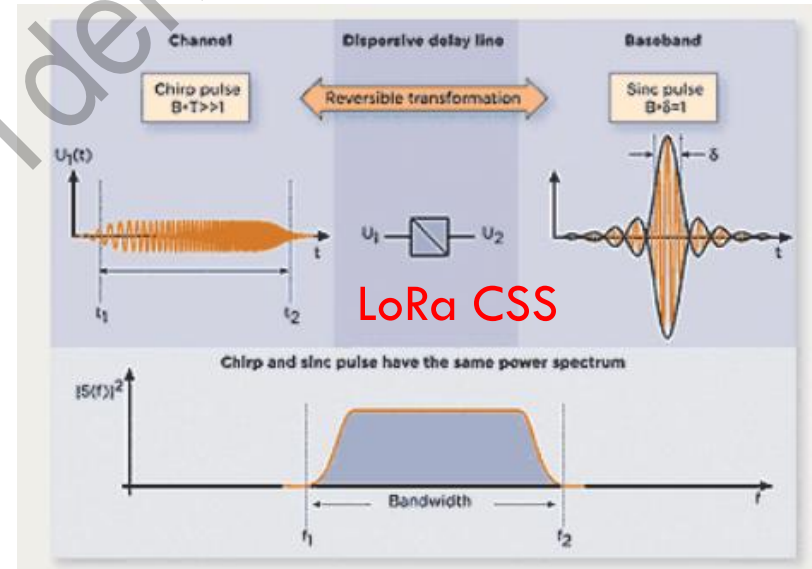
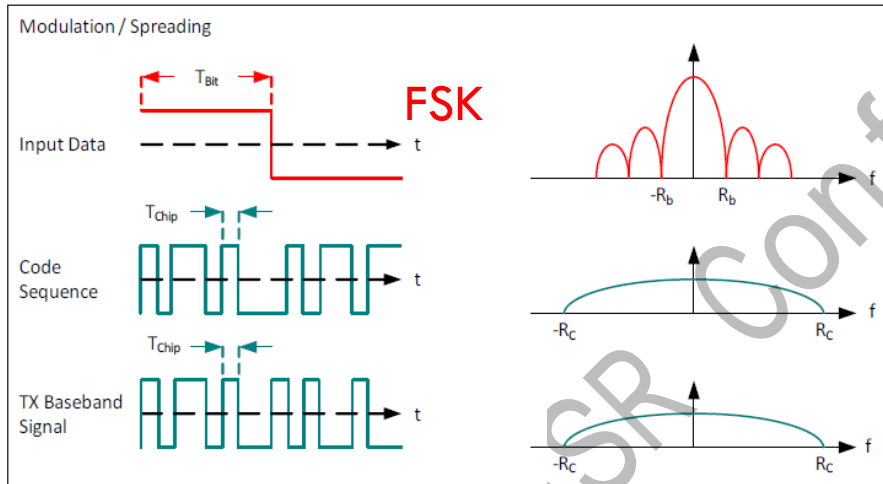
N = average noise or interference power (Watts)

S/N = signal to noise ratio (SNR) expressed as a linear power ratio

LoRa Introduction

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LoRa modulation -> LoRa vs. FSK



LoRa Introduction

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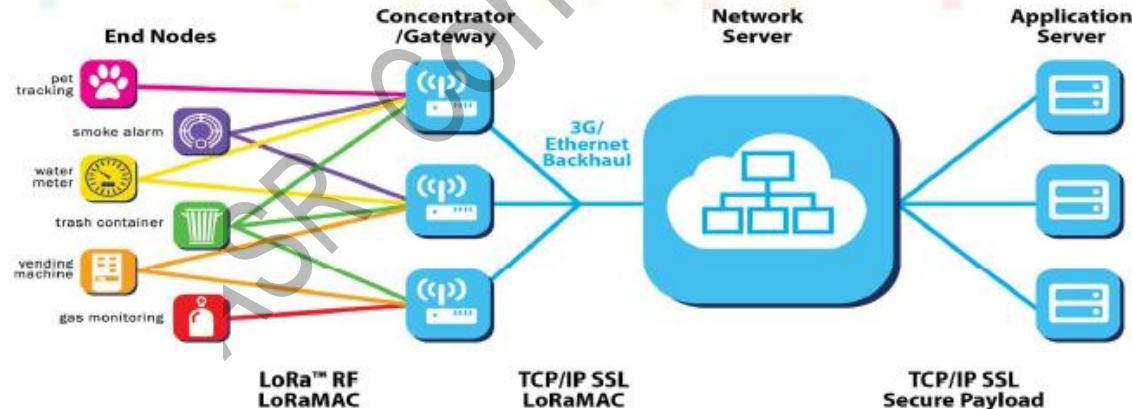
- LoRa modulation -> LoRa vs. FSK
 - ▣ Higher sensitivity than FSK. Signal which 25dBm below the noise floor can be detected.
 - ▣ Lower precision requirement for XO (TCXO for FSK), XO with 30ppm is enough for LoRa.
 - ▣ Lower Receiver current.
 - ▣ Faster preamble detection than FSK, low power in wake up sequence.
 - ▣ Higher interferer immunity.
 - ▣ Suitable for star connection network.
 - ▣ Ranging and positioning.

LoRaWAN Introduction

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LoRaWAN definition

- The LoRa modulation is the PHY, and LoRaWAN is the MAC protocol for a high capacity long range and low power star network that the LoRa Alliance is standardizing for Low Power Wide Area Networks (LPWAN).
- The LoRaWAN protocol is optimized for low cost, battery operated sensors and includes different classes of nodes to optimize the tradeoff between network latency and battery lifetime.



LoRaWAN Introduction

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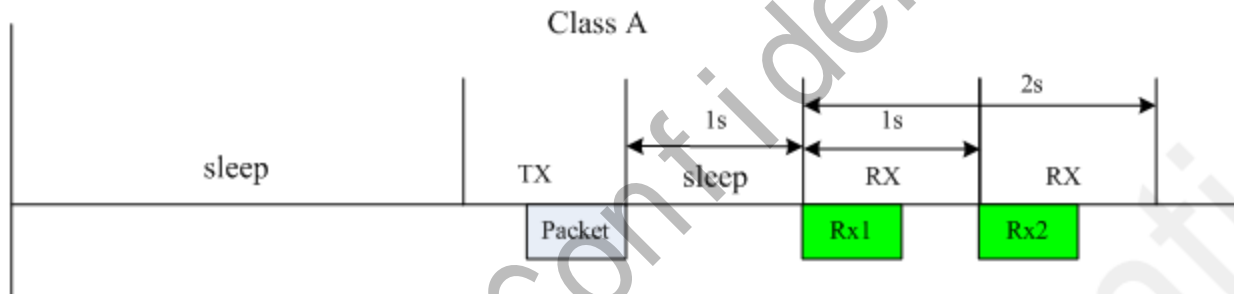
LoRaWAN Classes

Class name	Intended usage
A (« all »)	Battery powered sensors , or actuators with no latency constraint Most energy efficient communication class. Must be supported by all devices
B (« beacon »)	Battery powered actuators Energy efficient communication class for latency controlled downlink. Based on slotted communication synchronized with a network beacon.
C (« continuous »)	Mains powered actuators Devices which can afford to listen continuously. No latency for downlink communication.

LoRaWAN Introduction

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- LoRaWAN Class A -> Mostly used (up to 90%)



Class A:

1. 大部分时间都在sleep模式，唤醒的方式有两种：

a. 外部唤醒，例如IO唤醒，外设唤醒。

b. 内部定时唤醒，例如1个月唤醒1次，（水表应用），需要内部精确的低功耗时钟。

2. 在sleep模式，LoRa 全部off，MCU仅有内部32k时钟WCO和内部timming在计时，计时结束以后通过GPIO唤醒LoRa。

LoRaWAN Introduction

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LoRaWAN Class B (Beacon)



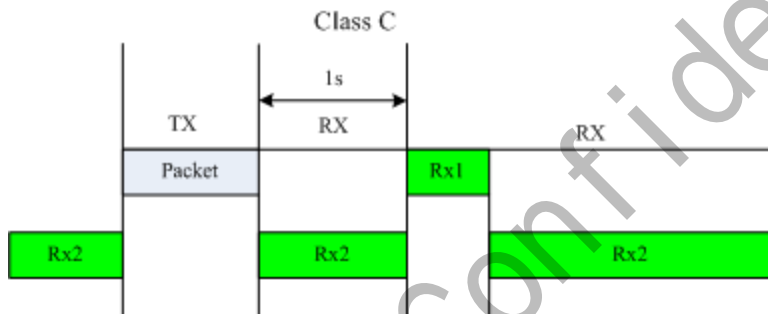
Class B:

1. End Node每128秒接收Gateway广播的Beacon，用于校准自身的时钟。
2. 在128s内，大部分时间是处于sleep模式，sleep模式需要精确的计时控制才能和128s对齐。
3. 允许有更多的接收窗口。
4. 和Class A的随机打开接收窗口不同，Class B按照既定的时间打开接收窗口。
5. Server可以精确的知道Node何时处于监听模式。

LoRaWAN Introduction

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LoRaWAN Class C (Continuous)



Class C:

1. End Node所有的时间不是在接收就是在发射，发射TX packet后，首先选择特定频率和下行通道Rx2，经过1s后再采用自己的下行通道Rx1。
2. 需要不停的在Rx-Rx2之间切换，需要精确的时钟频率，用外部WCO32k即可以实现。
3. Class C的优势是可以缩短Server和Node之间的通信延时。
4. Class C几乎是持续的接收和发射，功耗比Class A和Class B都大。

ASR6501 Introduction

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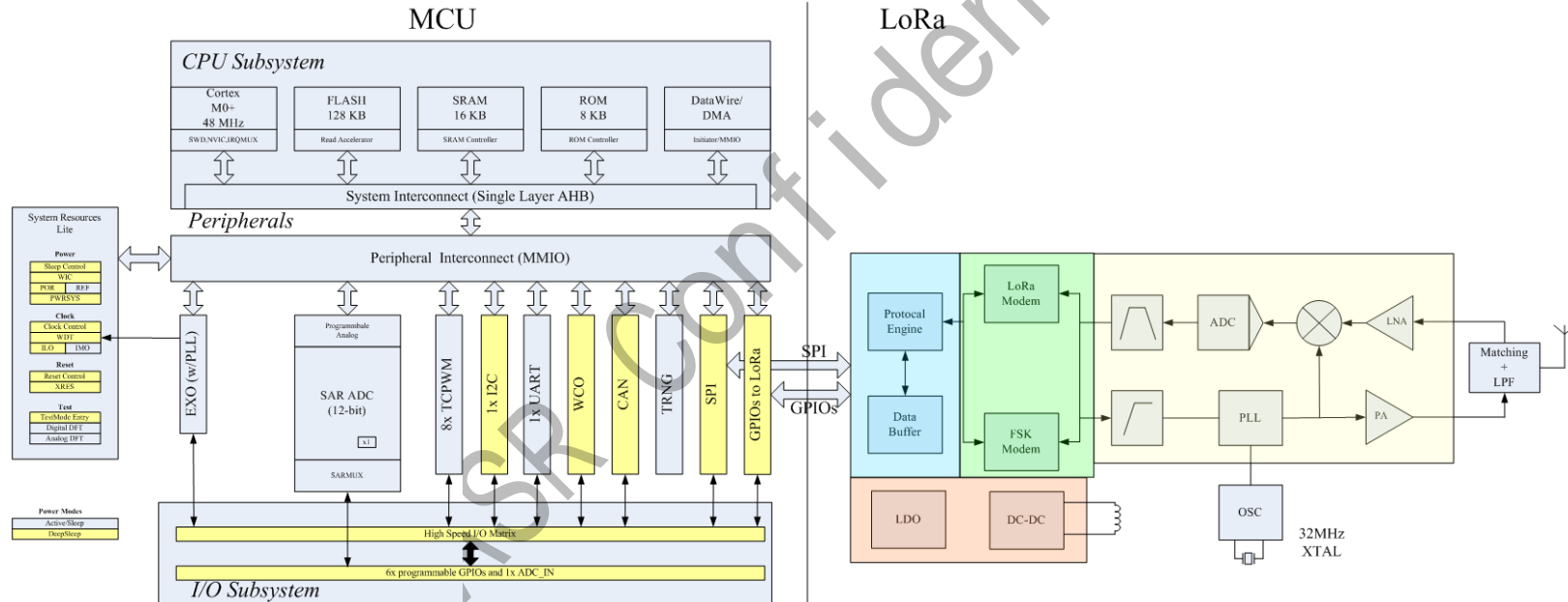
□ ASR6501 General Description

- The ASR6501 is a general LoRa Wireless Communication Chipset, with integrated LoRa Radio Transceiver, LoRa Modem and a 32-bit RISC MCU.
- The MCU uses ARM Cortex M0+. With 48MHz operation frequency.
- The LoRa Radio Transceiver has continuous frequency coverage from 150MHz to 960MHz.
- The LoRa supports LoRa modulation for LPWAN use cases and (G)FSK modulation for legacy use cases.
- The LoRa Wireless Communication module designed by ASR6501 provides ultra long rang, ultra low power communication for LPWAN application.

ASR6501 Introduction

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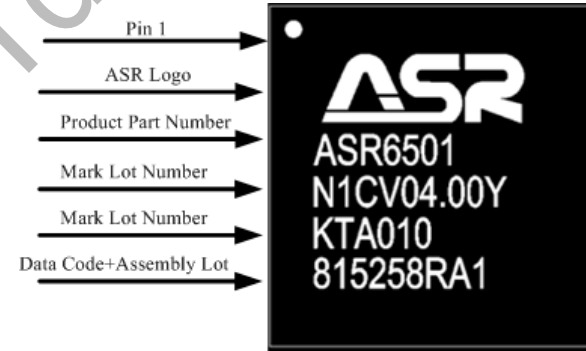
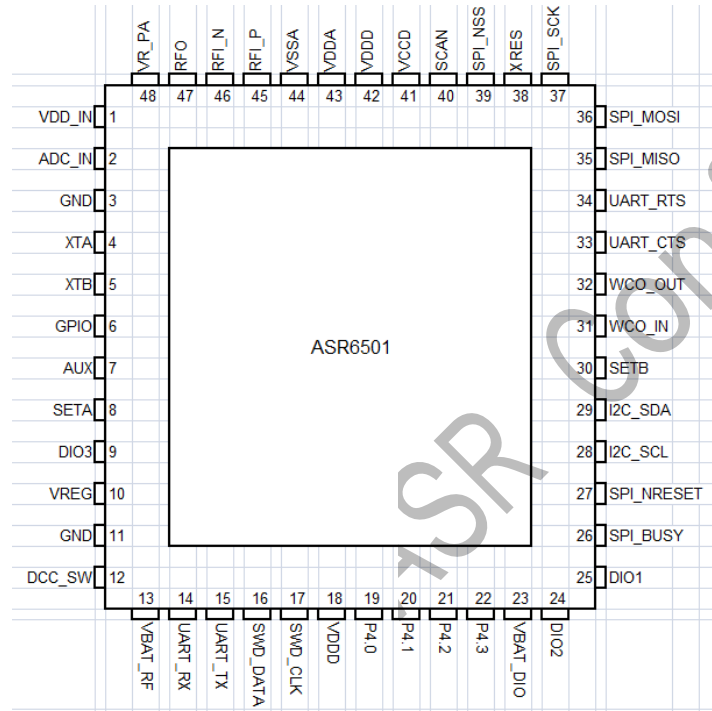
ASR6501 Block Diagram



ASR6501 Introduction

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ASR6501 Pin Assignment



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ASR6501 Introduction

ASR6501 Pin Assignment

Pin NO.	Pin Name	P/G/I/O	Description
1	VDD_IN	P	Input voltage for power amplifier, VR_PA
2	ADC_IN	I	ADC input pin.
3	GND	G	Ground
4	XTA	I	XO32M for LoRa input
5	XTB	I	XO32M for LoRa output
6	GPIO	I/O	MCU GPIO
7	AUX	I/O	MCU GPIO
8	SETA	I/O	MCU GPIO
9	DIO3	I/O	Multipurpose digital I/O-external TCXO32M supply voltage
10	VREG	O	Regulated output voltage from the internal LDO/DC-DC
11	GND	G	Ground
12	DCC_SW	O	DC-DC Switcher Output
13	VBAT_RF	P	Supply for the LoRa Radio
14	UART_RX	I/O	UART RX pin
15	UART_TX	I/O	UART TX pin
16	SWD_DATA	I/O	SWD Data pin
17	SWD_CLK	I/O	SWD Clock pin
18	VDDD	P	Power supply for MCU digital section
19	P4.0	I/O	MCU GPIO for SPI
20	P4.1	I/O	MCU GPIO for SPI
21	P4.2	I/O	MCU GPIO for SPI
22	P4.3	I/O	MCU GPIO for SPI
23	VBAT_DIO	P	Digital I/O supply voltage
24	DIO2	I/O	Multipurpose digital I/O-RF switch control
25	DIO1	I/O	Multipurpose digital I/O
26	SPI_BUSY	I/O	SPI busy indicator
27	SPI_NRESET	I/O	Reset signal, active low

28	I2C_SCL	I/O	I2C SCL pin
29	I2C_SDA	I/O	I2C SDA pin
30	SETB	I/O	MCU GPIO
31	WCO_IN	I	XO32K for MCU input
32	WCO_OUT	I	XO32K for MCU output
33	UART_CTS	I/O	UART CTS pin
34	UART_RTS	I/O	UART RTS pin
35	SPI_MISO	I/O	SPI slave output
36	SPI_MOSI	I/O	SPI slave input
37	SPI_SCK	I/O	SPI clock
38	XRES	I	SPI slave select
39	SPI_NSS	I/O	SPI slave select
40	SCAN	I	LoRa Scan pin
41	VCCD	P	Regulated digital supply (1.8V ± 5%)
42	VDDD	P	Power supply for MCU digital section
43	VDDA	P	Power supply for MCU analog section
44	VSSA	G	Ground
45	RFI_P	I	RF receiver input
46	RFI_N	I	RF receiver input
47	FRO	O	RF transmitter output
48	VR_PA	O	Regulated power amplifier supply

ASR6501 Specifications

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□ ASR6501 Key Features

- ◆ Small footprint: 6mm x 6mm x 0.9mm.↵
- ◆ LoRa Radio and LoRa Modem.↵
- ◆ Frequency Range: 150MHz ~ 960MHz.↵
- ◆ Maximum Power +21dBm constant RF output.↵
- ◆ High sensitivity: down to -140dBm.↵
- ◆ Programmable bit rate up to 62.5kbps in LoRa modulation mode.↵
- ◆ Programmable bit rate up to 300kbps in (G)FSK modulation mode.↵
- ◆ Preamble detection.↵
- ◆ Embedded memories (up to 128kbytes of Flash memory and 16Kbytes of SRAM).↵
- ◆ 6x configurable GPIOs, 1xI2C, 1xUART, 1xSWD. ↵
- ◆ 48-MHz ARM Cortex-M0+ CPU.↵
- ◆ 8-Channel DMA engine.↵
- ◆ Embedded 12-bit 1MSPS SAR ADC.↵
- ◆ 32.768kHz External Watch Crystal Oscillator.↵
- ◆ 4-33MHz External Crystal Oscillator for MCU (Optional).↵
- ◆ 32MHz External Crystal Oscillator for LoRa Radio.↵
- ◆ Embedded internal High frequency (48MHz) RC oscillator.↵
- ◆ Embedded internal Low frequency (40kHz) RC oscillator.↵
- ◆ Embedded internal PLL to generate 48MHz clock.↵

ASR6501 Specifications

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□ ASR6501 General Specification

Chipset Name	ASR6501
Module Name	ASR6501 LoRa Wireless Communication Module
Host Interface	UART, GPIO
Operation Conditions	
Temperature	<ul style="list-style-type: none"> ● Storage: -55C ~ +125C ● Operating: -40C ~ +85C
Dimension	6mm x 6mm x 0.9mm
Package	QFN Type

Symbol	Parameter	Min.	Typ.	Max.	Unit
VDD	Supply Voltage	-0.3		3.9	V
Vin	Digital Input Voltage Level	-0.3		3.9	V
Pin	RF Input Power			+10	dBm

ASR6501 Specifications

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□ ASR6501 Radio Specifications

LoRa Transmitter RF Characteristics					
Items	Condition	Min.	Typ.	Max.	Unit
Frequency Range		150	470	960	MHz
Tx Power	RFO Pin	18	20	21	dBm
LoRa Receiver RF Characteristics					
Items	Condition	Min.	Typ.	Max.	Unit
Frequency Range		150	470	960	MHz
Sensitivity	125kHz Bandwidth, SF=7		-125		dBm
	125kHz Bandwidth, SF=10		-134		dBm
	125kHz Bandwidth, SF=12		-140		dBm
2nd order harmonic	Tx Power = 20dBm		-38		dBm

ASR6501 Specifications

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□ ASR6501 Power Specifications

Symbol	Parameter	Conditions	Typ.	Max.	Unit
IDD_SL	Supply current in Sleep mode	Without RF Config Retention	2.7		uA
		With RF Config Retention	3.1		uA
IDD_RX	Supply current in Receiver mode		11		mA
IDD_TX	Supply current in Transmitter mode	Pout=+22dBm	108		mA
		Pout=+21dBm	106		mA
		Pout=+20dBm	98		mA
		Pout=+18dBm	90		mA
		Pout=+15dBm	78		mA
		Pout=+10dBm	59		mA
		Pout=+5dBm	47		mA

ASR6501 Specifications

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ASR6501 Compared with Other Products

Symbol	Conditions	ASR6501 (SX1262)	ACSiP S78S (SX1278)	MXCHIP DML3047 (SX1278)	EasyLinkin ELI-MD-111-B (SX1278)
Frequency Range		150~960MHz (All LoRa Channels Supported)	433MHz/470MHz	138~510MHz	430~510MHz
Band Width	LoRa Mode	7.8k~500kHz	62.5k~500kHz	62.5k~500kHz	62.5k~500kHz
Maximum Power		21dBm	20dBm	20dBm	20dBm
	@SF=12, BW=125kHz, LoRa	-140dBm	-138dBm	-140dBm	-140dBm?
Data Rate	LoRa Mode	0.018kbps~62.5kbps	1.7kbps~37.5kbps	1.7kbps~37.5kbps	1.7kbps~37.5kbps
	FSK Mode	0.6kbps~300kbps	1.2kbps~300kbps	1.2kbps~300kbps	1.2kbps~300kbps
RX Current	@BW=125kHz	11mA	17.7mA	11.73mA	16mA
TX Current	@TX_Power=22dBm/20dBm	108mA	128mA	119.21mA	130mA
	@TX_Power=17dBm	82mA	83mA	93.34mA	
	Configure Retained	3.1uA	5uA	11.12uA	5uA
Package Size		QFN48 6mm*6mm*0.9mm	LGA62 13mm*11mm*1.1mm	--	--
CPU Type		Cortex M0+	Cortex M0+	Cortex M0+	Cortex M0+
CPU Frequency		48MHz	32MHz	32MHz	32MHz
Flash Size		128 Kbytes	192 Kbytes	128 Kbytes	64Kbytes
SRAM Size		16 Kbytes	20 Kbytes	20 Kbytes	8 Kbytes
SPI			1x	1x	
UART		1x	1x	3x	1x
I2C		1x	1x	1x	1x
PWM		8x	1x	7x	
ADC		1x	1x	7x	
JTAG		1x	1x	1x	1x
GPIO		6x		13x	7x

ASR6501 Specifications

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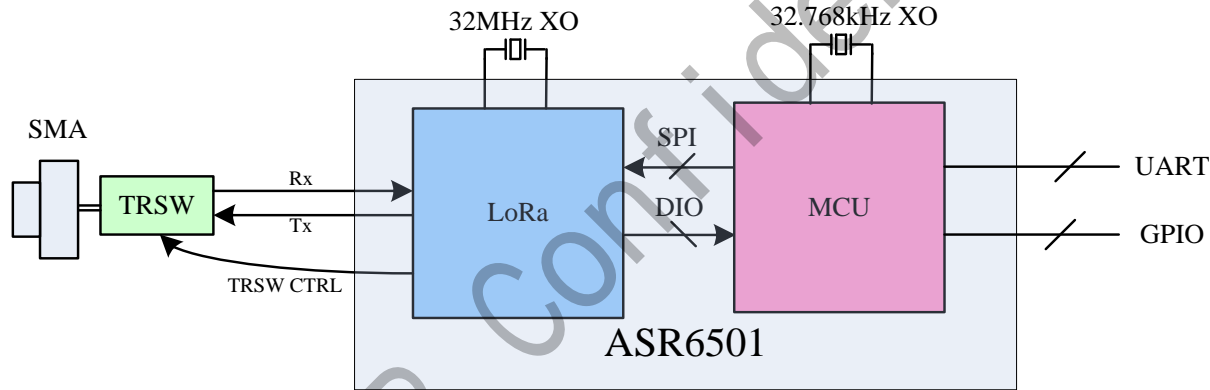
□ ASR6501 Compared with Other Products



ASR6501 Application Note

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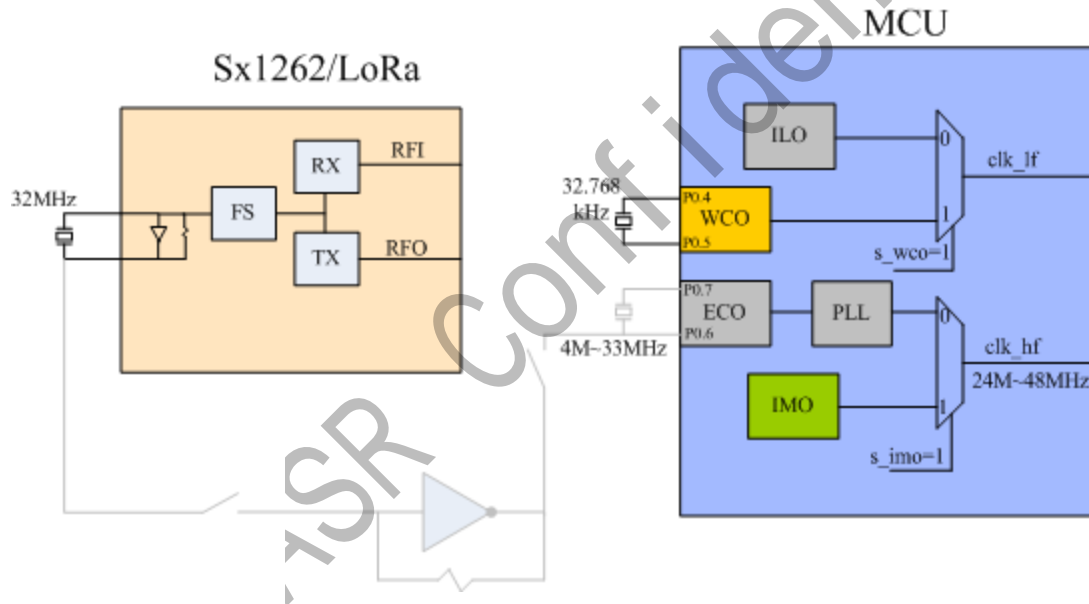
□ ASR6501 Demo module



ASR6501 Application Note

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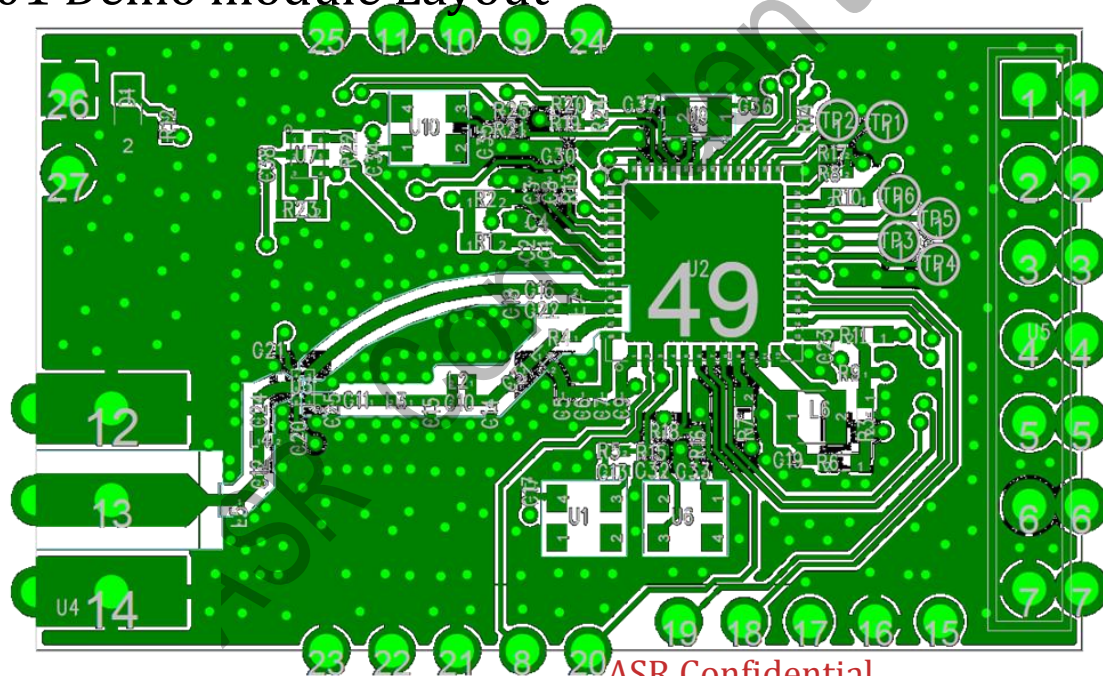
ASR6501 Demo module



ASR6501 Application Note

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□ ASR6501 Demo module Layout

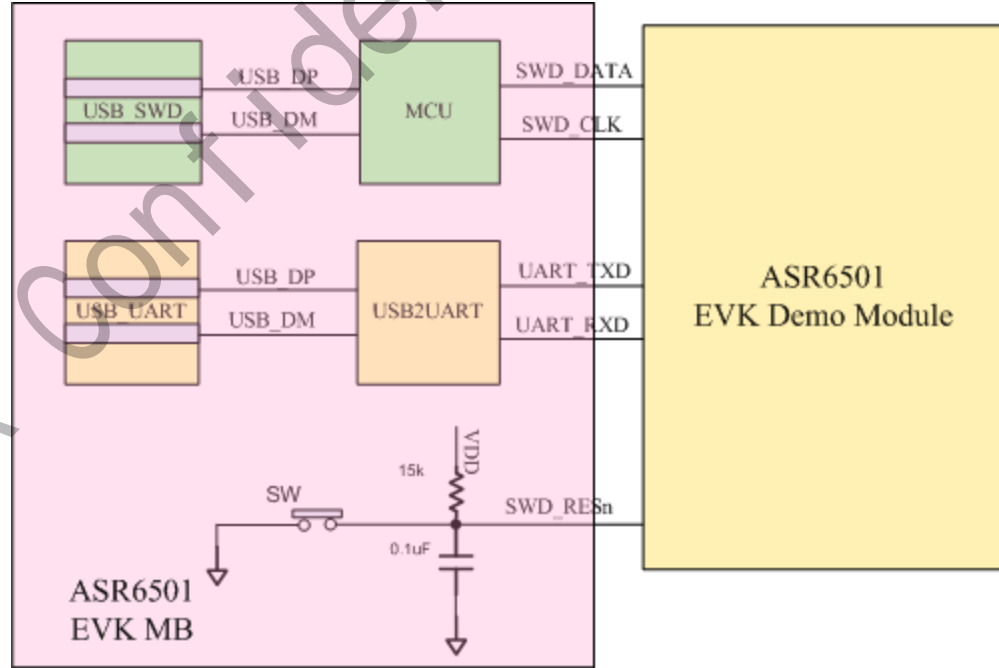
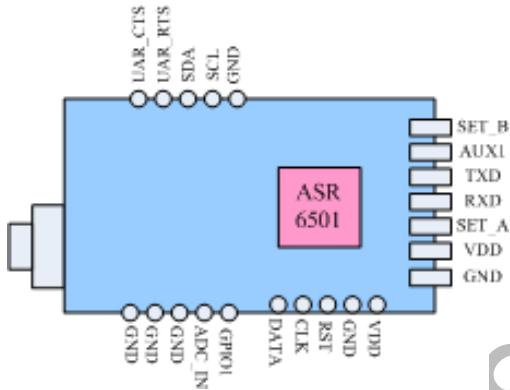


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ASR6501 EVK Introduction

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- ASR6501 EVK MB
 - ▣ ASR6501 EVK including Demo module and EVK mother board

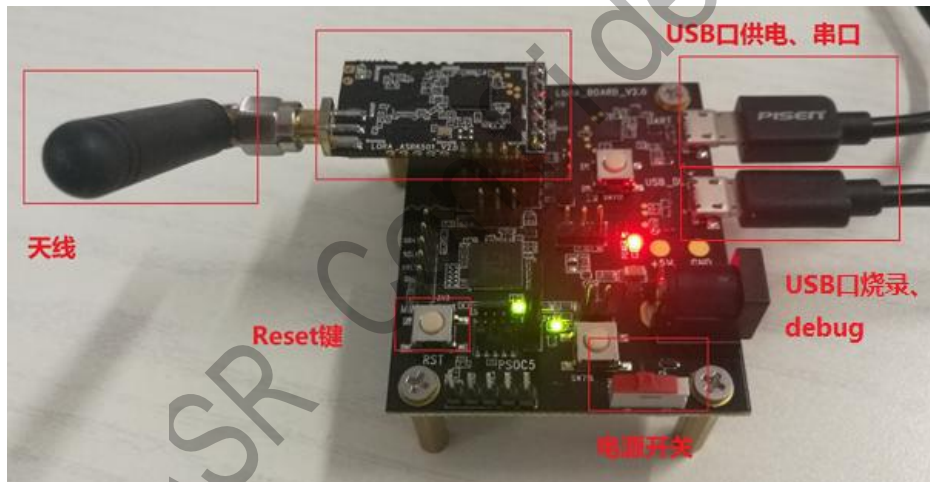


ASR6501 EVK Introduction

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□ ASR6501 EVK MB

- ▣ ASR6501 EVK including Demo module and EVK mother board



ASR6501 EVK Introduction

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□ ASR6501 EVK Usage

- ▣ SWD for downloading image; UART for communication with master controller.
- ▣ ASR LoRa hardwire driver images will be downloaded into ASR6501 Demo module.
- ▣ Some AT command will be provided to control the Node module.
- ▣ The GPIO voltage level should be 3.3V, don't exceed 3.6V.

ASR6501 EVK Introduction

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□ ASR6501 SDK

▣ ASR6501 SW SDK

ASR6501 软件SDK V2.0 7.20已经发布。文档及ReleaseNote参见SDK中doc目录。V2.0版本主要新增：

1. 动态deep sleep，低功耗timer级联以及整个lora场景的低功耗功能。
2. 支持ICA集合的AT命令。
3. Bug fix 及优化。
4. SDK集成AliOS 和 LoRaWAN协议栈。

ASR6501 EVK Introduction

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□ ASR6501 SDK

▣ ASR6501 SW TEST – Chip RF performance evaluation test

NO.	测试项	关注结果	命令
1	Deepsleep+wakeup, 包括GPIO wakeup和RTC timer wakeup测试。	Deepsleep功耗+Wakeup功能	GPIO wakeup:SLEEP=0 Timer wakeup:Sleep=10 Timer是10s, 后面跟的参数就是睡下去的时间。
2	MCU+LoRa on, TX continuous wave test, 测试发射功率。发射功率可以0-22dBm, 1dB/Step修改。	TX功耗+发射功率	TXC=5 发射功率是5, 后面跟的参数就是tx continuous模式下的发射功率(0~22)
3	MCU+LoRa on, RX接收灵敏度测试, SF可以修改SF5~SF12, 可以1/step修改。	RX功耗+接收灵敏度	RXC=5 接受DR是5, 后面跟的参数就是rx continuous模式下的接受DR (0~5)
4	MCU on + LoRa deepsleep, 功耗测试。只测试MCU功耗。	MCU功耗	MCU 关闭lora, 仅保留MCU

ASR6501 EVK Introduction

ASR6501 SDK

- ASR6501 SW TEST – Chip node to node communication test. 3km range from customer feedback.



ASR6501 EVK Introduction

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□ ASR6501 Documents

▣ ASR6501 documents release

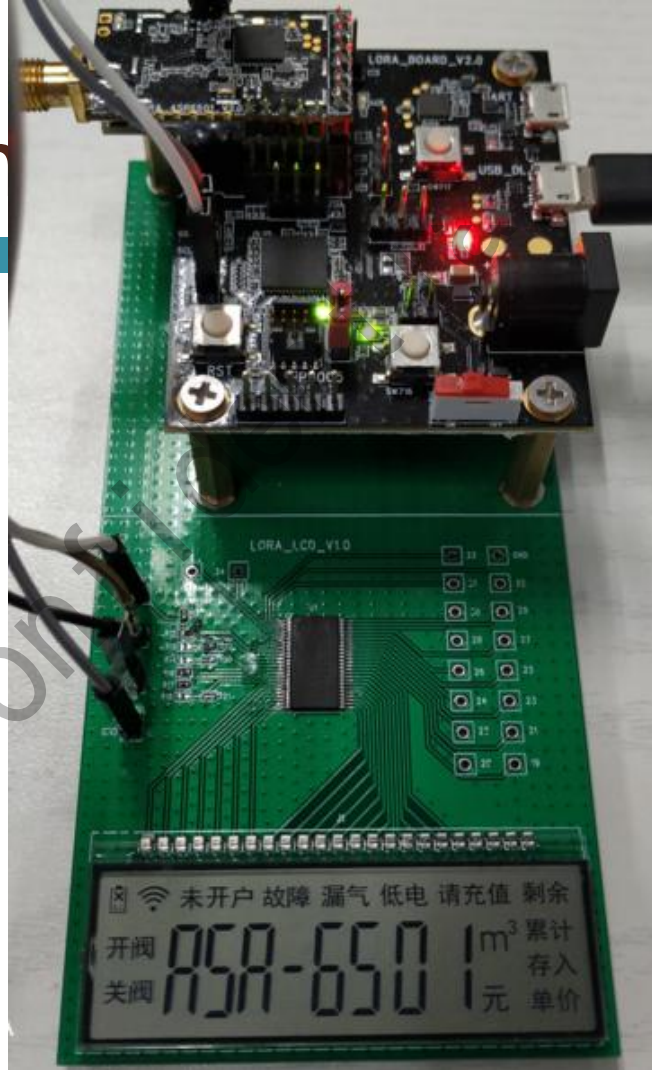
文档编号	文档类型	文档名称
1	开发板参考原理图	LORA_ASR6501_V20_Schematic_0516.pdf
2	开发板参考layout	LORA_ASR6501_V2.0_Layout_0518a.pdf
3	开发板参考BoM	LoRa_ASR6501_V20_BoM_0514.pdf
4	ASR6501 datasheet	ASR6501_Datasheet_V0.5.pdf
5	ASR6501应用笔记包含开发套件应用说明	ASR6501_Application_Note_V0.1_2018.6.21.pdf
6	软件AT命令说明, 应用于开发套件	ASR6501-AT-Commands-Introduction-V2.0.pdf
7	ASR6501培训报告	ASR6501_LoRa_Communication_Solution_Training_20180620.pdf
8	LORA_EVB_PCB封装库	LORA_EVB_PCB封装库.rar
9	ASR6501常见问题Q&A	ASR6501_QA.pdf
10	Alpha SDK应用手册	ASR6501-LoRa-SW-Release-Notes.pdf
11	Alpha SDK代码	https://github.com/asr-lora/alios-asr-lora
12	ASR6501固件烧录说明	ASR6501固件烧录说明.pdf
13	ASR6501串口驱动及驱动说明	ASR6501_driver.zip
14	LORA_EVB_PCB封装库pads4版本	LORA_EVB_PCB封装库-pads4版本.rar

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- ASR6501 I2C LCD Demo



ASR6502

□ ASR6502 Specification

	ASR6501	ASR6502-1	ASR6502-2
GPIO	5	13	9
ADC	1	3	3
SPI	0	0	1
UART	1	2	2
I2C	1	1	1
Total	48	60	60
PKG	6*6 QFN48	7*7 QFN60	7*7 QFN60

The End !
Thanks !