Features

- Embedded EEPROM
  - Very Easy Development with RFPDK
  - All Features Programmable
- Frequency Range: 240 to 480 MHz
- OOK Modulation
- Symbol Rate: 0.5 to 30 kbps
- 1-wire Interface
- Output Power: -10 to +13 dBm
- Supply Voltage: 1.8 to 3.6 V
- Current Consumption: 12.4 mA @ +10 dBm
- Sleep Current < 20 nA
- FCC / ETSI Compliant
- RoHS Compliant
- Module Size:17.8*12.8*5.0mm

RFM110

Descriptions

The RFM110 is an ultra low-cost, highly flexible, high performance, single-chip OOK transmitter for various 240 to 480 MHz wireless applications. It is part of the CMOSTEK NextGenRF™ family, which includes a complete line of transmitters, receivers and transceivers. The device only requires 1-wire interface for the external MCU or encoder to send in the data and control the transmission. An embedded EEPROM allows the frequency, output power and other features to be programmed into the chip using the CMOSTEK USB Programmer and RFPDK. Alternatively, in stock products of 315/433.92 MHz are available for immediate demands with no need of EEPROM programming. The RFM110 uses a 1-pin crystal oscillator circuit with the required crystal number of external components. The RFM110 receiver together with the RFM110 transmitterenables an ultra low cost RF link.

Applications

- Low-Cost Consumer Electronics Applications
- Home and Building Automation
- Remote Fan Controllers
- Infrared Transmitter Replacements
- Industrial Monitoring and Controls
- Remote Lighting Control
- Wireless Alarm and Security Systems
- Remote Keyless Entry (RKE)

Abbreviations

Abbreviations used in this data sheet are described below

AN	Application Notes	**OOK**	On-Off Keying **BOM**
	Bill of Materials	**PA**	Power Amplifier
BSC	Basic Spacing between Centers	**PC**	Personal Computer
BW	Bandwidth	**PCB**	Printed Circuit Board
DC	Direct Current	**PLL**	Phase Lock Loop
EEPROM	Electrically Erasable Programmable	**PN**	Phase Noise
	Read-Only Memory	**RBW**	Resolution Bandwidth
ESD	Electro-Static Discharge	**RCLK**	Reference Clock
ESR	Equivalent Series Resistance	**RF**	Radio Frequency
GUI	Graphical User Interface	**RFPDK**	RF Product Development Kit
IC	Integrated Circuit	**RoHS**	Restriction of Hazardous Substances
LDO	Low Drop-Out	**Rx**	Receiving, Receiver
Max	Maximum	**SOT**	Small-Outline Transistor
MCU	Microcontroller Unit	**TBD**	To Be Determined
Min	Minimum	**Tx**	Transmission, Transmitter
MOQ	Minimum Order Quantity	**Typ**	Typical
NP0	Negative-Positive-Zero	**XO/XOSC**	Crystal Oscillator
OBW	Occupied Bandwidth	**XTAL**	Crystal

Table of Contents

1. Electrical Characteristics

V_{DD} = 3.3 V, T_{OP} = 25 ℃, F_{RF} = 433.92 MHz, output power is +10 dBm terminated in a matched 50 Ω impedance, unless otherwise noted

1.1 Recommended Operating Conditions

Table 2. Recommended Operation Conditions

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Operation Voltage Supply	V_{DD}		1.8		3.6	V
Operation Temperature	T_{OP}		-40		85	℃
Supply Voltage Slew Rate			1			mV/us

1.2 Absolute Maximum Ratings

Table 3. Absolute Maximum Ratings[1]

Parameter	Symbol	Conditions	Min	Max	Unit
Supply Voltage	V_{DD}		-0.3	3.6	V
Interface Voltage	V_{IN}		-0.3	V_{DD} + 0.3	V
Junction Temperature	T_J		-40	125	℃
Storage Temperature	T_{STG}		-50	150	℃
Soldering Temperature	T_{SDR}	Lasts at least 30 seconds		255	℃
ESD Rating		Human Body Model (HBM)	-2	2	kV
Latch-up Current		@ 85 ℃	-100	100	mA

Note:

[1]. Stresses above those listed as “absolute maximum ratings” may cause permanent damage to the device. This is a stress rating only and functional operation of the device under these conditions is not implied. Exposure to maximum rating conditions for extended periods may affect device reliability.

Caution! ESD sensitive device. Precaution should be used when handling the device in order to prevent permanent damage.

1.3 Transmitter Specifications

Table 4. Transmitter Specifications

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Frequency Range[1]	F_{RF}		240		480	MHz
Synthesizer Frequency Resolution	F_{RES}			198		Hz
Maximum Output Power	$P_{OUT(Max)}$			+13		dBm
Minimum Output Power	$P_{OUT(Min)}$			-10		dBm
Output Power Step Size	P_{STEP}			1		dB
PA Ramping Time[2]	t_{RAMP}		0		1024	us
Current Consumption @ 315 MHz	I_{DD315}	0 dBm, 50% duty cycle, 9.6 kbps		6.8		mA
		+10 dBm, 50% duty cycle, 9.6 kbps		12.4		mA
		+13 dBm, 50% duty cycle, 9.6 kbps		16.0		mA
Current Consumption @ 433.92 MHz	$I_{DD433.92}$	0 dBm, 50% duty cycle, 9.6 kbps		6.9		mA
		+10 dBm, 50% duty cycle, 9.6 kbps		13.4		mA
		+13 dBm, 50% duty cycle, 9.6 kbps		17.4		mA
Sleep Current	I_{SLEEP}			20		nA
Symbol Rate	SR		0.5		30	kbps
Frequency Tune Time	t_{TUNE}			370		us
Phase Noise	PN	100 kHz offset from F_{RF}		-80		dBc/Hz
		200 kHz offset from F_{RF}		-82		dBc/Hz
		400 kHz offset from F_{RF}		-92		dBc/Hz
		600 kHz offset from F_{RF}		-98		dBc/Hz
	$H3_{315}$	1.2 MHz offset from F_{RF} OUT		-107		dBc/Hz
Harmonics Output for 315 MHz[3]	$H2_{315}$	2nd harm @ 630 MHz, +13 dBm P_{OUT}		-60		dBm
		3rd harm @ 945 MHz, +13 dBm P		-65		dBm
Harmonics Output for 433.92 MHz[3]	$H2_{433.92}$	2nd harm @ 867.84 MHz, +13 dBm P_{OUT}		-52		dBm
	$H3_{433.92}$	3rd harm @ 1301.76 MHz, +13 dBm P_{OUT}		-60		dBm
OOK Extinction Ration				60		dB
Occupied Bandwidth @ 315 MHz	F_{OBW315}	Measured @ -20 dBc, RBW = 1 kHz, SR = 1.2 kbps, t_{RAMP} = 256 us		6		kHz
Occupied Bandwidth @ 433.92 MHz	$F_{OBW433.92}$	Measured @ -20 dBc, RBW = 1 kHz, SR = 1.2 kbps, t_{RAMP} = 256 us		7		kHz

Notes:

[1]. The frequency range is continuous over the specified range.

[2]. 0 and 2^n us, n = 0 to 10, when set to “0”, the PA output power will ramp to its configured value in the shortest possible time.

[3]. The harmonics output is measured with the application shown as Figure 10.

2. Pin Descriptions

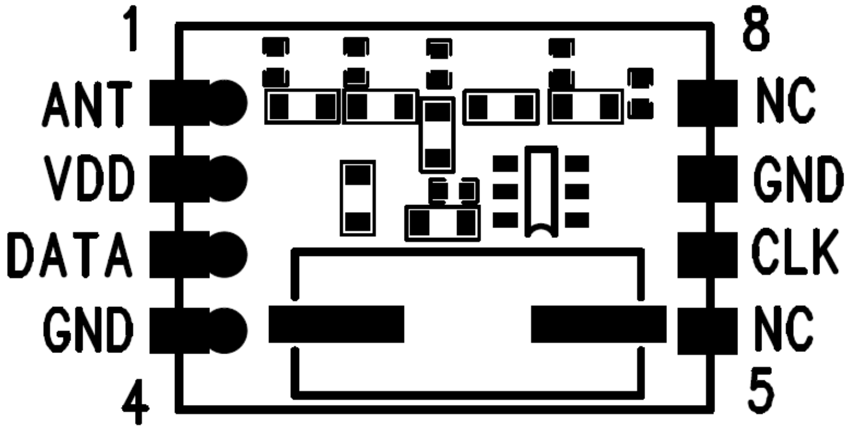


Figure 2. Pin Diagram

Table 6. RFM110 Pin Descriptions

Pin Number	Name	I/O	Descriptions
1	ANT	**O**	Transmitter RF Output
2	VDD	**I**	Power Supply 1.8V to 3.6V
3	DATA	**I/O**	Data input to be transmitted or Data pin to access the embedded EEPROM
4	GND	**I**	Ground
5	NC	---	Connect to GND
6	CLK	**I**	Clock pin to access the embedded EEPROM
7	GND	**I**	Ground
8	NC	---	Connect to GND

3. Typical Performance Characteristics

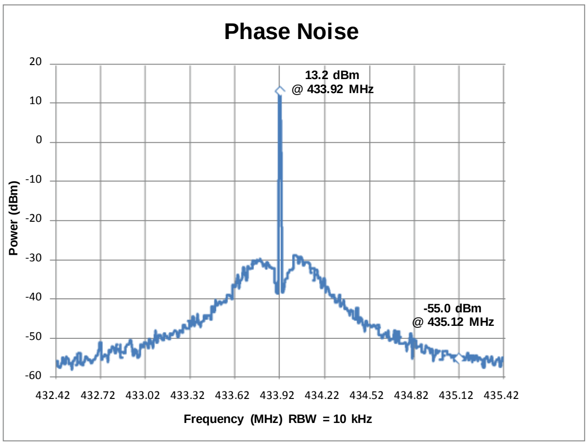


Figure 3. Phase Noise, F_{RF} = 433.92 MHz, P_{OUT} = +13 dBm, Unmodulated

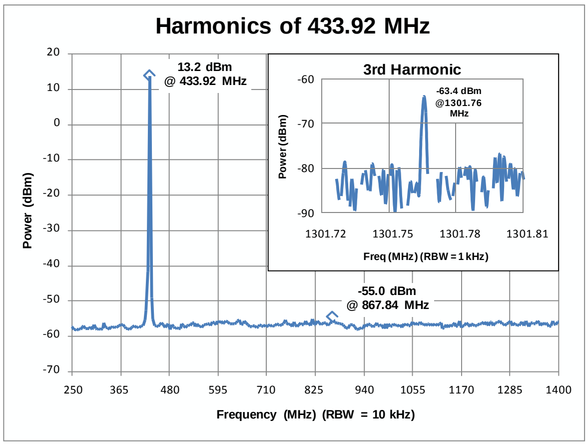


Figure 4. Harmonics of 433.92 MHz, P_{OUT} = +13 dBm

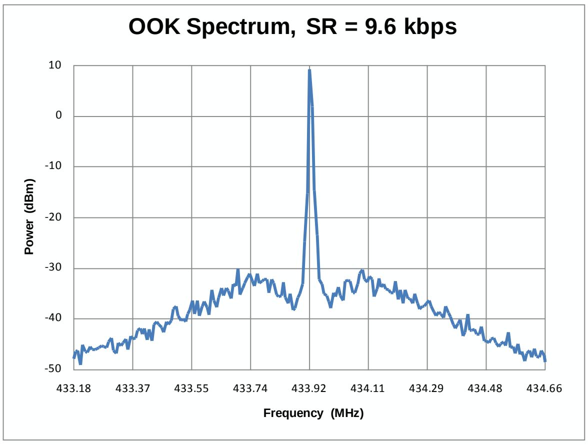


Figure 5. OOK Spectrum, SR = 9.6 kbps, P_{OUT} = +10 dBm, t_{RAMP} = 32 us

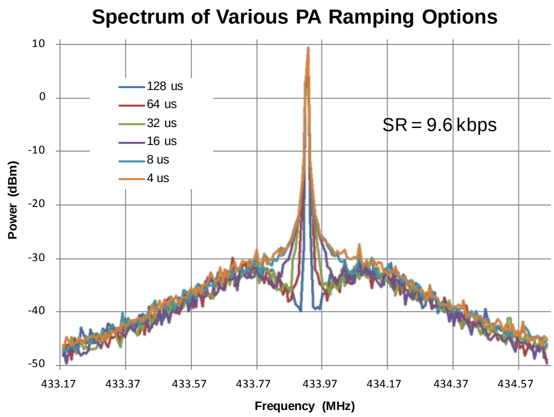


Figure 6. Spectrum of PA Ramping, SR = 9.6 kbps, P_{OUT} = +10 dBm

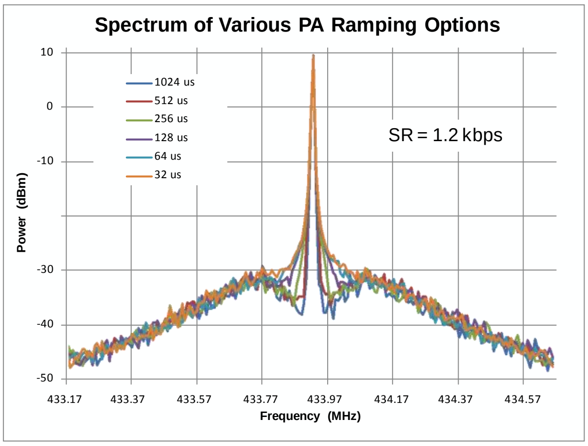


Figure 7. Spectrum of PA Ramping, SR = 1.2 kbps, P_{OUT} = +10 dBm

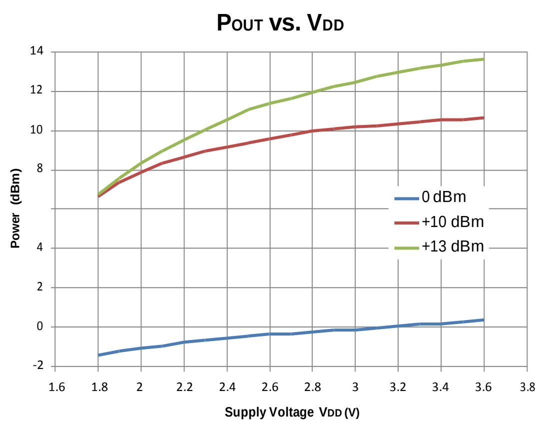


Figure 8. Output Power vs. Supply Voltages, F_{RF} = 433.92 MHz

4. Typical Application Schematics

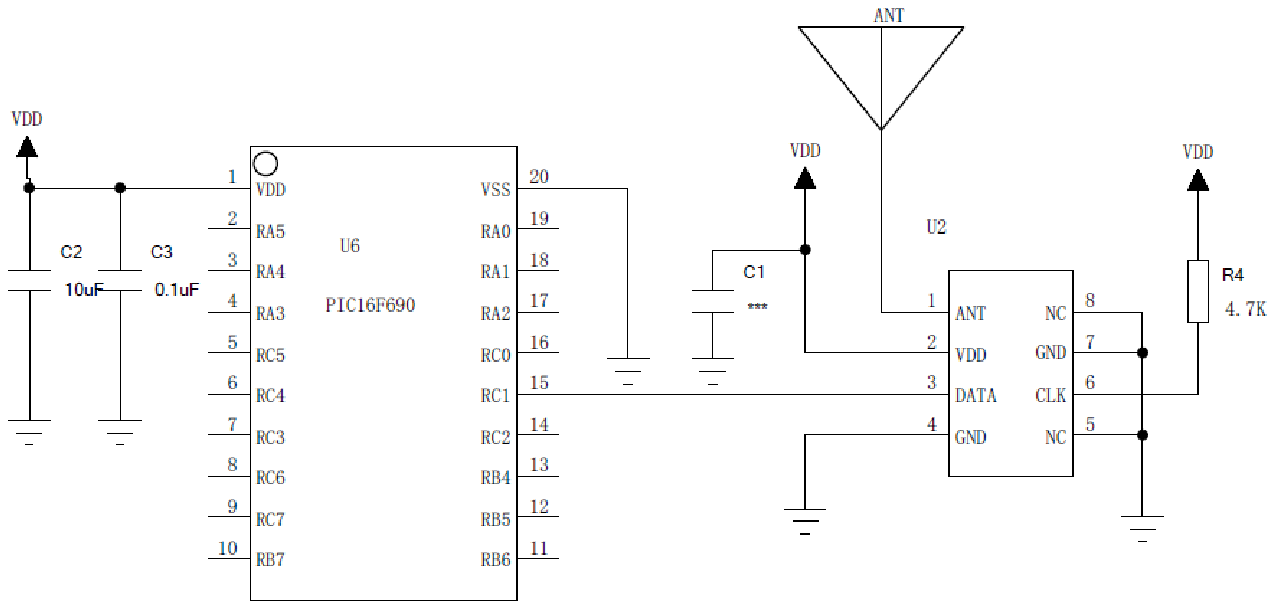


Figure 9: Typical Application Schematic

5. Functional Descriptions

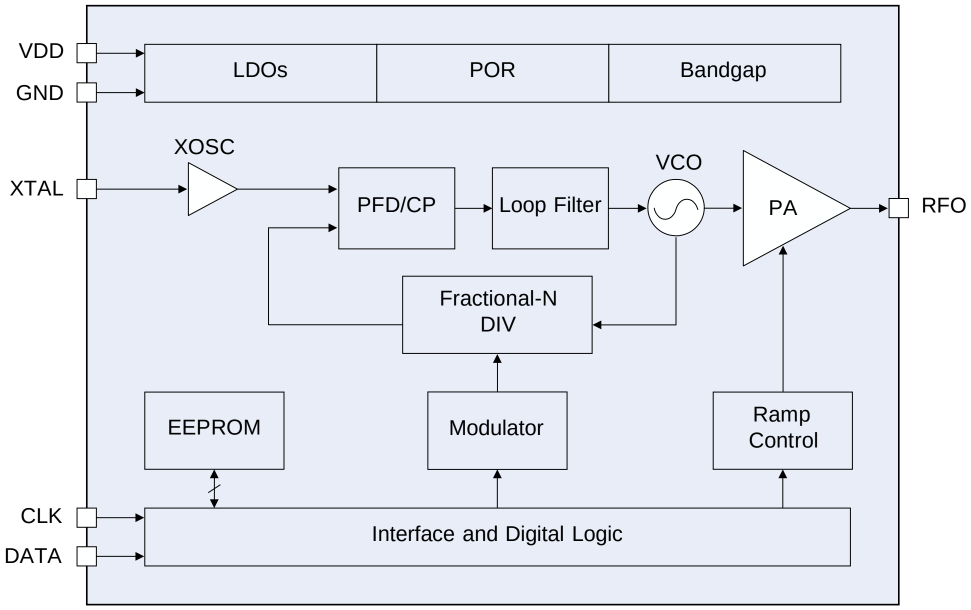


Figure 11. RFM110 Functional Block Diagram

5.1 Overview

The RFM110 is an ultra low-cost, highly flexible, high performance, single-chip OOK transmitter for various 240 to 480 MHz wireless applications. It is part of the CMOSTEK NextGenRF^{TM} family, which includes a complete line of transmitters, receivers and transceivers. The chip is optimized for the low system cost, low power consumption, battery powered application with its highly integrated and low power design.

The functional block diagram of the RFM110 is shown in Figure 11. The RFM110 is based on direct synthesis of the RF frequency, and the frequency is generated by a low-noise fractional-N frequency synthesizer. It uses a 1-pin crystal oscillator circuit with the required crystal load capacitance integrated on-chip to minimize the number of external components. Every analog block is calibrated on each Power-on Reset (POR) to the reference voltage generated by Bandgap. The calibration can help the chip to finely work under different temperatures and supply voltages. The RFM110 requires only 1 wire for the external MCU or encoder to send in the data and control the transmission. The input data will be modulated and sent out by a highly efficient PA
which output power can be configured from -10 to +13 dBm in 1 dB step size. RF Frequency, PA output power and other product features can be programmed into the embedded EEPROM by the RFPDK and USB Programmer. This saves the cost and simplifies the product development and manufacturing effort. Alternatively, in stock products of 315/433.92 MHz are available for immediate demands with no need of EEPROM programming. The RFM110 operates from 1.8 to 3.6 V so that it can finely work with most batteries to their useful power limits. It only consumes 12.4 mA when transmitting +10 dBm power under 3.3 V supply voltage.

5.2 Modulation, Frequency and Symbol Rate

The RFM110 supports OOK modulation with the symbol rate up to 30 kbps. It continuously covers the frequency range from 240 to 480 MHz, including the license free ISM frequency band around 315 MHz and

433.92 MHz. The device contains a high spectrum purity low power fractional-N frequency synthesizer with output frequency resolution better than 198 Hz. See Table 9 for the modulation, frequency and symbol rate specifications.

Table 9. Modulation, Frequency and Symbol Rate

Parameter	Value	Unit
Modulation	OOK	-
Frequency	240 to 480	MHz
Frequency Resolution	198	Hz
Symbol Rate	0.5 to 30	kbps

5.3 Embedded EEPROM and RFPDK

The RFPDK (RF Products Development Kit) is a very user-friendly software tool delivered for the user configuring the RFM110 in the most intuitional way. The user only needs to fill in/select the proper value of each parameter and click the "Burn" button to complete the chip configuration. No register access and control is required in the application program. See Figure 12 for the accessing of the EEPROM and Table 10 for the summary of all the configurable parameters of the RFM110 in the RFPDK.

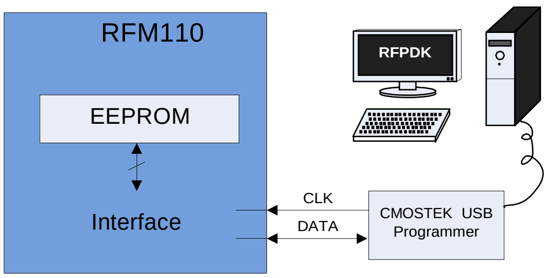


Figure 12. Accessing Embedded EEPROM

For more details of the CMOSTEK USB Programmer and the RFPDK, please refer to "AN103 CMT2110A/2210A One-Way RF Link Development Kits User's Guide". For the detail of RFM110 configurations with the RFPDK, please refer to "AN102 CMT2110A Configuration Guideline".

Table 10. Configurable Parameters in RFPDK

Category	Parameters	Descriptions	Default	Mode
RF Settings	Frequency	To input a desired transmitting radio frequency in the range from 240 to 480 MHz.	433.92 MHz	Basic Advanced
	Tx Power	To select a proper transmitting output power from -10 dBm to +14 dBm, 1 dBm margin is given above +13 dBm.	+13 dBm	Basic Advanced
	Xtal Cload	On-chip XOSC load capacitance options: from 10 to 22 pF.	15 pF	Basic Advanced
	PA Ramping	To control PA output power ramp up/down time, options are 0 and 2^n us (n from 0 to 10).	0 us	Advanced
Transmitting Settings	Start by	Start condition of a transmitting cycle, by Data Pin Rising/Falling Edge.	Data Pin Rising Edge	Advanced
	Stop by	Stop condition of a transmitting cycle, by Data Pin Holding Low for 20 to 90 ms.	Data Pin Holding Low for 20 ms	Advanced

5.4 Power Amplifier

A highly efficient single-ended Power Amplifier (PA) is integrated in the RFM110 to transmit the modulated signal out.The output power of the PA can be configured by the user within the range from -10 dBm to +13 dBm in 1 dB step size using the CMOSTEK USB Programmer and RFPDK.

5.5 PA Ramping

When the PA is switched on or off quickly, its changing input impedance momentarily disturbs the VCO output frequency. This process is called VCO pulling, and it manifests as spectral splatter or spurs in the output spectrum around the desired carrier frequency. By gradually ramping the PA on and off, PA transient spurs are minimized. The RFM110 has built-in PA ramping configurability with options of 0, 1, 2, 4, 8, 16, 32, 64, 128, 256, 512 and 1024 us, as shown in Figure 13. When the option is set to “0”, the PA output power will ramp up to its configured value in the shortest possible time. The ramp down time is identical to the ramp up time in the same configuration.

CMOSTEK recommends that the maximum symbol rate should be no higher than 1/2 of the PA ramping “rate”, as shown in the formula below:

$$SR_{Max} \leq 0.5 * \left(\frac{1}{t_{RAMP}}\right)$$

In which the PA ramping "rate" is given by ($1/t_{RAMP}$). In other words, by knowing the maximum symbol rate in the application, the PA ramping time can be calculated by:

$$t_{RAMP} \le 0.5 * (\frac{1}{SR_{MAX}})$$

The user can select one of the values of the t_{RAMP} in the available options that meet the above requirement. If somehow the t_{RAMP} is set to be longer than "0.5 * ($1/SR_{Max}$)", it will possibly bring additional challenges to the OOK demodulation of the Rx device. For more detail of calculating t_{RAMP}, please refer to "AN102 CMT2110A Configuration Guideline".

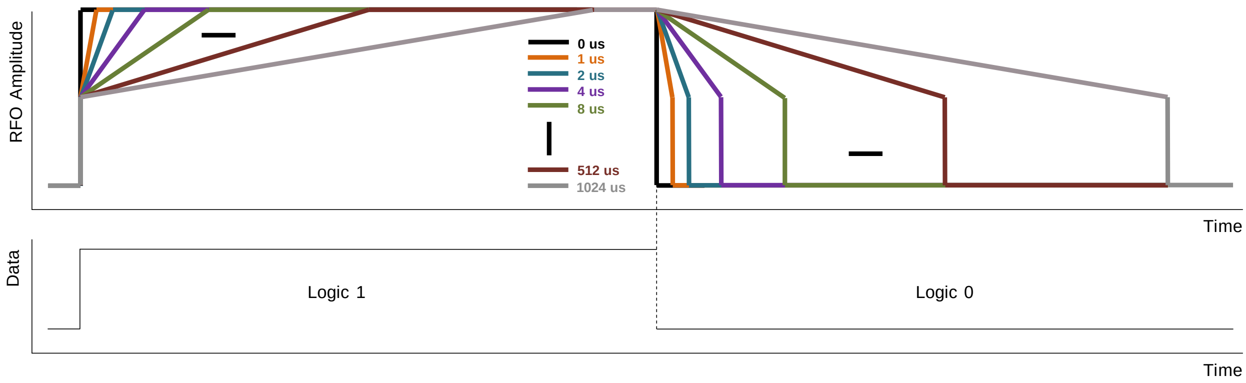


Figure 13. PA Ramping Time

5.6 Working States and Control Interface

The RFM110 has following 4 different working states: SLEEP, XO-STARTUP, TUNE and TRANSMIT.

SLEEP

When the RFM110 is in the SLEEP state, all the internal blocks are turned off and the current consumption is minimized to 20 nA typically. The 1-wire interface is ready to sense a valid rising or falling edge on DATA pin to start a transmitting cycle.

XO-STARTUP

After the RFM110 received the valid control signal, it will go into the XO-STARTUP state, and the internal XO starts to work. The user has to wait for the t_{XTAL} to allow the XO to get stable. The t_{XTAL} is to a large degree crystal dependent. A typical value of t_{XTAL} is provided in the Table 11.

TUNE

The frequency synthesizer will tune the RFM110 to the desired frequency in the time t_{TUNE}. The PA can be turned on to transmit the incoming data only after the TUNE state is done, before that the incoming data (Don't Care shown in Figure 14 and 15) will not be transmitted.

TRANSMIT

The RFM110 starts to modulate and transmit the data coming from the DATA pin. After the DATA pin is driven to low for the time t_{STOP} (can be configured from 20 to 90 ms in 10 ms step size through the RFPDK), the transmission will be ended and the RFM110 will go back to the SLEEP state, waiting for the next transmitting cycle.

The transmission can be enabled by either “DATA Pin Rising Edge” or “DATA Pin Falling Edge”. See Table 11 and Figure 14, 15 for the timing requirement of each working state in the 2 different modes.

Table 11.Timing in Different Working States

Parameter	Symbol	Min	Typ	Max	Unit
XTAL Startup Time [1]	t_{XTAL}		400		us
Time to Tune to Desired Frequency	t_{TUNE}		370		us
Hold Time After Rising Edge	t_{HOLD}	10			ns
Time to Stop The Transmission[2]	t_{STOP}	20		90	ms
Notes: [1]. This parameter is to a large degree crystal dependent [2]. Configurable from 20 to 90 ms in 10 ms step size					

5.6.1 Tx Enabled by DATA Pin Rising Edge

As shown in the Figure 14, once the RFM110 detects a rising edge on the DATA pin, it goes into the XO-STARTUP state. The user has to pull the DATA pin high for at least 10 ns (t_{HOLD}) after detecting the rising edge, as well as wait for the sum of t_{XTAL} and t_{TUNE} before sending any useful information (data to be transmitted) into the chip on the DATA pin. The logic state of the DATA pin is “don't' care” from the end of t_{HOLD} till the end of t_{TUNE}. In the TRANSMIT state, PA sends out the input data after they are modulated. The user has to pull the DATA pin low for t_{STOP} in order to end the transmission.

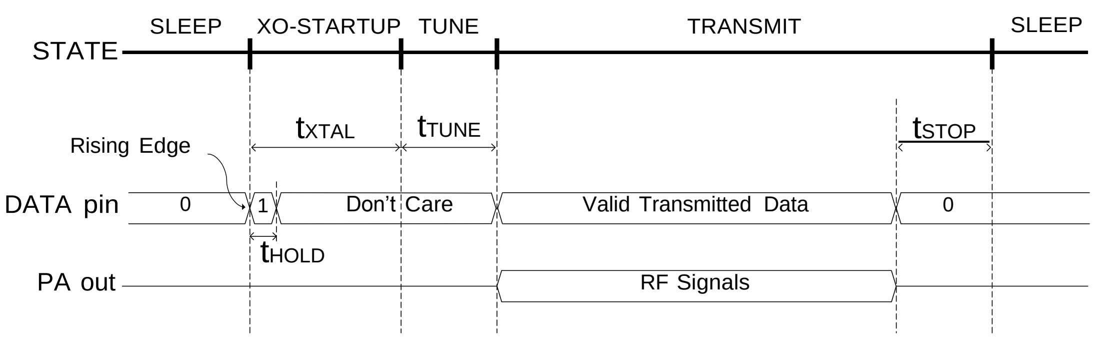


Figure 14. Transmission Enabled by DATA Pin Rising Edge

5.6.2 Tx Enabled by DATA Pin Falling Edge

As shown in the Figure 15, once the RFM110 detects a falling edge on the DATA pin, it goes into XO-STARTUP state and the XO starts to work. During the XO-STARTUP state, the DATA pin needs to be pulled low. After the XO is settled, the RFM110 goes to the TUNE state. The logic state of the DATA pin is “don't' care” during the TUNE state. In the TRANSMIT state, PA sends out the input data after they are modulated. The user has to pull the DATA pin low for t_{STOP} in order to end the transmission. Before starting the next transmit cycle, the user has to pull the DATA pin back to high.

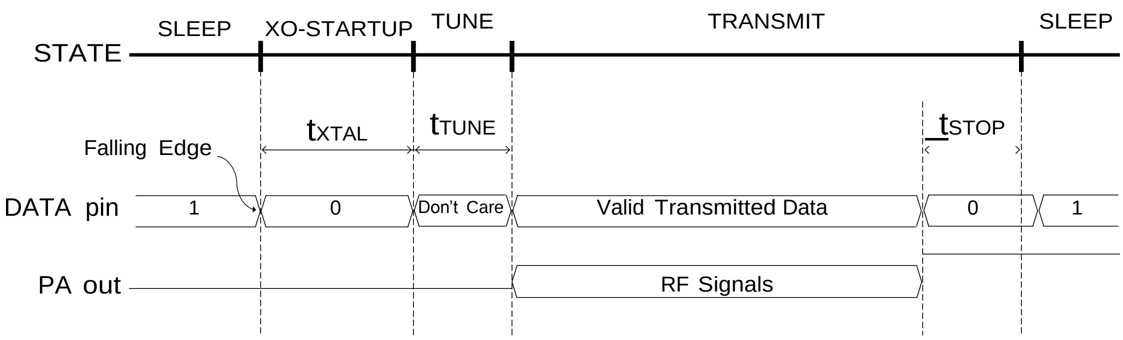
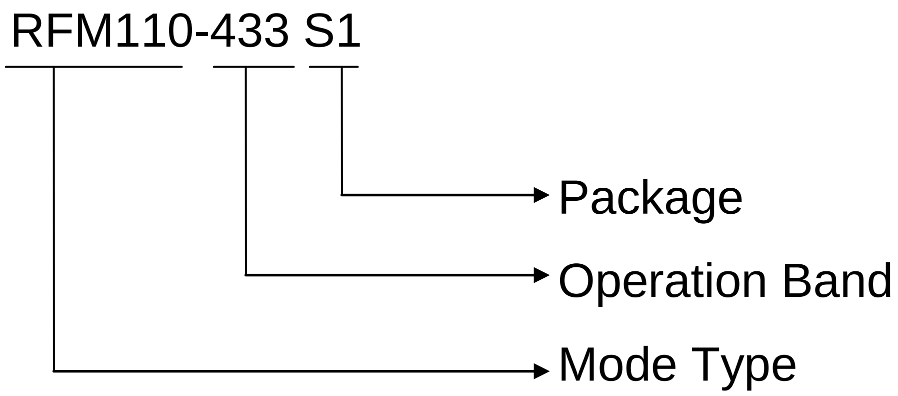


Figure 15. Transmission Enabled by DATA Pin Falling Edge

6. Ordering Information



P/N: RFM110-315S1

RFM110 module at 315MHz band,SMD Package

P/N: RFM110-433S1

RFM110 module at 433MHz band ,SMD Package

7. Package Outline

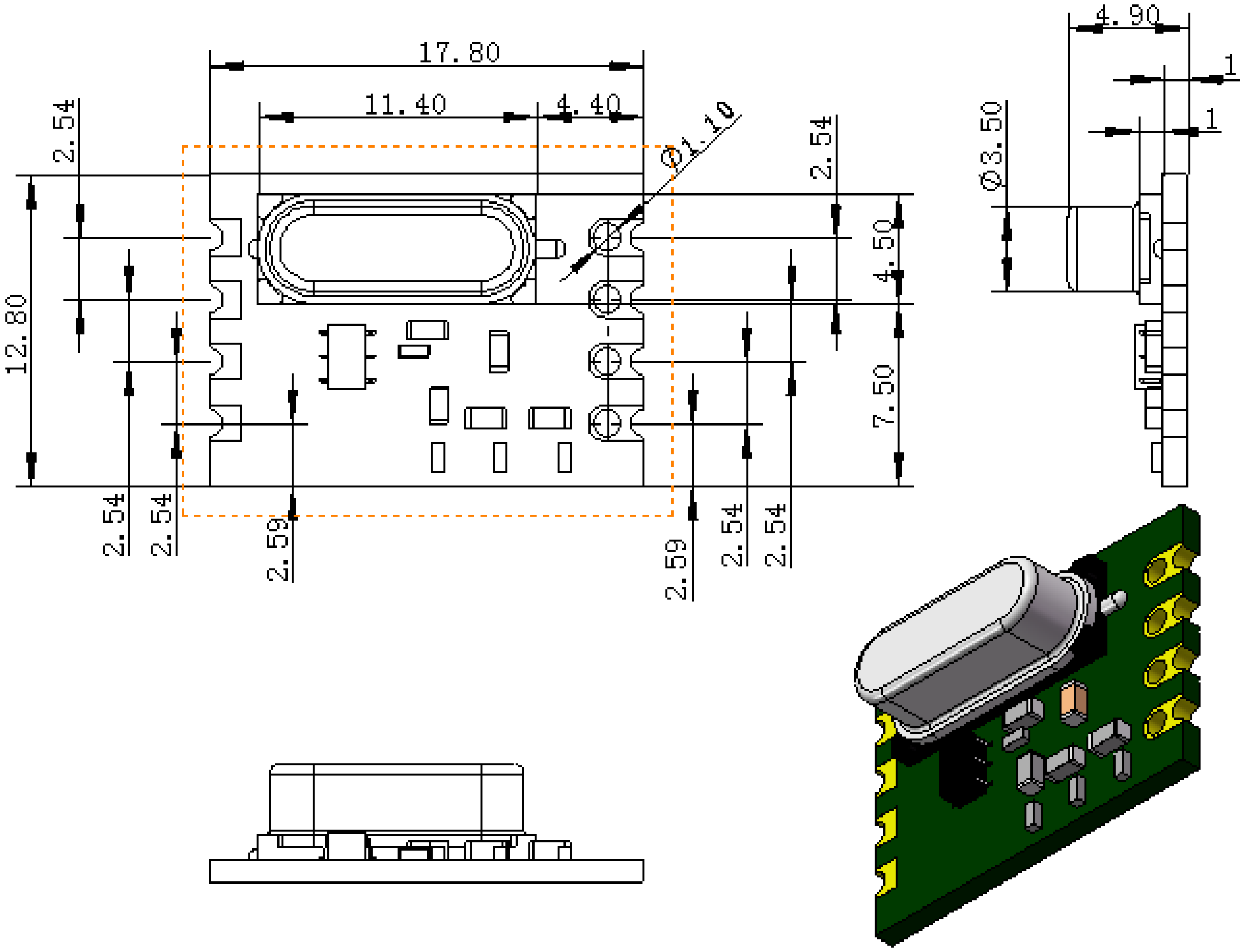


Figure 18 S2 Package Outline Drawing

8. Contact Information

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