CMOSTEK

CMT2210LW

Low-Cost 315/433.92 MHz OOK Stand-Alone Receiver

Features

- Operation Frequency: 315/433.92 MHz
- OOK Demodulation
- Symbol Rate: 0.1 to 3.4 ksps
- Sensitivity: -108 dBm at 2.4 ksps, 0.1% BER
- Receiver Bandwidth: 200 kHz
- Image Rejection Ratio: 25 dB
- Large Signal Handling: 10 dBm
- Stand-Alone, No External MCU Control Required
- No Register Configuration Required
- Supply Voltage: 1.8 to 3.6 V
- Low Power Consumption
  - 3.3 mA @ 315 MHz
  - 3.8 mA @ 433.92 MHz
- RoHS Compliant
- SOP8 Package

Descriptions

The CMT2210LW is an ultra low-cost, low power, high performance OOK stand-alone RF receiver for 315/433.92 MHz wireless applications. It is part of the CMOSTEK NextGenRF™ family, which includes a complete line of transmitters, receivers and transceivers. The CMT2210LW is a true plug-and-run device, no register configuration and manually-tune is required. The device operates at either 315 MHz or 433.92 MHz through selecting an 18.8744 MHz or 26 MHz crystal, the data rate is optimized to around 2.4 ksps which fits well with the low-end data encoder or MCU based transmitter. The CMT2210LW operates from 1.8 V to 3.6 V, finely work till the end of most batteries' power. It consumes 3.3 mA current while achieving -109 dBm receiving sensitivity at 315 MHz and consumes 3.8 mA current while achieving -108 dBm receiving sensitivity at 433.92 MHz. The SOP8 package is available for easier and lower-cost manufacturing. The CMT2210LW receiver together with the CMT211x transmitter enables an ultra low cost RF link. For NextGenRF™ receivers with more flexibility, the user can use the CMT2210AW.
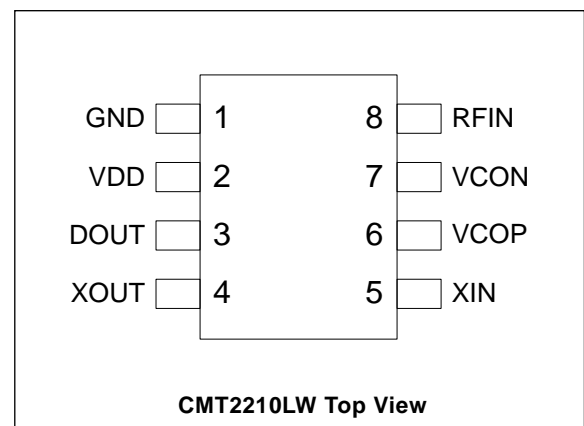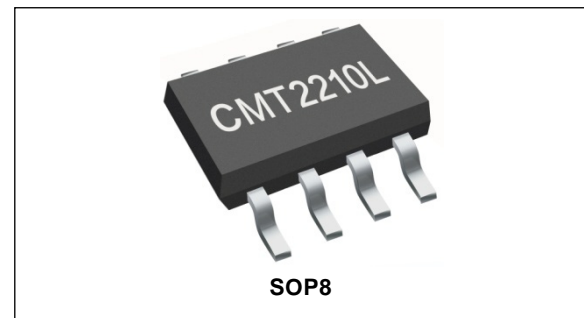
Applications

- Low-Cost Consumer Electronics Applications
- Home and Building Automation
- Infrared Receiver Replacements
- Industrial Monitoring and Controls
- Remote Automated Meter Reading
- Remote Lighting Control System
- Wireless Alarm and Security Systems
- Remote Keyless Entry (RKE)

Ordering Information

Part Number	Frequency	Package	MOQ
CMT2210LW-ESR	315/433.92 MHz	SOP8 /T&R	2,500 pcs
CMT2210LW-ESB	315/433.92 MHz	SOP8 /Tube	1,000 pcs
More Ordering Info: See			

SOP8

GND	1	8	RFIN
VDD	2	7	VCON
DOUT	3	6	VCOP
XOUT	4	5	XIN

CMT2210LW Top View

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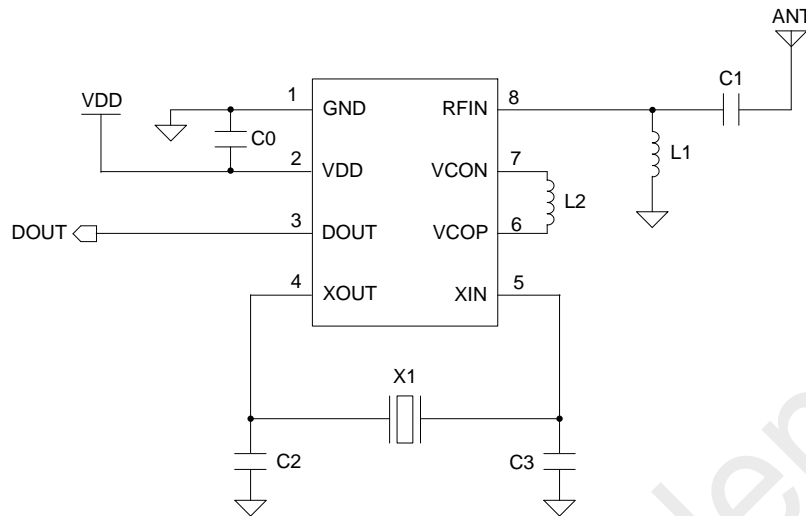
Typical Application

Figure 1. CMT2210LW Typical Application Schematic

Table 1. BOM of 315/433.92 MHz Typical Application

Designator	Descriptions	Value (Match to 50Ω ANT)		Value (Common Used ANT)		Unit	Manufacturer
		315 MHz	433.92 MHz	315 MHz	433.92 MHz		
U1	CMT2210LW, low-cost 315/433.92 MHz OOK stand-alone receiver	-		-		-	CMOSTEK
X1	±20 ppm, SMD32*25 mm, crystal	18.8744	26	18.8744	26	MHz	EPSON
L1	±5%, 0603 multi-layer chip inductor	33	27	68	33	nH	Murata LQG18
L2	±5%, 0603 multi-layer chip inductor	33	22	33	22	nH	Murata LQG18
C1	±0.25 pF, 0402 NP0, 50 V	5.6	3.3	4.3	2.7	pF	Murata GRM15
C0	±20%, 0402 X7R, 25 V	0.1		0.1		uF	Murata GRM15
C2, C3	±5%, 0402 NP0, 50 V	27		27		pF	Murata GRM15

Abbreviations

Abbreviations used in this data sheet are described below

AGC	Automatic Gain Control	**PC**	Personal Computer
AN	Application Notes	**PCB**	Printed Circuit Board
BER	Bit Error Rate	**PLL**	Phase Lock Loop
BOM	Bill of Materials	**PN9**	Pseudorandom Noise 9
BSC	Basic Spacing between Centers	**POR**	Power On Reset
BW	Bandwidth	**PUP**	Power Up
DC	Direct Current	**QFN**	Quad Flat No-lead
EEPROM	Electrically Erasable Programmable Read-Only Memory	**RF**	Radio Frequency
		RFPDK	RF Products Development Kit
ESD	Electro-Static Discharge	**RoHS**	Restriction of Hazardous Substances
ESR	Equivalent Series Resistance	**RSSI**	Received Signal Strength Indicator
IF	Intermediate Frequency	**Rx**	Receiving, Receiver
LNA	Low Noise Amplifier	**SAR**	Successive Approximation Register
LO	Local Oscillator	**SOP**	Small Outline Package
LPOSC	Low Power Oscillator	**SPI**	Serial Port Interface
Max	Maximum	**TH**	Threshold
MCU	Microcontroller Unit	**Tx**	Transmission, Transmitter
Min	Minimum	**Typ**	Typical
MOQ	Minimum Order Quantity	**VCO**	Voltage Controlled Oscillator
NP0	Negative-Positive-Zero	**XOSC**	Crystal Oscillator
NC	Not Connected	**XTAL/Xtal**	Crystal
OOK	On-Off Keying		

Table of Contents

1. Electrical Characteristics

VDD = 3.3 V, T_{OP} = 25 ℃, F_{RF} = 433.92 MHz, sensitivities are measured in receiving a PN9 sequence and matching to 50 Ω impedance, with the BER of 0.1%. All measurements are performed using the board CMT2210LW-EM V1.0, unless otherwise noted.

1.1 Recommended Operation 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[2]		Human Body Model (HBM)	-2	2	kV
Latch-up Current		@ 85 ℃	-100	100	mA

Notes:

[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.

[2]. The CMT2210LW is high-performance RF integrated circuits with VCON/P pins having an ESD rating < 2 kV HBM. Handling and assembly of this device should only be done at ESD-protected workstations.
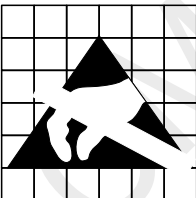
Caution! ESD sensitive device. Precaution should be used when handling the device in order to prevent permanent damage.

1.3 Receiver Specifications

Table 4. Receiver Specifications

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Frequency Range	F_{RF}	F_{XTAL} = 18.8744 MHz		315		MHz
		F_{XTAL} = 26 MHz		433.92		MHz
Symbol Rate	SR		0.1		3.4	ksps
Sensitivity	S_{315}	F_{RF} = 315 MHz, SR = 2.4 ksps, BER = 0.1%		-109		dBm
	$S_{433.92}$	F_{RF} = 433.92 MHz, SR = 2.4 ksps, BER = 0.1%		-108		dBm
Saturation Input Signal Level	P_{LVL}			10		dBm
Working Current	I_{DD315}	F_{RF} = 315 MHz		3.3		mA
	$I_{DD433.92}$	F_{RF} = 433.92 MHz		3.8		mA
Sleep Current	I_{SLEEP}			60		nA
Frequency Resolution	F_{RES}			24.8		Hz
Frequency Synthesizer Settle Time	T_{LOCK}	From XOSC settled		150		us
Blocking Immunity	BI	SR = 1 ksps, ±1 MHz offset, CW interference		52		dB
		SR = 1 ksps, ±2 MHz offset, CW interference		74		dB
		SR = 1 ksps, ±10 MHz offset, CW interference		75		dB
Image Rejection Ratio	IMR	IF = 280 kHz		25		dB
Input 3rd Order Intercept Point	IIP3	Two tone test at 1 MHz and 2 MHz offset frequency. Maximum system gain settings		-25		dBm
Receiver Bandwidth	BW			200		kHz
Receiver Start-up Time	$T_{START-UP}$	From power up to receive		7.3		ms

1.4 Crystal Oscillator

Table 5. Crystal Oscillator Specifications

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Crystal Frequency[1]	$F_{XTAL315}$	F_{RF} = 315 MHz		18.8744		MHz
	$F_{XTAL433.92}$	F_{RF} = 433.92 MHz		26		MHz
Crystal Tolerance[2]				±20		ppm
Load Capacitance	C_{LOAD}		10	15	20	pF
Crystal ESR	Rm				60	Ω
XTAL Startup Time[3]	t_{XTAL}			400		us

Notes:

[1]. The CMT2210LW can directly work with external reference clock input to XIN pin (a coupling capacitor is required) with peak-to-peak amplitude of 0.3 to 0.7 V.

[2]. This is the total tolerance including (1) initial tolerance, (2) crystal loading, (3) aging, and (4) temperature dependence. The acceptable crystal tolerance depends on RF frequency and channel spacing/bandwidth.

[3]. This parameter is to a large degree crystal dependent.
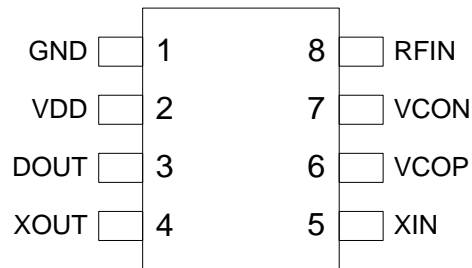
2. Pin Descriptions

```
        GND  ┌──┐ 1        8 ┌──┐  RFIN
        VDD  ┌──┐ 2        7 ┌──┐  VCON
       DOUT  ┌──┐ 3        6 ┌──┐  VCOP
       XOUT  ┌──┐ 4        5 ┌──┐  XIN
```

Figure 2. CMT2210LW Pin Assignments

Table 6. CMT2210LW Pin Descriptions

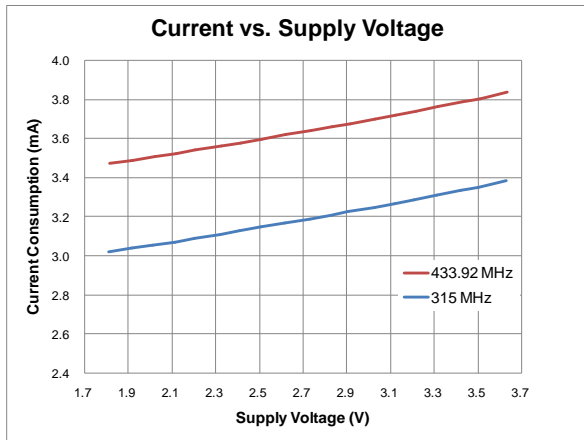| Pin Number	Name	I/O	Descriptions
1	GND	I	Ground
2	VDD	I	Power supply input
3	DOUT	O	Received data output
4	XOUT	O	Crystal oscillator output
5	XIN	I	Crystal oscillator input or external reference clock input
6	VCOP	IO	VCO tank, connected to an external inductor
7	VCON		
8	RFIN	I	RF signal input to the LNA

3. Typical Performance Characteristics

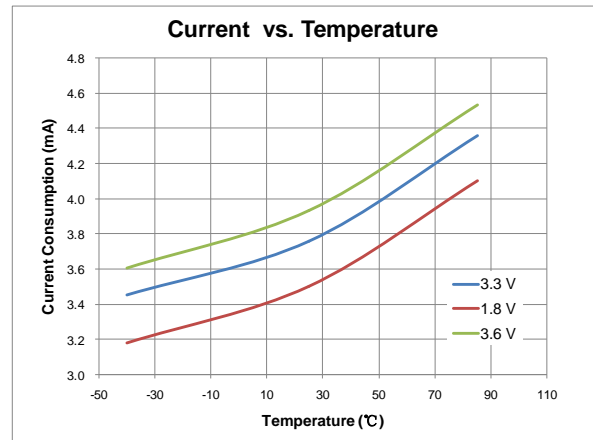**Figure 3. Current vs. Voltage, F_{RF} = 315/433.92 MHz, SR = 1 ksps**

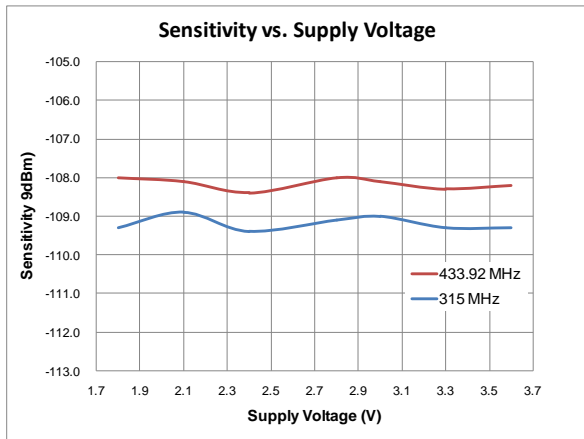**Figure 4. Current vs. Temperature, F_{RF} = 433.92 MHz, SR = 1 ksps**

Figure 5. Sensitivity vs. Supply Voltage, SR = 1 ksps, BER = 0.1%
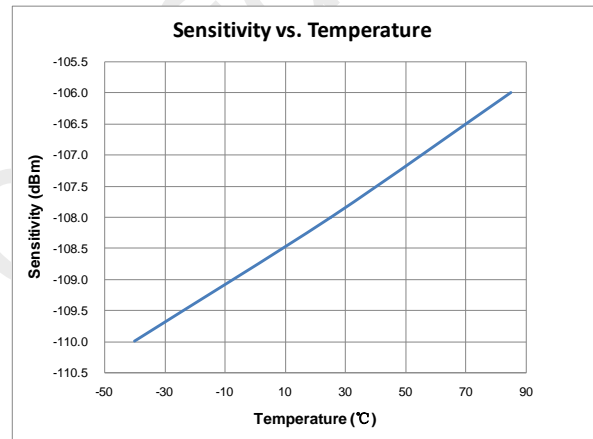
Figure 6. Sensitivity vs. Temperature, F_{RF} = 433.92 MHz, V_{DD} = 3.3 V, SR = 1 ksps, BER = 0.1%
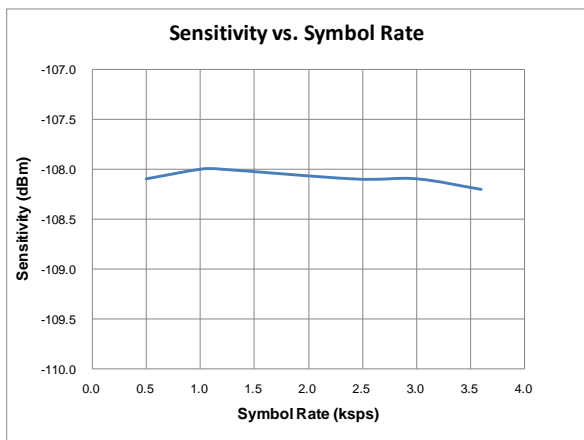
Figure 7. Sensitivity vs. SR, F_{RF} = 433.92 MHz, V_{DD} = 3.3 V, BER = 0.1%
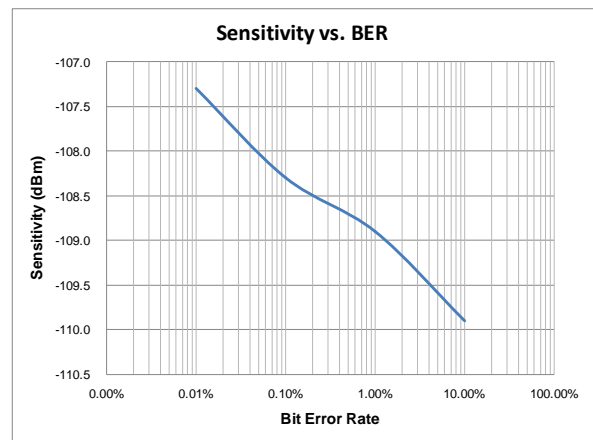
Figure 8. Sensitivity vs. BER, F_{RF} = 433.92 MHz, V_{DD} = 3.3 V, SR = 1 ksps
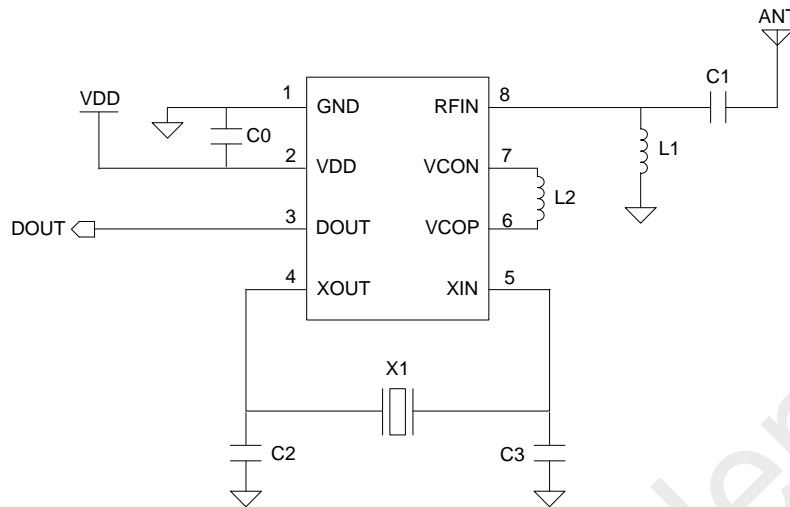
4. Typical Application Schematic

Figure 9. Typical Application Schematic

Notes:

1. The general layout guidelines are listed below. For more design details, please refer to "AN107 CMT221x Schematic and PCB Layout Design Guideline".

   - Use as much continuous ground plane metallization as possible.
   - Use as many grounding vias (especially near to the GND pins) as possible to minimize series parasitic inductance between the ground pour and the GND pins.
   - Avoid using long and/or thin transmission lines to connect the components.
   - Place C0 as close to the CMT2210LW as possible for better filtering.

2. The table below shows the BOM of typical application for 50 Ω antennas and other common used antennas in the market.

Table 7. BOM of 315/433.92 MHz Typical Application

| Designator	Descriptions	Value (Match to 50Ω ANT)		Value (Common Used ANT)		Unit	Manufacturer
		315 MHz	433.92 MHz	315 MHz	433.92 MHz		
U1	CMT2210LW, low-cost 315/433.92 MHz OOK stand-alone receiver	-		-		-	CMOSTEK
X1	±20 ppm, SMD32*25 mm, crystal	18.8744	26	18.8744	26	MHz	EPSON
L1	±5%, 0603 multi-layer chip inductor	33	27	68	33	nH	Murata LQG18
L2	±5%, 0603 multi-layer chip inductor	33	22	33	22	nH	Murata LQG18
C1	±0.25 pF, 0402 NP0, 50 V	5.6	3.3	4.3	2.7	pF	Murata GRM15
C0	±20%, 0402 X7R, 25 V	0.1		0.1		uF	Murata GRM15
C2, C3	±5%, 0402 NP0, 50 V	27		27		pF	Murata GRM15

5. Functional Descriptions
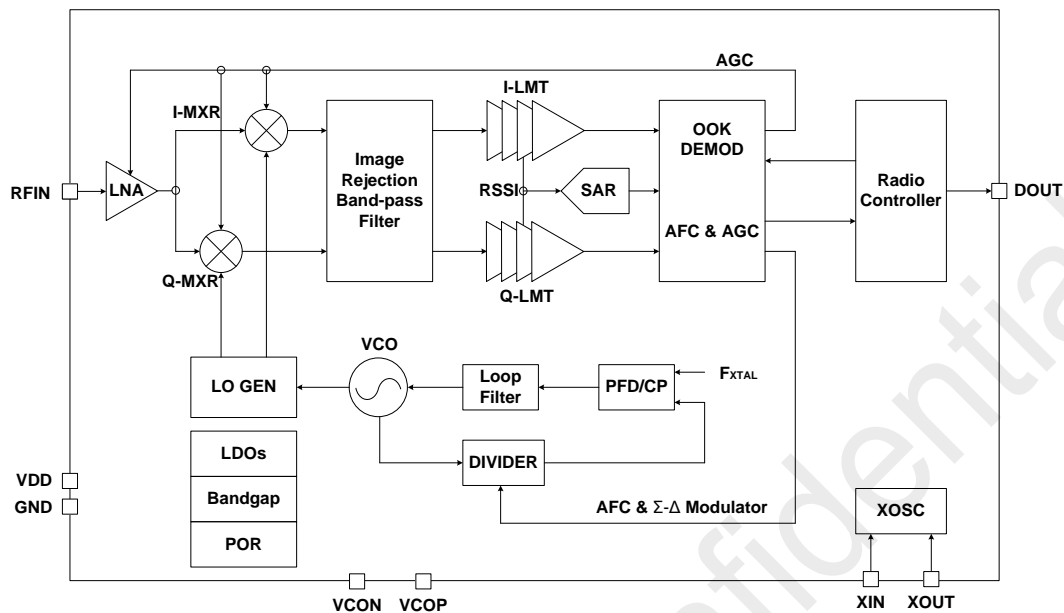
Figure 10. Functional Block Diagram

5.1 Overview

The CMT2210LW is ultra low power, high performance, low-cost OOK stand-alone RF receiver for various 315/433.92 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 based on a fully integrated, low-IF receiver architecture. The low-IF architecture facilitates a very low external component count and does not suffer from powerline - induced interference problems. The synthesizer contains a VCO and a low noise fractional-N PLL with an output frequency resolution of 24.8 Hz. The VCO operates at 2x the Local Oscillator (LO) frequency to reduce spurious emissions. Every analog block is calibrated on each Power-on Reset (POR) to the internal reference voltage. The calibration helps the device to finely work under different temperatures and supply voltages. The baseband filtering and demodulation is done by the digital demodulator. The demodulated signal is output to the external MCU via the DOUT pin.

The CMT2210LW is a true plug-and-run device, no register control or manufacturing programming is needed. This simplifies the development and manufacturing effort significantly. The operation frequency can be changed between 315 and 433.92 MHz by selecting proper value of crystal, and it can work with most low end transmitters with its good adaptability. The CMT2210LW operates from 1.8 to 3.6 V so that it can finely work with most batteries to their useful power limits. The receive current is only 3.3 mA at 315 MHz and 3.8 mA at 433.92 MHz. The CMT2210LW receiver together with the CMT211x transmitter enables an ultra low cost RF link.

5.2 Modulation, Frequency and Symbol Rate

The CMT2210LW supports OOK demodulation with the symbol rate from 0.1 to 3.4 ksps. It supports the license free ISM frequencies around 315 MHz and 433.92 MHz. The internal frequency synthesizer contains a high-purity VCO and a low noise fractional-N PLL with an output frequency resolution of 24.8 Hz. See the table below for the demodulation, frequency and symbol rate information.

Table 8. Modulation, Frequency and Symbol Rate

Parameter	Value	Unit
Demodulation	OOK	-
Frequency	315/433.92	MHz
Frequency Resolution	24.8	Hz
Symbol Rate	0.1 to 3.4	ksps

5.3 Main Configurations

Unlike other NextGenRF™ receivers, the CMT2210LW does not need any register control or manufacturing programming. The configuration of the device is fixed in order to save the development effort, reduce system cost and simplify the manufacturing process. The main configurations are listed in the table below. Please note that if more flexibility is needed in the system, the user can use other NextGenRF™ receivers like CMT2210AW and etc. For those products, an embedded EEPROM is available on chip for the user to configure all the product features.

Table 9. CMT2210LW Main Configurations

Parameters		CMT2210LW-ESR	Unit
RF Settings	Frequency	315/433.92	MHz
	Modulation	OOK	-
	Symbol Rate	0.1 – 3.4	ksps
	Receiver Bandwidth	200	kHz
	Xtal Stabilizing Time	310	us
Operation Settings	Sleep Time	3	ms
	Rx Time	2000	ms
OOK Settings	Demod Method	Fixed TH	-
	Fixed Demod TH	60	-

5.4 Internal Blocks Description

5.4.1 RF Front-end and AGC

The CMT2210LW features a low-IF receiver. The RF front-end of the receiver consists of a Low Noise Amplifier (LNA), I/Q mixer and a wide-band power detector. Only a low-cost inductor and a capacitor are required for matching the LNA to any 50 Ω antennas. The input RF signal induced on the antenna is amplified and down-converted to the IF frequency for further processing.

By means of the wide-band power detector and the attenuation networks built around the LNA, the Automatic Gain Control (AGC) loop regulates the RF front-end's gain to get the best system linearity, selectivity and sensitivity performance, even though the receiver suffers from strong out-of-band interference.

5.4.2 IF Filter

The signals coming from the RF front-end are filtered by the fully integrated 3rd-order band-pass image rejection IF filter which achieves over 25 dB image rejection ratio typically. The IF center frequency is dynamically adjusted to enable the IF filter to locate to the right frequency band, thus the receiver sensitivity and out-of-band interference attenuation performance are kept optimal despite the manufacturing process tolerances. The IF bandwidth is fixed at 200 kHz.

5.4.3 RSSI

The subsequent multistage I/Q Log amplifiers enhance the output signal from IF filter before it is fed for demodulation. Receive Signal Strength Indicator (RSSI) generators are included in both Log amplifiers which produce DC voltages that are directly proportional to the input signal level in both of I and Q path. The resulting RSSI is a sum of both these two paths. Extending from the nominal sensitivity level, the RSSI achieves dynamic range over 66 dB.

The CMT2210LW integrates a patented DC-offset cancellation engine. The receiver sensitivity performance benefits a lot from the novel, fast and accurate DC-offset removal implementation.

5.4.4 SAR ADC

The on-chip 8-bit SAR ADC digitalizes the RSSI for OOK demodulation.

5.4.5 Crystal Oscillator

The crystal oscillator is used as the reference clock for the PLL frequency synthesizer and system clock for the digital blocks. A crystal should be used with appropriate loading capacitors (C2 and C3 in Figure 9 of Page 9). The values of the loading capacitors depend on the total load capacitance C_L specified for the crystal. The total load capacitance seen between the XIN and XOUT pin should equal C_L for the crystal to oscillate at desired frequency.

$$C_L = \frac{1}{\frac{1}{C_2} + \frac{1}{C_3}} + C_{parasitic}$$

The parasitic capacitance is constituted by the input capacitance and PCB tray capacitance. The ESR of the crystal should be within the specification in order to ensure a reliable start-up. An external signal source can easily be used in place of a conventional XTAL and should be connected to the XIN pin. The incoming clock signal is recommended to have a peak-to-peak swing in the range of 300 mV to 700 mV and AC-coupled to the XIN pin.

5.4.6 Frequency Synthesizer

A fractional-N frequency synthesizer is used to generate the LO frequency for the down conversion I/Q mixer. The frequency synthesizer is fully integrated except the VCO tank inductor which enables the ultra low-power receiver system design. Using the 26 MHz reference clock provided by the crystal oscillator or the external clock source, it can generate receive frequencies of 315 and 433.92 MHz with a frequency resolution of 24.8 Hz.

The VCO always operates at 2x of LO frequency. A high Q (at VCO frequency) tank inductor should be chosen to ensure the VCO oscillates at any conditions meanwhile burns less power and gets better phase noise performance. In addition, properly layout the inductor matters a lot of achieving a good phase noise performance and less spurious emission. The recommended VCO inductors for different LO frequency bands are shown as bellow.

Table 10. VCO Inductor for 315/433.92 MHz Frequency Band

LO Frequency Band (MHz)	**315**	**433.92**
VCO Inductor (nH)	33	22

Multiple subsystem calibrations are performed dynamically to ensure the frequency synthesizer operates reliably in any working conditions.

5.5 Operation States

As the CMT2210LW is operating in duty cycle receive mode, the device will go through the states shown as the figure below after
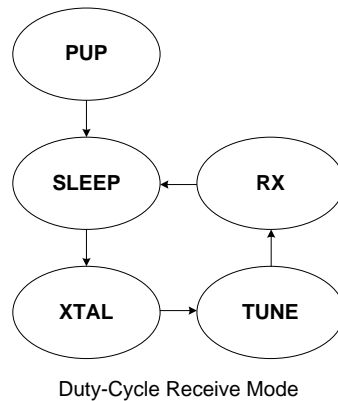
the power up.

Duty-Cycle Receive Mode

Figure 11. Operation States in Duty Cycle Receive Mode

Power Up (PUP) State

Once the device is powered up, the device will go through the Power Up (PUP) sequence which includes the task of releasing the Power-On Reset (POR), turning on the crystal and calibrating the internal blocks. The PUP takes about 4 ms to finish in the always receive mode. The average current of the PUP sequence is about 0.9 mA.

SLEEP State

In this state, all the internal blocks are powered down except the sleep timer. The sleep time is fixed at 3 ms. The sleep current is about 60 nA.

XTAL State

Once the device wakes up from the SLEEP State, the crystal oscillator restarts to work. The current consumption in this state is about 520 uA.

TUNE State

The device is tuned to the desired frequency and ready to receive. It usually takes approximately 300 us to complete the tuning sequence. The current consumption in this state is about 2 mA.

RX State

The device receives the incoming signals and outputs the demodulated data on the DOUT pin. The current in this state is about 3.3 mA (315 MHz) or 3.8 mA (433.92 MHz).

5.6 Duty Cycle Receive Mode

In the duty-cycle mode, after the PUP the device will automatically repeat the sequence of SLEEP, XTAL, TUNE and RX until the device is powered down. This allows the device to re-tune the synthesizer regularly to adept to the changeable environment and therefore remain its highest performance. The device will continuously receive any incoming signals during the RX state and send out the demodulated data on the DOUT pin. The PUP sequence consumes about 4 ms. See the figure below for the timing and current consumption of the duty cycle receive mode
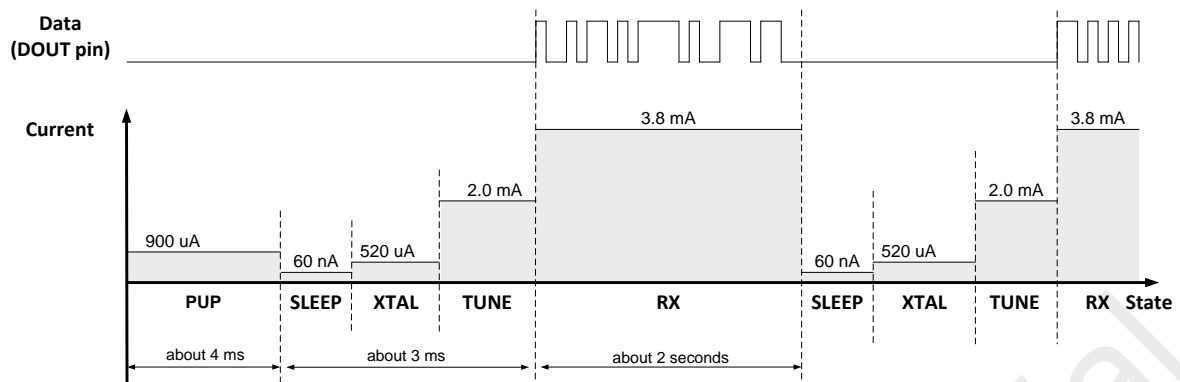
Figure 12. Timing and Current Consumption for Duty-Cycle Receive Mode

The advantages of the duty-cycle receive mode are listed below.

- Maintaining the highest performance of the device by regular frequency re-tune.
- Increasing the system stability by regular sleep (resetting most of the blocks).

If more current saving is required in the application, or other parameter need to be configured, the user can also use CMT2210AW or other NextGenRF^{TM} receivers with embedded EEPROM built-in and all product features configurable. For the more details, please refer to the "AN108 CMT2210A Configuration Guideline".

6. Ordering Information

Table 11. CMT2210LW Ordering Information

Part Number	Descriptions	Package Type	Package Option	Operating Condition	MOQ / Multiple
CMT2210LW-ESR[1]	Low-Cost 315/433.92 MHz OOK Stand-Alone Receiver	SOP8	Tape & Reel	1.8 to 3.6 V, -40 to 85 ℃	2,500
CMT2210LW-ESB[1]	Low-Cost 315/433.92 MHz OOK Stand-Alone Receiver	SOP8	Tube	1.8 to 3.6 V, -40 to 85 ℃	1,000

Note:

[1]. "E" stands for extended industrial product grade, which supports the temperature range from -40 to +85 ℃.

"S" stands for the package type of SOP8.

"R" stands for the tape and reel package option, the minimum order quantity (MOQ) for this option is 2,500 pieces. "B" stands for the tube package option, the minimum order quantity (MOQ) for this option is 1,000 pieces.

If the CMT2210LW-ESR cannot meet the application requirements, the user can order the CMT2210AW-EQR for self-customizing with the RFPDK.

Visit www.cmostek.com/products to know more about the product and product line.

Contact sales@cmostek.com or your local sales representatives for more information.

7. Package Outline

The SOP8 illustrates the package details for the CMT2210LW. The table below lists the values for the dimensions shown in the illustration.
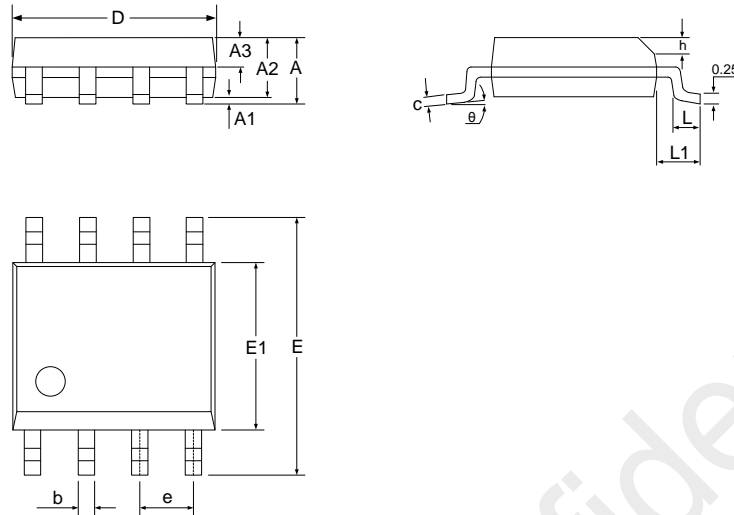

Figure 13. SOP8 Package

Table 12. SOP8 Package Dimensions

Symbol	Size (millimeters)		
	Min	Typ	Max
A	-	-	1.75
A1	0.10	-	0.225
A2	1.30	1.40	1.50
A3	0.60	0.65	0.70
b	0.39	-	0.48
c	0.21	-	0.26
D	4.70	4.90	5.10
E	5.80	6.00	6.20
E1	3.70	3.90	4.10
e	1.27 BSC		
h	0.25	-	0.50
L	0.50	-	0.80
L1	1.05 BSC		
θ	0	-	8°

8. Top Marking

8.1 CMT2210LW Top Marking

CMT2210L

YYWW①②③④⑤⑥

○

Figure 14. CMT2210LW Top Marking

Table 13. CMT2210LW Top Marking Explanation

Mark Method	Laser
Pin 1 Mark	Circle's diameter = 1 mm
Font Height	0.6 mm, right-justified
Font Width	0.4 mm
Line 1 Marking	CMT2210L, represents part number CMT2210LW
Line 2 Marking	YYWW is the Date code assigned by the assembly house. YY represents the last two digits of the mold year and WW represents the workweek ①②③④⑤⑥ is the internal tracking number

9. Other Documentations

Table 14. Other Documentations for CMT2210LW

Brief	Name	Descriptions
AN107	CMT221x Schematic and PCB Layout Design Guideline	Details of CMT2210/13/17/19AW and CMT2210LW PCB schematic and layout design rules, RF matching network and other application layout design related issues.
AN108	CMT2210A Configuration Guideline	Details of configuring CMT2210AW features on the RFPDK.

CMT2210LW

10. Document Change List

Table 15. Document Change List

Rev. No	Chapter	Description of Changes	Date
0.7	All	Initial released version	2014-11-28
0.8	All	Supported frequency range is changed	2015-01-16

11. Contact Information

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