

### Features

- 2.4 - 2.485GHz Frequency Range
- High Efficiency Optimized for Battery Operation
- Delivers up to +22dBm Output Power at 3.3V
- 153.5mA at +22dBm Output Power at 3.3V
- 1.92dB LNA Noise Figure at High current mode
- 2.2 - 3.8V Operation
- Integrated Antenna Diversity Switching
- -40°C to 125°C Extended Temperature Range
- 3mm x 3mm x 0.45mm 16-Pin QFN Package

### Applications

- 802.15.4 ZigBee, RF4CE, Proprietary ISM
- Thread, Matter, Wi-Fi (low-data-rate use cases)
- IoT (Internet of Things), M2M Connectivity
- Mesh Network
- Smart Home Hubs and Gateways
- Consumer Electronics, Smart Appliances
- Smart Lighting, Smart Light Fixture, Smart Metering
- Drone, Game, Toy, Media Remote Controller
- Industrial Wireless Sensor Networks
- Home, Industrial, Factory Automation
- Wireless Sensor Nodes & Networks
- Wireless Audio & Video

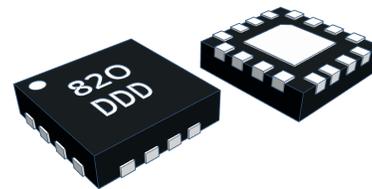
### Description

The 8TR8223 is a compact, multi-function Front-End RFIC (Radio Frequency Integrated Circuit) intended for 802.15.4 ZigBee, Thread, Matter and proprietary ISM wireless protocol systems in the 2.4GHz band.

The 8TR8223 is optimized for battery operation with enhanced efficiency, operating over a wide voltage supply range from 2.2V to 3.8V, suited for a wide array of applications including battery-powered wireless systems.

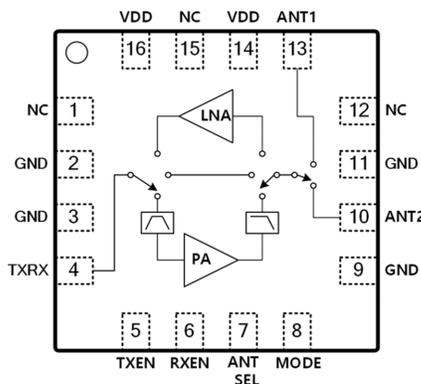
The 8TR8223 combines a transmit power amplifier (PA), receive low noise amplifier (LNA), a single pole, double throw (SPDT) transmit / receive (T/R) switch (Figure 1) in a 3mm x 3mm x 0.45mm 16-pin QFN package. It also comes integrated with filter networks and input / output matching circuitry. The device delivers up to +22dBm saturated output power at a supply voltage of 3.3V.

The 8TR8223 is RoHS compliant, halogen-free and REACH Compliant. It is rated for Moisture Sensitivity Level 1 (MSL1), reflow at 260°C per JEDEC J-STD-020. Refer to IPC / JEDEC J-STD-020 for detailed solder reflow temperature and profile.



16-Lead 3mm x 3mm x 0.45mm, QFN Package

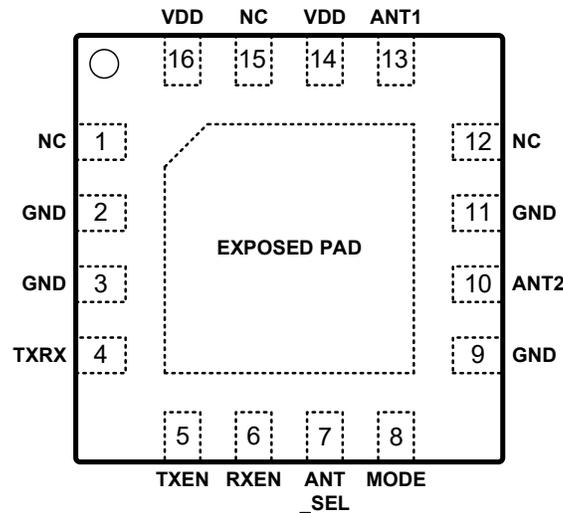
**Figure 2. 8TR8223 Package Type**



**Figure 1. 8TR8223 Functional Block Diagram**

### Ordering Information

Part Number	Description
8TR8223	2.4GHz Front-End RFIC 2500pieces per Tape and Reel
8TR8223-EVB	Fully Tested and Characterize Evaluation Board
8TR8223-DWF	2.4GHz Front-End RFIC Die in Wafer Form

**Pin Descriptions**

**Figure 3. 8TR8223 Pinout (Top View)**
**Table 1. 8TR8223 Signal Descriptions**

Pin	Name	Description	Pin	Name	Description
1	NC	Not connected internally	9	GND	Ground
2	GND	Ground	10	ANT2	Antenna Port2 (DC shorted to GND)
3	GND	Ground	11	GND	Ground
4	TXRX	Transmit/Receive Port (DC shorted to GND)	12	NC	Not connected internally
5	TXEN	Control Logic Pin	13	ANT1	Antenna Port1 (DC shorted to GND)
6	RXEN	Control Logic Pin	14	VDD	DC Voltage Supply
7	ANT_SEL	Control Logic Pin	15	NC	Not connected internally
8	MODE	Control Logic Pin	16	VDD	DC Voltage Supply
EXPOSED PAD		Exposed pad should be connected to GND.			

### Electrical and Mechanical Specifications

The absolute maximum ratings of the 8TR8223 are provided in Table 2. The recommended operating conditions are specified in Table 3. The electrical specifications are provided in Tables 4 through 10, as measured on 8TR8223 evaluation board(Figure 5). The state of the 8TR8223 is determined by the logic provided in Table 11 and 12.

**Table 2. 8TR8223 Absolute Maximum Ratings**

Parameter		Units	Min	Max	Remark
Supply Voltage (VDD)		V	0	4.0	
Control Logic Pin (TXEN, RXEN, MODE)		V	0	VDD	
Transmit Output Power at ANT Port		dBm		24	
Transmit Input Power at TXRX Port		dBm		10	
Receive Input power at ANT Port		dBm		10	
Bypass Input power at ANT Port		dBm		20	
Storage Temperature		°C	-40	150	
ESD - HBM <sup>1</sup>	All pins	V		±4000	
ESD - CDM <sup>2</sup>	All pins	V		±1000	
MSL <sup>3</sup>		Level		MSL1	

Note: Sustained operation at or above the Absolute Maximum Ratings for any single or combinations of the above parameters may result in permanent damage to the device and is not recommended. All Maximum RF Input Power Ratings assume 50Ω terminal impedance.

1. Electrostatic discharge Human Body Model(HBM) Reference Document: ANSI/ESDA/JEDEC JS-001-2017
2. Electrostatic discharge Charged Device Model(CDM) Reference Document: ANSI/ESDA/JEDEC JS-002-2018
3. Moisture Sensitivity Level(MSL) Reference Document: JEDEC Standard J-STD-020

**Table 3. 8TR8223 Recommended Operating Conditions**

Parameter	Units	Min	Typ	Max
Supply Voltage (VDD, recommended) <sup>1</sup>	V	2.2	3.3	3.8
Control Pin - Logic High State (TXEN, RXEN, MODE, ANT_SEL)	V	1.5		VDD <sup>2</sup>
Control Pin - Logic Low State (TXEN, RXEN, MODE, ANT_SEL)	V	0		0.4
Operating Frequency Range	GHz	2.4		2.485
Operating Temperature	°C	-40	25	125

1. Functional working with degraded performance for the supply voltage range 2.2V to 2.7V.
2. For Control Voltages > 3.0V, a 10kΩ series resistor should be used at the Control Logic Pins.

**Table 4. 8TR8223 Dual Antenna Switch Characteristics**

Parameter	Units	Min	Typ	Max	Remark
Isolation between ANT1 and ANT2 Ports	dB		21.6		
ANT1 to ANT2 Switching Time	nsec		1000		From 50% of ANT_SEL to 90% of RF power

**Table 5. 8TR8223 Electrical Specifications: Transmit Mode**

(VDD = 3.3V, TXEN = High, RXEN = High or Low, MODE = Low, T<sub>Ambient</sub> = 25°C, Excluding PCB and Connector Loss, Unless Otherwise Noted)

Parameter	Units	Min	Typ	Max	Test Conditions
Saturated Output Power	dBm		22.3		
EDR Spectral Mask	dBm		10.6		Spectral Mask compliant, 3Mbps EDR signal
Large-Signal Gain	dB		24.4		+22dBm Pout
Current Consumption	mA		98.7		+19.5dBm Pout
			149.1		+22dBm Pout
Tx Quiescent Current	mA		20.7		No RF applied
Second Harmonic	dBm/MHz		-24.5		+19.5dBm Pout Without external harmonic filter
Third Harmonic	dBm/MHz		-13.2		
Input Return Loss	dB		21		
Output Return Loss	dB		12		
Load VSWR for Stability			6:1		All Non-harmonic Spurs Less than -55dBm/MHz Up to +22dBm
Load VSWR for Ruggedness			10:1		No Damage

**Table 6. 8TR8223 Electrical Specifications: Receive(High current) Mode**

(VDD = 3.3V, TXEN = Low, RXEN = High, MODE = Low, T<sub>Ambient</sub> = 25°C, Excluding PCB and Connector Loss, Unless Otherwise Noted)

Parameter	Units	Min	Typ	Max	Test Conditions
Small-Signal Gain	dB		18.9		
Current Consumption	mA		12.3		
Noise Figure	dB		1.99		
Input P1dB	dBm		-14		
Input IP3	dBm		-3.6		Pin = -35dBm/Tone, 1MHz spacing
Input Return Loss	dB		10.0		
Output Return Loss	dB		10.2		

**Table 7. 8TR8223 Electrical Specifications: Receive(Low current) Mode**

(VDD = 3.3V, TXEN = Low, RXEN = High, MODE = High, T<sub>Ambient</sub> = 25°C, Excluding PCB and Connector Loss, Unless Otherwise Noted)

Parameter	Units	Min	Typ	Max	Test Conditions
Small-Signal Gain	dB		16.5		
Current Consumption	mA		5.9		
Noise Figure	dB		2.2		
Input P1dB	dBm		-14		
Input IP3	dBm		-3.6		Pin = -35dBm/Tone, 1MHz spacing
Input Return Loss	dB		8.2		
Output Return Loss	dB		9.9		

**Table 8. 8TR8223 Electrical Specifications: Bypass Mode**

 (VDD = 3.3V, TXEN = Low, RXEN = Low, MODE = High, T<sub>Ambient</sub> = 25°C, Excluding PCB and Connector Loss, Unless Otherwise Noted)

Parameter	Units	Min	Typ	Max	Test Conditions
Bypass Current	uA		5.1		
Insertion Loss	dB		2.71		

**Table 9. 8TR8223 Electrical Specifications: Shutdown Mode**

 (VDD = 3.3V, TXEN = Low, RXEN = Low, MODE = Low, T<sub>Ambient</sub> = 25°C, Excluding PCB and Connector Loss, Unless Otherwise Noted)

Parameter	Units	Min	Typ	Max	Test Conditions
Shutdown Current	uA		1.0		

**Table 10. 8TR8223 Electrical Specifications: Switching Time**

 (VDD = 3.3V, T<sub>Ambient</sub> = 25°C, Unless Otherwise Noted)

Parameter	Units	Min	Typ	Max	Test Conditions
TX to RX	nsec		400		From 50% of TXEN to 90% of RX power
TX to Bypass	nsec		400		From 50% of MODE to 90% of Bypass power
TX to Shutdown	nsec		100		From 50% of TXEN to 10% of TX power
RX to TX	nsec		800		From 50% of TXEN to 90% of TX power
RX to Bypass	nsec		400		From 50% of MODE to 90% of Bypass power
RX to Shutdown	nsec		100		From 50% of RXEN to 10% of RX power
Bypass to TX	nsec		800		From 50% of TXEN to 90% of TX power
Bypass to RX	nsec		400		From 50% of RXEN to 90% of RX power
Bypass to Shutdown	nsec		800		From 50% of MODE to 10% of Bypass power
Shutdown to TX	nsec		800		From 50% of TXEN to 90% of TX power
Shutdown to RX	nsec		400		From 50% of RXEN to 90% of RX power
Shutdown to Bypass	nsec		200		From 50% of MODE to 90% of Bypass power

**Table 11. 8TR8223 Electrical Specifications: Mode Control Logic**

"1" = Logic High, "0" = Logic Low, All Control logic pins must have a state defined as either "0" or "1".

TXEN	RXEN	MODE	Operational Mode
0	0	0	Shutdown Mode
0	0	1	Bypass Mode
0	1	0	RX High Current Mode
0	1	1	RX Low Current Mode
1	0 or 1	0	TX Mode

**Table 12. 8TR8223 Electrical Specifications: Antenna Select Logic**

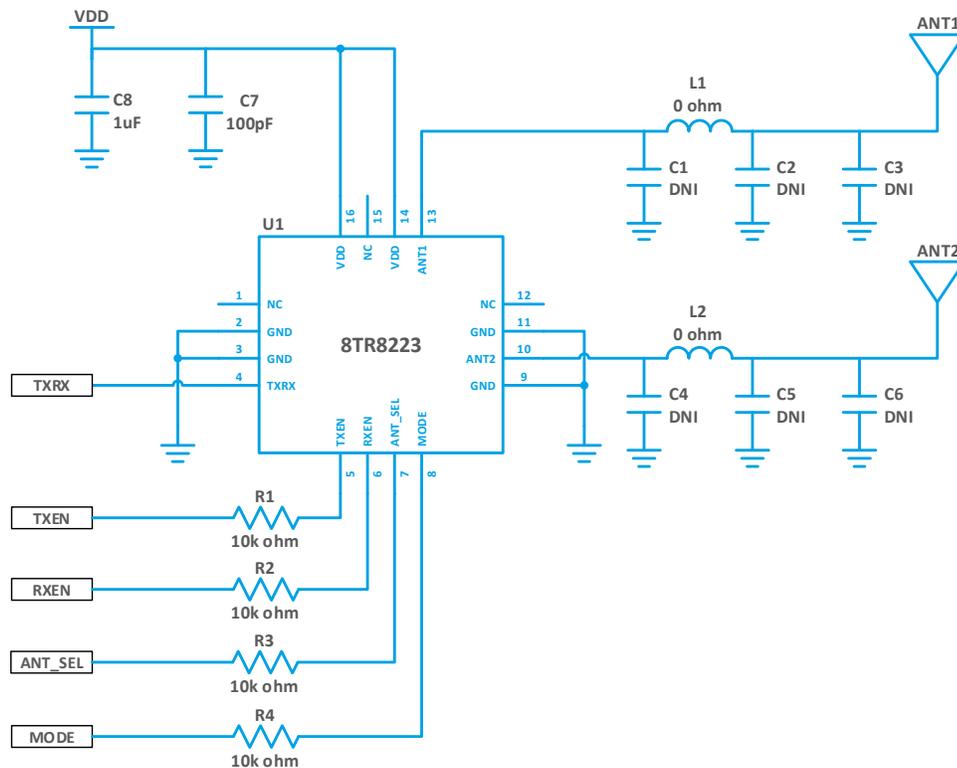
"1" = Logic High, "0" = Logic Low, All Control logic pins must have a state defined as either "0" or "1".

ANT_SEL	Operational Mode
NC/0	ANT1 Port Enabled
1	ANT2 Port Enabled

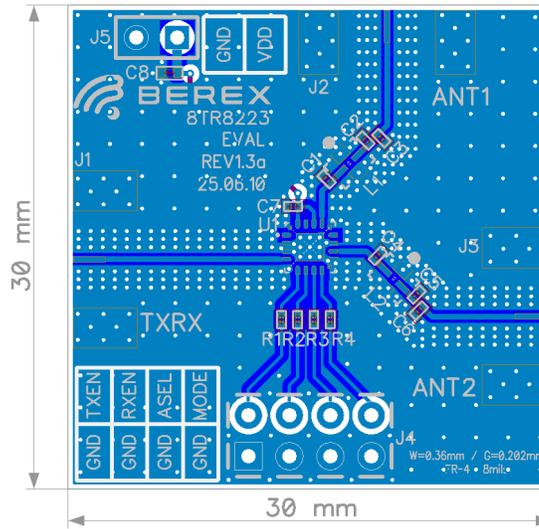
### Application Note

The 8TR8223 Application note provides detailed descriptions and test data over various operating conditions. Visit [www.berex.com](http://www.berex.com) or contact BeRex at [sales@berex.com](mailto:sales@berex.com) to request additional documentation.

### Evaluation Board Schematic and PCB Layout



**Figure 4. 8TR8223 Evaluation Board Schematic**

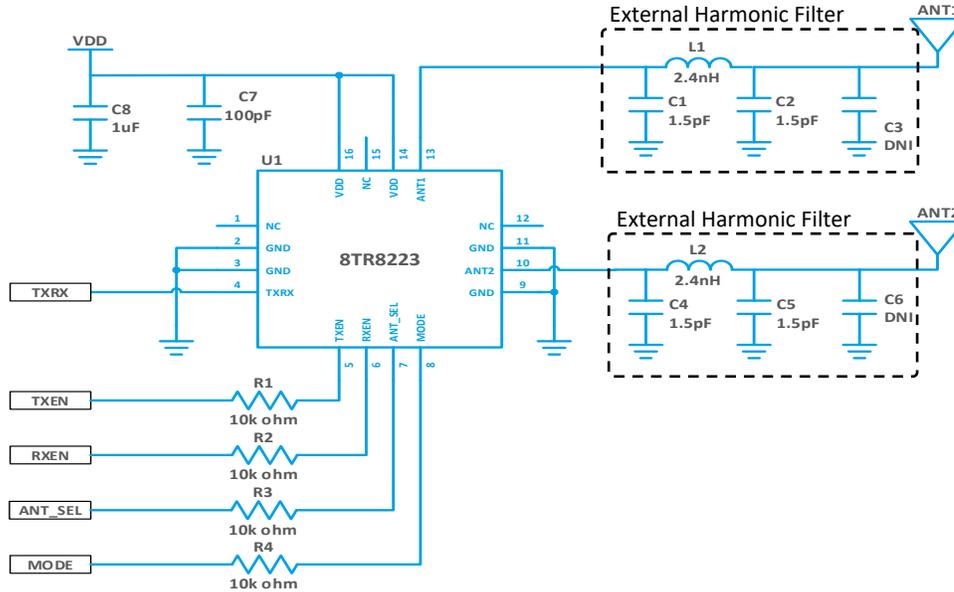


**Figure 5. 8TR8223 Evaluation Board PCB Layout**

**Table 13. 8TR8223 Evaluation Board Bill of Materials (BOM)**

Component	Value	Manufacturer	Mfr Part Number	Size	Description
R1, R2, R3, R4	10kΩ	Panasonic	ERJ-1GNF1002C	0201	RES SMD 10kΩ 1% 1/20W 0201
C1 - C6	DNI			0201	
C7	100pF	muRata	GRM0335C1H101JA01D	0201	CAP CER 100pF 50V C0G/NP0 0201
C8	1uF	muRata	GRM155Z71A105KE01J	0402	CAP CER 1uF 10V X7R 0402
L1, L2	0Ω	Panasonic	ERJ-1GN0R00C	0201	RES SMD 0Ω JUMPER 1/20W 0201
J1, J2, J3	SMA	Gigalane	PAF-S05-008	End launch	SMA 50Ω End Launch Jack Receptacle
J4	2x4	Adam Tech	PH2RA-08-UA	2x4	HEADER DR RA TH 2x4
J5	1x2	Adam Tech	PH1RA-02-UA	1x2	HEADER DR RA TH 1x2
U1	8TR8223	BeRex	8TR8223	QFN 3x3	2.4GHz ZigBee/Thread FEM

### Application Schematic



⊗ External Harmonic Filter

Performance is sensitive to PCB parasitics. Therefore, custom PCB layout should emulate the Evaluation Board PCB layout attached to this design as closely as possible.

All inductors and capacitors must be populated and located as close as possible to ANT pin. Use ceramic multi-layer inductors for effective filtering. Depending on layout, all inductor and capacitor values may require minor value tweaks for optimum impedance matching.

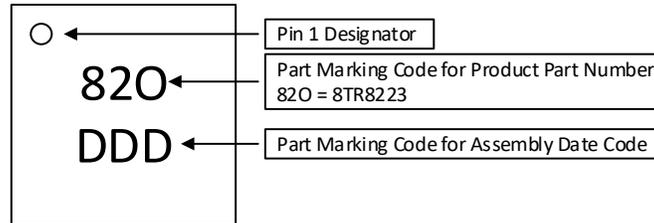
**Figure 6. 8TR8223 Application Schematic**

**Table 14. 8TR8223 Application Bill of Materials (BOM)**

Component	Value	Manufacturer	Mfr Part Number	Size	Description
R1, R2, R3, R4	10kΩ	Panasonic	ERJ-1GNF1002C	0201	RES SMD 10kΩ 1% 1/20W 0201
C1, C2, C4, C5	1.5 pF	muRata	GRM0335C1E1R5BA01D	0201	CAP CER 1.5PF 25V COG/NP0 0201
C3, C6	DNI			0201	
C7	100pF	muRata	GRM0335C1H101JA01D	0201	CAP CER 100pF 50V COG/NP0 0201
C8	1uF	muRata	GRM155Z71A105KE01J	0402	CAP CER 1uF 10V X7R 0402
L1, L2	2.4 nH	muRata	LQP03TN2N4B02D	0201	Fixed IND 2.4 nH 500mA 200mΩ
J1, J2, J3	SMA	Gigalane	PAF-S05-008	End launch	SMA 50Ω End Launch Jack Receptacle
J4	2x4	Adam Tech	PH2RA-08-UA	2x4	HEADER DR RA TH 2x4
J5	1x2	Adam Tech	PH1RA-02-UA	1x2	HEADER DR RA TH 1x2
U1	8TR8223	BeRex	8TR8223	QFN 3x3	2.4GHz ZigBee/Thread FEM



### Package Marking



Note: The part marking: 820 represents the Product Part Number: 8TR8223.

Due to the size limitations of this package, only three (3) characters can be marked on each of two (2) rows. Therefore the Product Part Number is represented in the part marking by a 3-character code.

**Figure 9. 8TR8223 Typical Part Marking**

### ESD Handling Information

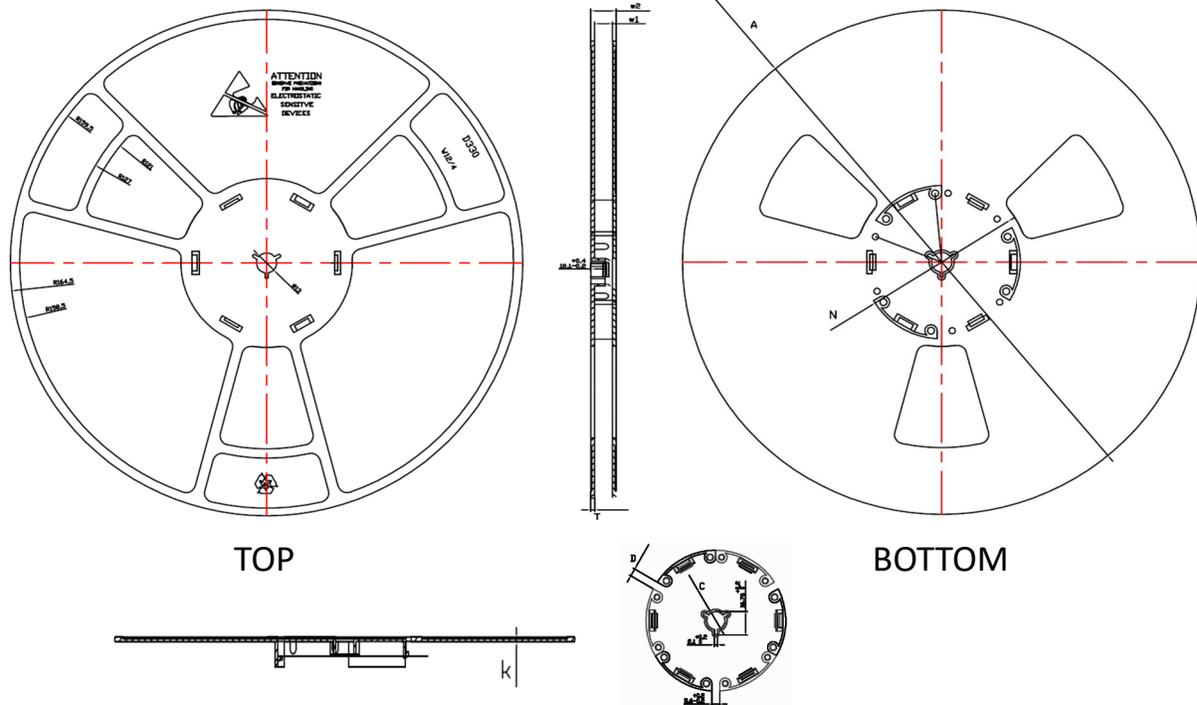
Electro Static Discharge (ESD) can cause immediate (or latent) failures in semiconductor Integrated Circuits (ICs). BeRex, Inc. RFIC products are designed with integral ESD protection structures, and all IC products are tested to meet industry standards for ESD event survival. Users must adhere to all precautions for handling ESD sensitive devices throughout the manufacturing, test, shipping, handling, or operational processes, and during field service operations in order to achieve optimum system performance and life expectancy. Production quantities of this product are shipped in a standard tape and reel format.

### RoHS Compliance

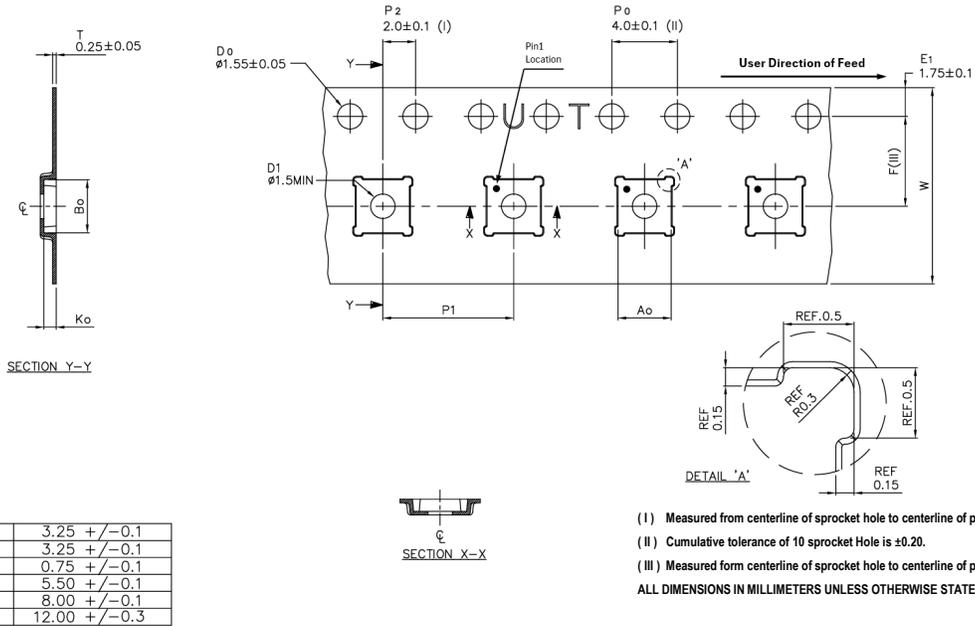
This part is compliant with Restrictions on the Use of Certain Hazardous Substances in Electrical and Electronic Equipment (RoHS) Directive 2011/65/EU as amended by Directive 2015/863/EU.

This part is lead-free, halogen-free and compliant with a concentration of the Substances of Very High Concern (SVHC) candidate list which are contained in a quantity of less than 0.1%(w/w) in each component of a product and/or its packaging placed on the European Community market by the BeRex and Suppliers.

### Tape & Reel



TYPE	A	N	C	D	w1	w2	T	k
12MM	$\phi 330_{-2}^{+2}$	$\phi 100_{-2}^{+2}$	$\phi 13.1_{-0.2}^{+0.2}$	$5.6_{-0.5}^{+0.5}$	$12.4_{-0}^{+2}$	$16.6_{-0}^{+2}$	$2.1 \pm 0.15$	$1.4_{-0.1}^{+0.15}$



Ao	$3.25 \pm 0.1$
Bo	$3.25 \pm 0.1$
Ko	$0.75 \pm 0.1$
F	$5.50 \pm 0.1$
P1	$8.00 \pm 0.1$
W	$12.00 \pm 0.3$

- (I) Measured from centerline of sprocket hole to centerline of pocket.
  - (II) Cumulative tolerance of 10 sprocket Hole is  $\pm 0.20$ .
  - (III) Measured from centerline of sprocket hole to centerline of pocket.
- ALL DIMENSIONS IN MILLIMETERS UNLESS OTHERWISE STATED.

Figure 10. 8TR8223 Tape and Reel Dimension