SKY65352-11: 2.4 GHz Transmit/Receive Front-End Module with Integrated Low-Noise Amplifier

Applications

- 2.4 GHz ISM band radios
- ZigBee® FEMs
- IEEE 802.15.4 applications

Features

- Transmit output power > +20 dBm
- Receive path NF < 2.5 dB
- High efficiency PA
- Configurable transmit/receive paths
- Internal switching and control circuits
- Internal RF match and bias circuits
- Single DC supply = 3.3 V
- All RF ports are internally DC blocked
- Small footprint, MCM (20-pin, 6 x 6 mm) SMT package (MSL3, 260 °C per JEDEC J-STD-020)

Skyworks Pb-free products are compliant with all applicable legislation. For additional information, refer to *Skyworks Definition of Lead (Pb)-Free*, document number SQ04-0073.

Description

Skyworks SKY65352-11 is a high-efficiency Front-End Module (FEM). The device contains a 2400 to 2500 MHz high efficiency transmit path and a low-noise receive path.

The transmit path consists of a high efficiency Power Amplifier (PA) and harmonic filter. The receive path contains a low current Low-Noise Amplifier (LNA).

The transmit and receive paths are connected to a common Single-Pole, Double-Throw (SPDT) switch at both the input and output.
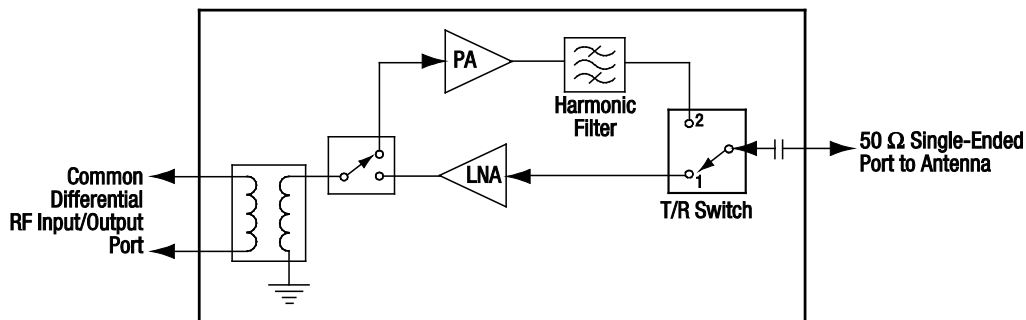
There is an internal balun that allows either the transmit input or the receive output to connect to a differential port.

The device is mounted in a 20-pin, 6 x 6 mm Multi-Chip Module (MCM) Surface-Mounted Technology (SMT) package, which allows for a highly manufacturable low-cost solution.

A block diagram of the SKY65352-11 is shown in Figure 1. The device package and pinout for the 20-pin MCM are shown in Figure 2.
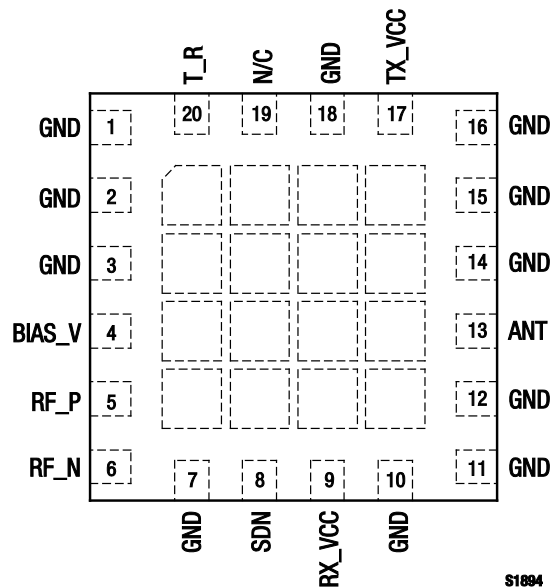

Figure 1. SKY65352-11 Block Diagram

Figure 2. SKY65352-11 Pinout – 20-Pin MCM
(Top View)

Technical Description

Shut Down and T/R Switch Mode Control

Pin 8 (SDN) is used to enable the device while pin 20 (T_R) enables transmit or receive mode. The following control logic is used to configure the transmit, receive, or shut down mode of the SKY65352-11:

SDN (Pin 8)	T_R (Pin 20)	Mode
High	High	Transmit mode
High	Low	Receive mode
Low	Low	Shut Down mode

Bottom Center Paddle

The bottom center paddles must be electrically grounded for proper RF performance. Customers should place adequate thermal vias under the ground paddles for optimum thermal performance. The Evaluation Board layout can be used as a guide for RF ground and thermal layout.

Electrical and Mechanical Specifications

Signal pin assignments and functional pin descriptions are described in Table 1. The absolute maximum ratings of the SKY65352-11 are provided in Table 2. The recommended operating conditions are specified in Table 3 and electrical specifications are provided in Table 4.

The SKY65352-11 provides one RF differential port composed of the RF_P and RF_N pin signals (pins 5 and 6, respectively). The Smith chart shown in Figure 3 plots the impedance of the RF differential port. Typical performance characteristics are shown in Figures 4, 5, and 6.

Package and Handling Information

Since the device package is sensitive to moisture absorption, it is baked and vacuum packed before shipping. Instructions on the shipping container label regarding exposure to moisture after the container seal is broken must be followed. Otherwise, problems related to moisture absorption may occur when the part is subjected to high temperature during solder assembly.

The SKY65352-11 is rated to Moisture Sensitivity Level 3 (MSL3) at 260 °C. It can be used for lead or lead-free soldering. For additional information, refer to Skyworks Application Note, *PCB Design and SMT Assembly/Rework Guidelines for MCM-L Packages*, document number 101752.

Care must be taken when attaching this product, whether it is done manually or in a production solder reflow environment. Production quantities of this product are shipped in a standard tape and reel format.

Table 1. SKY65352-11 Signal Descriptions

Pin #	Name	Description	Pin #	Name	Description
1	GND	Ground	11	GND	Ground
2	GND	Ground	12	GND	Ground
3	GND	Ground	13	ANT	Antenna port
4	BIAS_V	DC bias voltage to balun center tap	14	GND	Ground
5	RF_P	Positive common differential RF input/output	15	GND	Ground
6	RF_N	Negative common differential RF input/output	16	GND	Ground
7	GND	Ground	17	TX_VCC	Transmit DC supply, +3.3 V
8	SDN	Shut down enable	18	GND	Ground
9	RX_VCC	Receive DC supply, +3.3 V	19	N/C	No connection
10	GND	Ground	20	T_R	Transmit/receive control

Note: The bottom ground pad **must be** connected to RF ground.

Table 2. SKY65352-11 Absolute Maximum Ratings (Note 1)

Parameter	Symbol	Minimum	Maximum	Units
Supply voltage	RX_VCC, TX_VCC	1.8	4	V
Control voltage	SDN, T_R		3.6	V
Bypass voltage	BIAS_V		4	V
RF input power, antenna port	P_{IN_ANT}		+10	dBm
RF input power, differential	P_{IN_TX}		+8	dBm
Case operating temperature	T_C	−40	+85	°C
Storage temperature	T_{ST}	−55	+125	°C
Junction temperature	T_J		+150	°C

Note 1: Exposure to maximum rating conditions for extended periods may reduce device reliability. There is no damage to device with only one parameter set at the limit and all other parameters set at or below their nominal value. Exceeding any of the limits listed here may result in permanent damage to the device.

CAUTION: Although this device is designed to be as robust as possible, Electrostatic Discharge (ESD) can damage this device. This device must be protected at all times from ESD. Static charges may easily produce potentials of several kilovolts on the human body or equipment, which can discharge without detection. Industry-standard ESD precautions should be used at all times.

Table 3. SKY65352-11 Recommended Operating Conditions

Parameter	Symbol	Minimum	Typical	Maximum	Units
Frequency range	f	2400		2500	MHz
Supply voltage (TX_VCC, RX_VCC)	VCC	2.7	3.3	3.6	V
Shut down and T/R control voltage: Low High	 T_R_L, SDN_L T_R_H, SDN_H	 1.62	 0 1.80	 0.1 3.60	 V V

Table 4. SKY65352-11 Electrical Specifications (Note 1)
(VCC = 3.3 V, Tc = 25 °C, PIN = +3 dBm, Unless Otherwise Noted)

Parameter	Symbol	Test Condition	Min	Typical	Max	Units
Frequency range	f		2400		2500	MHz
Return loss (Note 2)	RL	All RF ports		12		dB
Differential port impedance (RF_P and RF_N pins) (Note 2): Transmit mode Receive mode	 Z_{DTX} Z_{DRX}			 60 + j78 123 + j31		 Ω Ω
Transmitter Section						
Saturated output power (Note 2)	P_{SAT}			+21		dBm
Transmit output power	P_{OUT}		+19.5	+20.0		dBm
Operating current	I_{OP}	P_{OUT} = +20 dBm		110	130	mA
2nd harmonic	Pn2	IEEE 802.15.4 OQPSK modulated		−53	−43	dBm
3rd harmonic	Pn3	IEEE 802.15.4 OQPSK modulated		−53	−43	dBm
Small signal gain (Note 2)	G_H	P_{IN} = −10 dBm		20		dB
Leakage current	I_{LEAK}	No RF input, VCC = 3.3 V, SDN = 0 V, T_R = 0 V		0.3	1	µA
Spur (Note 2)		VSWR up to 10:1 (all phase angles)	No parasitic oscillation > −44 dBm			–
Ruggedness (Note 2)		VSWR up to 10:1 (all phase angles)	No module damage or permanent degradation			–
Receive Section						
Small signal gain	G	CW, P_{IN} = −20 dBm	7	10		dB
Noise Figure	NF			2	3	dB
3rd Order Input Intercept Point	IIP3	Two CW tones, spaced 1 MHz apart @ P_{IN} = −9 dBm	−10	−4		dBm
Operating current	I_{CC}	CW		7	12	mA

Note 1: Performance is guaranteed only under the conditions listed in this Table.

Note 2: Parameter is characterized under the conditions in this Table, but is not production tested.

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SddTX : Impedance TX mode
m4 (2.45GHz) : 60+j.78 ohms

SddRX : Impedance RX mode
m1 (2.45GHz) : 123+j.31 ohms

m4

m1

SddTX
SddRX

100 ohms Smith Chart

freq (2.400GHz to 2.500GHz)

Figure 3. Transmit and Receive Differential Impedance
(100 Ω Reference)
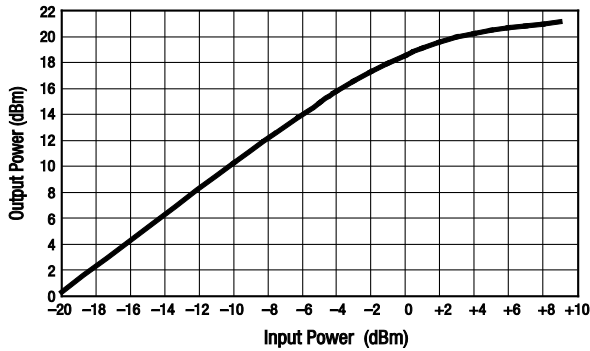
Figure 4. Output Power vs Input Power
(f= 2.445 GHz, Vcc = 3.3 V, Tc = 25 °C)
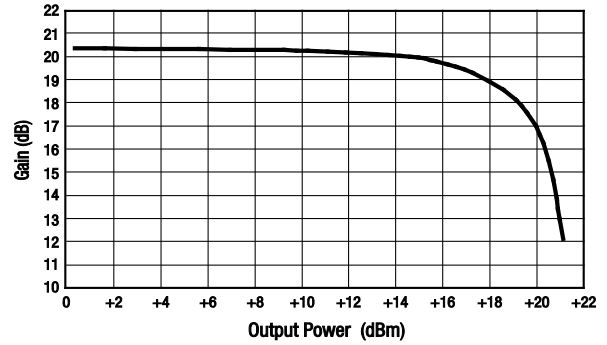
**Figure 5. Transmit Gain vs Output Power**
(f= 2.445 GHz, Vcc = 3.3 V, Tc = 25 °C)
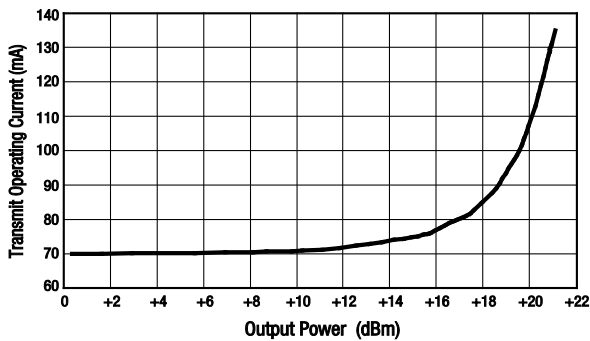
Figure 6. Transmit Operating Current vs Output Power
(f= 2.445 GHz, Vcc = 3.3 V, Tc = 25 °C)

Evaluation Board Description

The SKY65352-11 Evaluation Board is used to test the performance of the SKY65352-11 FEM. The Evaluation Board schematic diagram is shown in Figure 7. An assembly drawing for the Evaluation Board is shown in Figure 8.

Package Dimensions

The phone board layout footprint for the SKY65352-11 is shown in Figure 9. Package dimensions for the 20-pin MCM are shown in Figure 10, and tape and reel dimensions are provided in Figure 11.
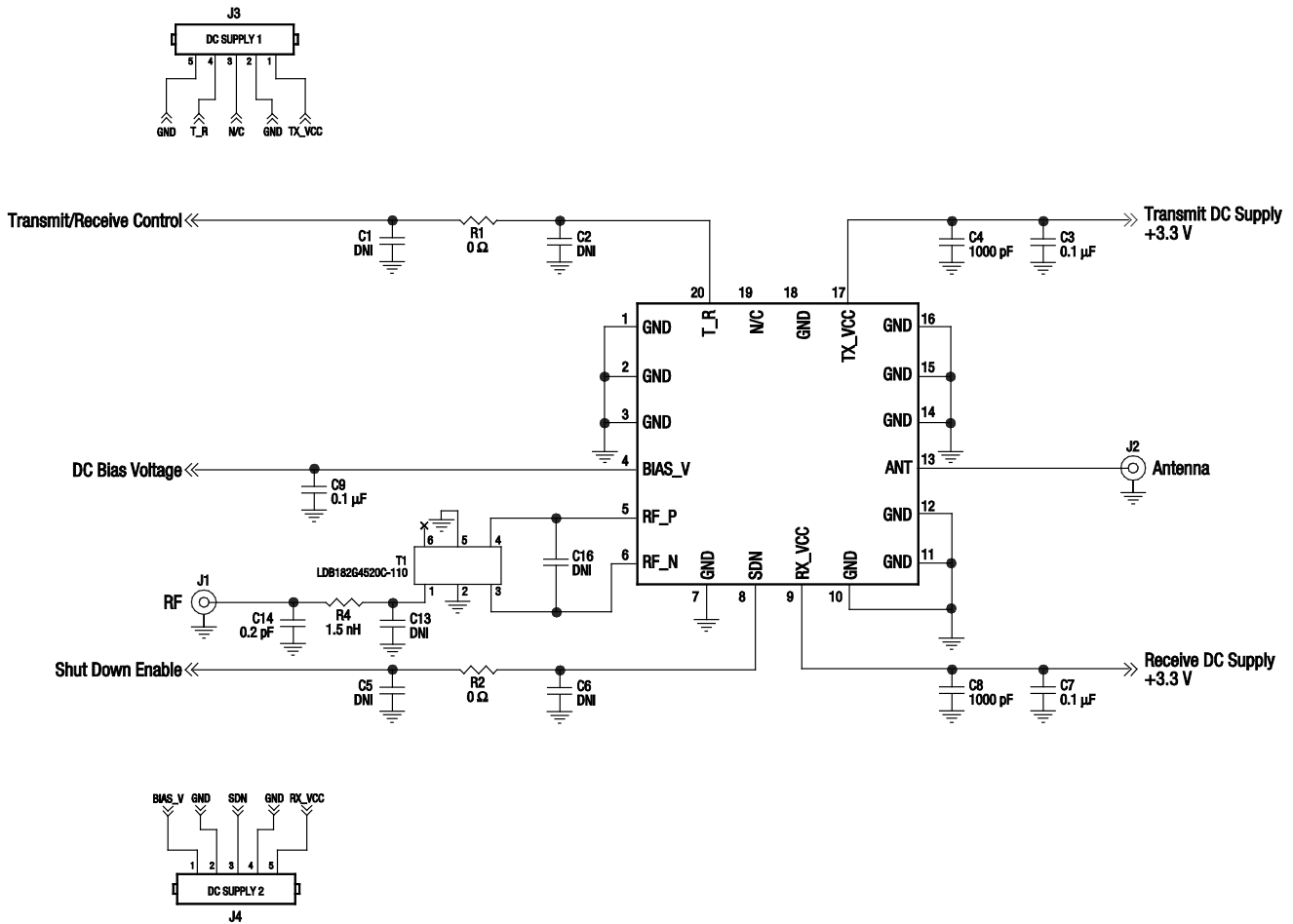
Note: Some component labels may be different than the corresponding component symbol shown here.
Component values, however, are accurate as of the date of this Data Sheet.

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Figure 7. SKY65352-11 Evaluation Board Schematic
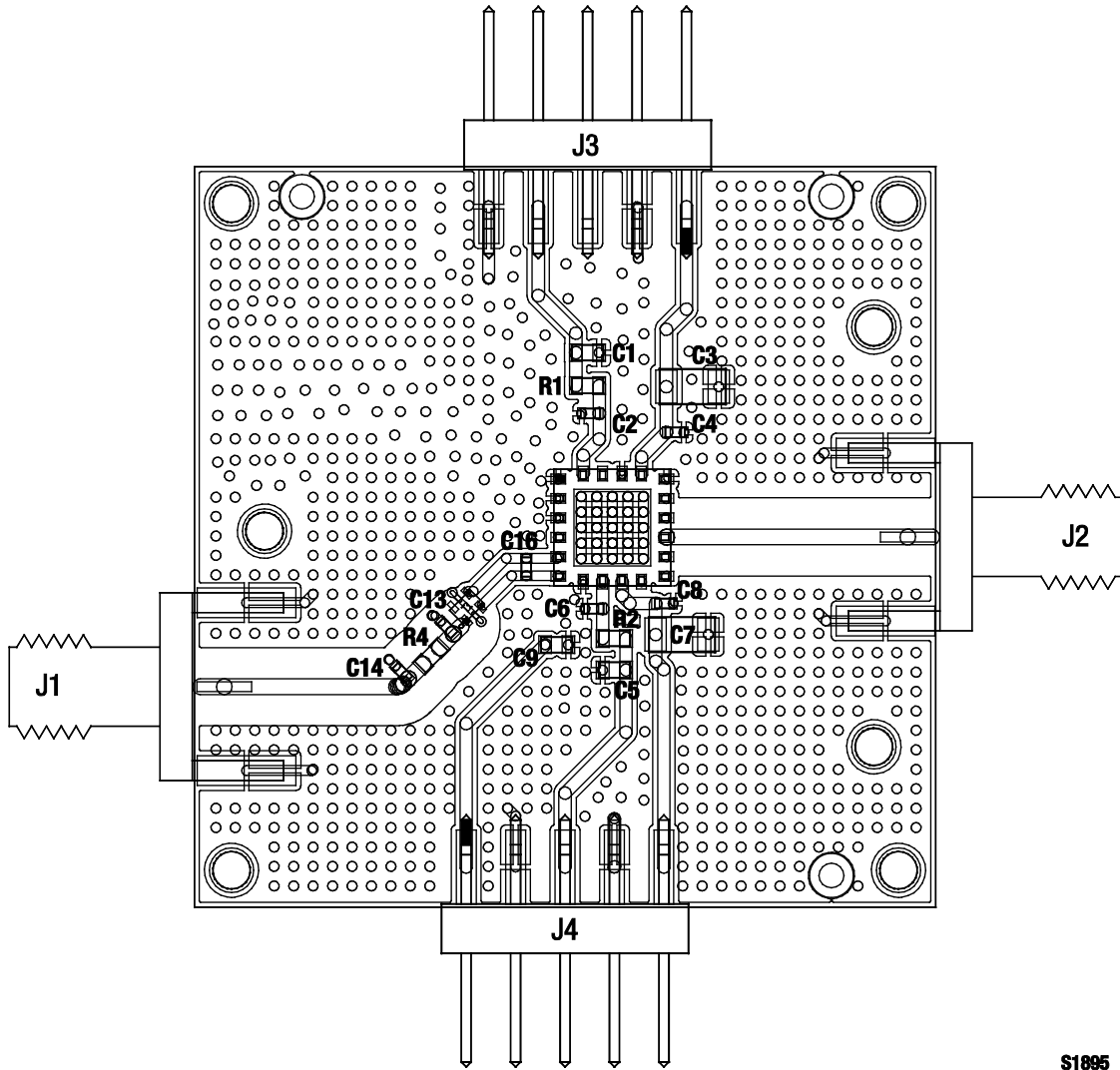
Figure 8. SKY65352-11 Evaluation Board Assembly Drawing
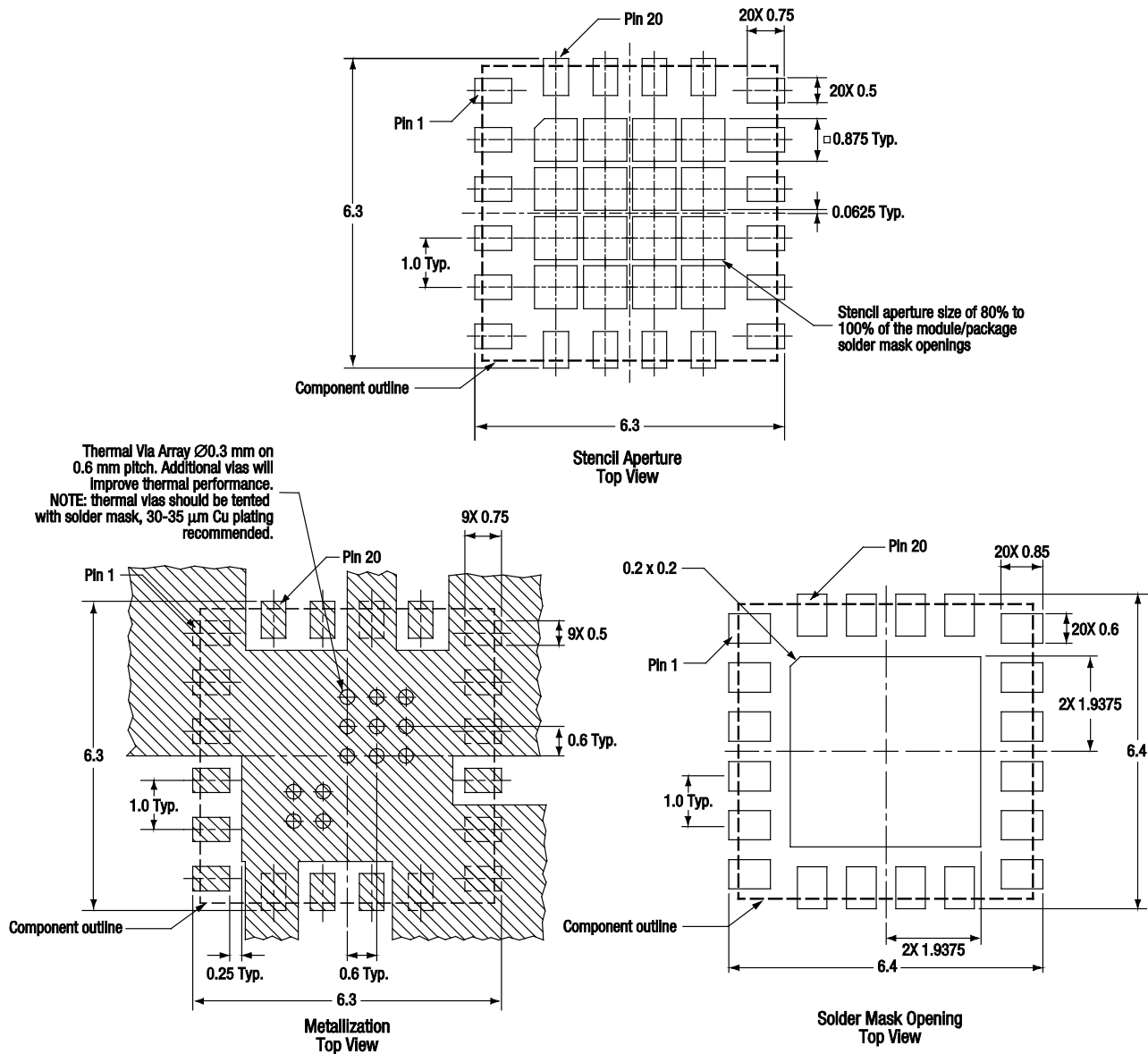
Figure 9. SKY65352-11 Phone Board Layout Footprint
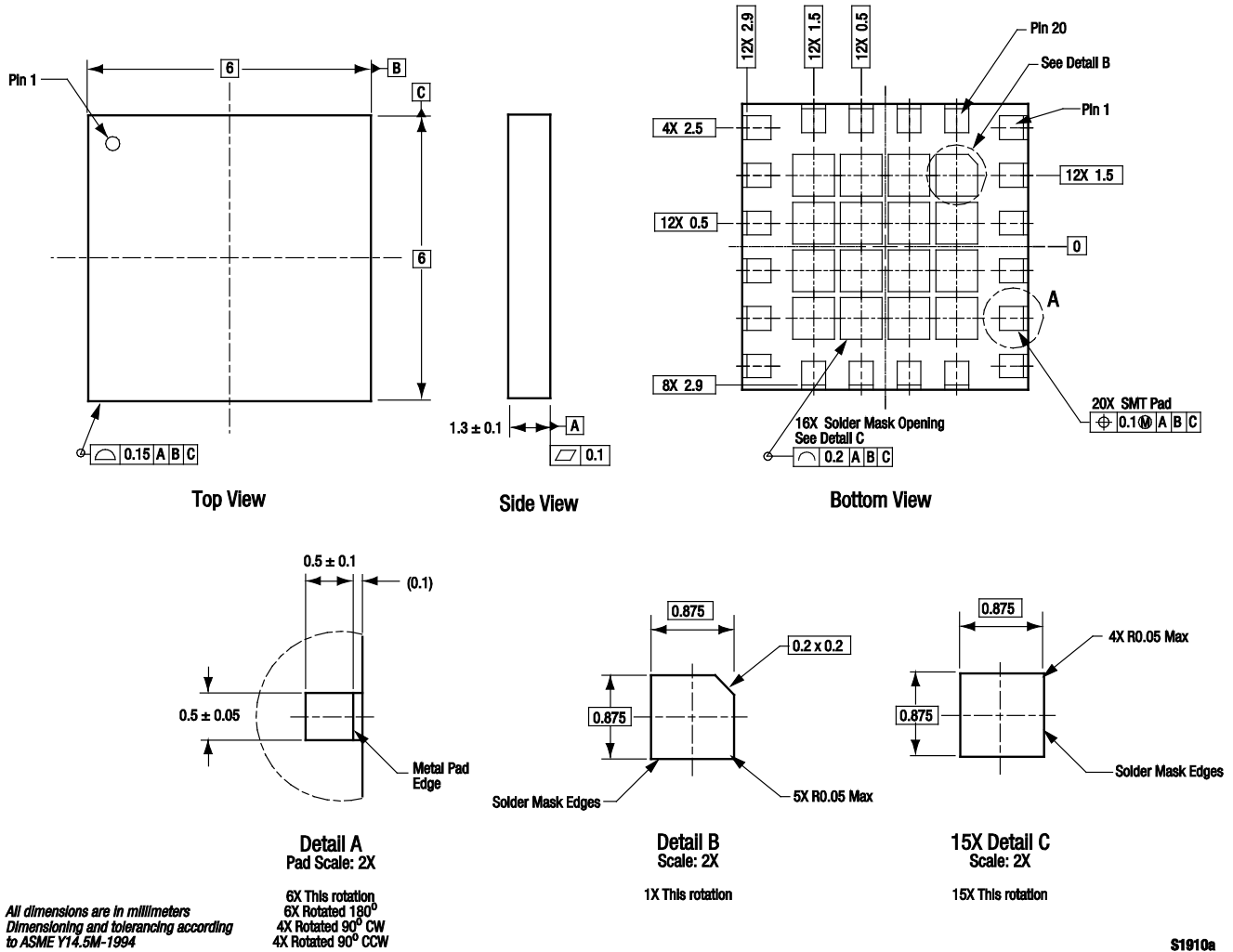
Figure 10. SKY65352-11 20-Pin MCM Package Dimensions
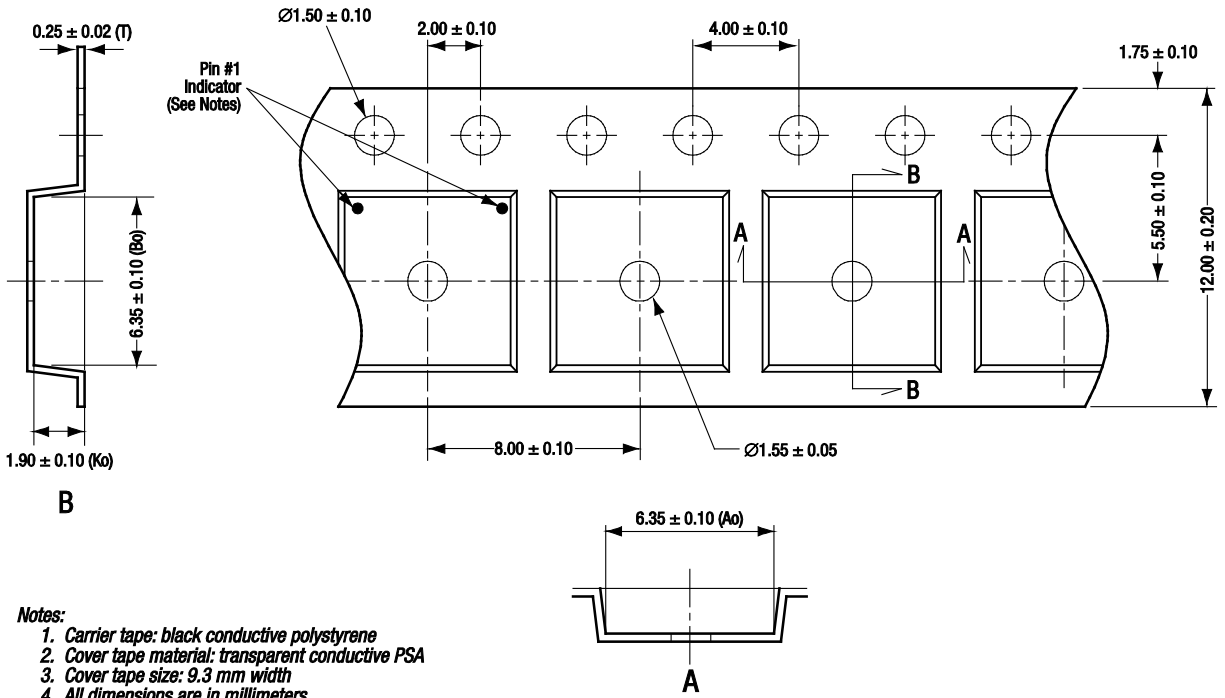
Notes:
1. Carrier tape: black conductive polystyrene
2. Cover tape material: transparent conductive PSA
3. Cover tape size: 9.3 mm width
4. All dimensions are in millimeters
5. Ao and Bo measurement point is 0.3 mm from bottom pocket
5. Pin 1 orientation is in top left corner for the following Skyworks products:

SKY65205-11
SKY65208-11
SKY65215-11

For all other 6 x 6 mm MCM/RFLGA products, pin 1 orientation is
in top right corner.

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Figure 11. SKY65352-11 20-Pin MCM Tape and Reel Dimensions

Ordering Information

Model Name	Manufacturing Part Number	Evaluation Board Part Number
SKY65352-11 T/R Front-End Module with LNA	SKY65352-11	TW18-D335