DATA SHEET

SKY65346-11: 900 MHz Transmit/Receive Front-End Module

Applications

- Automated meter reading

Features

- Externally available bias circuits
- Control logic
- Cascaded receive gain: 12.4 dB
- Cascaded Noise Figure: 2.4 dB
- Transmit power: +26 dBm
- Single DC supply
- Shutdown mode
- Small, MCM (26-pin, 5 x 5 mm) package (MSL3, 260 °C per JEDEC J-STD-020)

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Description

The SKY65346-11 is a high performance transmit/receive (T/R) Front-End Module (FEM) ideally suited for use in 900 MHz Industrial, Scientific, and Medical (ISM) applications.

A double-pole, double-throw (DPDT) switch allows the device to select between two antenna ports (ANT1 and ANT2 pins) for the transmit or receive path. A single-pole, double-throw (SPDT) switch selects which signal path is routed to the transceiver port (RFIO pin). The receive path has a Low-Noise Amplifier (LNA) bypass switch.

The Power Amplifier (PA) and LNA biasing can be independently controlled with an external bias resistor. The device has a shutdown mode to minimize power consumption. All eight operating modes are controlled using three digital input pins (CTL1, CTL2, and CTL3).

The SKY65346-11 T/R FEM is provided in a compact, 26-pin 5 x 5 mm Multi-Chip Module (MCM). A functional block diagram is shown in Figure 1. The pin configuration and package are shown in Figure 2. Signal pin assignments and functional pin descriptions are provided in Table 1.

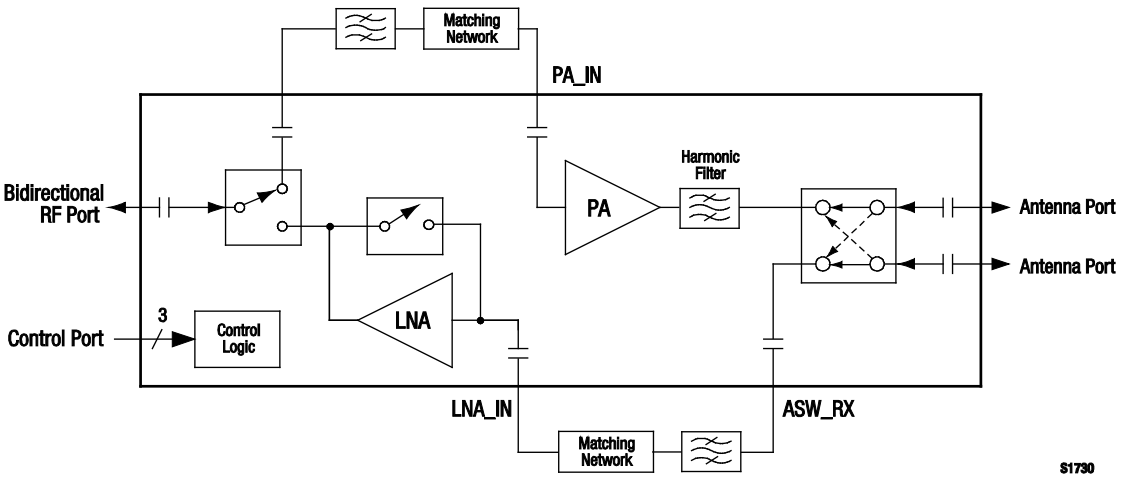


Figure 1. SKY65346-11 Block Diagram

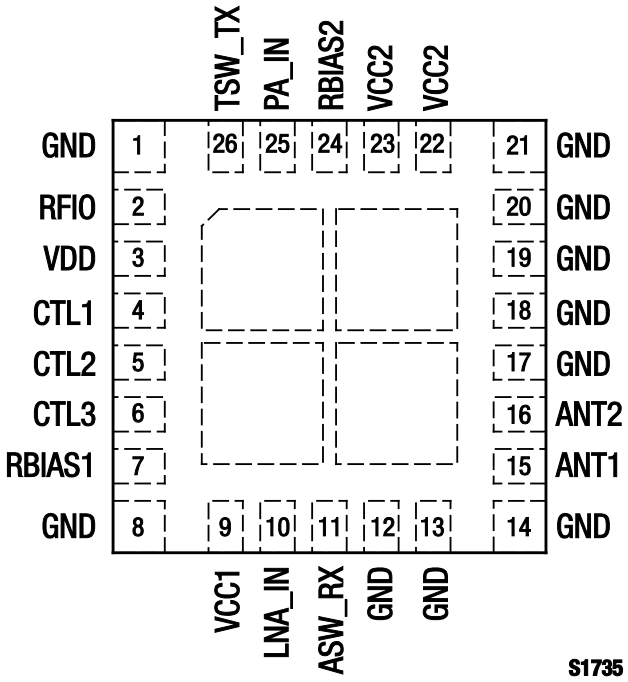


Figure 2. SKY65346-11 Pinout – 26-Pin MCM
(Top View)

Table 1. SKY65346-11 Signal Descriptions

Pin #	Name	Description	Pin #	Name	Description
1	GND	Ground	14	GND	Ground
2	RFIO	RF transceiver port	15	ANT1	Antenna port
3	VDD	Digital power supply	16	ANT2	Antenna port
4	CTL1	Digital control line	17	GND	Ground
5	CTL2	Digital control line	18	GND	Ground
6	CTL3	Digital control line	19	GND	Ground
7	RBIAS1	LNA external bias resistor	20	GND	Ground
8	GND	Ground	21	GND	Ground
9	VCC1	LNA power supply	22	VCC2	PA power supply
10	LNA_IN	LNA input port. Internally matched to 50 Ω.	23	VCC2	PA power supply
11	ASW_RX	Antenna switch receive port	24	RBIAS2	PA external bias resistor
12	GND	Ground	25	PA_IN	PA input port
13	GND	Ground	26	TSW_TX	Transceiver switch transmit port

Functional Description

The SKY65346-11 provides input and output amplifier stages, and is internally matched for optimum efficiency. An active bias circuit provides both input and output stages with excellent gain tracking over temperature and voltage variations. The module operates with positive DC voltages, and maintains high efficiency and good linearity. The nominal operating voltage is 3.3 V for maximum power. The PA and LNA biasing can be independently controlled with an external bias resistor.

Operational Modes

By using three control signals (CTRL1, CTRL2, and CTRL3), the SKY65346-11 can be configured to one of eight operational modes:

- Receive ANT1 bypass. In this mode, a low-loss broadband, bidirectional RF path allows easy switching of the signal between the transceiver and antenna port 1.
- Receive ANT2 bypass. In this mode, a low-loss broadband, bidirectional RF path allows easy switching of the signal between the transceiver and antenna port 2.
- Receive ANT1. In this mode, the SKY65346-11 amplifies the received signal at antenna port 1 through the LNA.
- Receive ANT2. In this mode, the SKY65346-11 amplifies the received signal at antenna port 2 through the LNA.
- Transmit ANT1. In this mode, the transmit path provides an harmonic filter and high efficiency PA on the Antenna 1 Port.
- Transmit ANT2. This is the same mode of operation as Transmit ANT1 except that the output is the Antenna 2 Port.
- Shut down. In this mode, the PA and LNA are powered down for minimal current consumption and low leakage current (<1 μA).

Table 2 provides the control logic for each of the eight operational modes.

Electrical and Mechanical Specifications

The absolute maximum ratings of the SKY65346-11 are provided in Table 3 and the recommended operating conditions in Table 4. Electrical characteristics for the SKY65346-11 are provided in Table 5 through Table 10.

Typical performance characteristics of the SKY65346-11 are illustrated in Figures 3 through 8.

Table 2. SKY65346-11 Truth Table

Operation Mode	Control Voltage (Note 1)			Internal States				
	CTL1 (Pin 4)	CTL2 (Pin 5)	CTL3 (Pin 6)	LNA On	PA On	RFIO Switch	ANT1 Switch	ANT2 Switch
Receive ANT1 bypass	1	1	1	off	off	Receive LNA	ASW_RX	Transmit PA
Receive ANT2 bypass	1	1	0				Transmit PA	ASW_RX
Receive ANT1	1	0	1	on	off		ASW_RX	Transmit PA
Receive ANT2	1	0	0				Transmit PA	ASW_RX
Transmit ANT1	0	1	1	off	on	TSW_TX		
Transmit ANT2	0	1	0				ASW_RX	Transmit PA
Shut down	0	0	0		off	open	open	open
Shut down (Note 2)	0	0	1	off	off	open	open	open

Note 1: See Table 4 for logic 0 and logic 1 characteristics.

Note 2: In the high state, the CTL3 pin has an input current of 33 μA due to an internal 100 kΩ pulldown. This mode is not recommended for lowest leakage current.

Table 3. SKY65346-11 Absolute Maximum Ratings (Note 1)

Parameter	Symbol	Minimum	Maximum	Units
LNA supply voltage (VCC1)	V_{CC1}	–0.3	+5.0	V
PA supply voltage (VCC2)	V_{CC2}	–0.3	+5.0	V
Digital supply voltage (VDD)	V_{DD}	–0.5	4.6	V
Digital input voltage (CTL1, CTL2, CTL3)	V_{CTL}	–0.5	V_{DD} + 0.3	V
LNA supply current (VCC1)	I_{CC1}		20	mA
PA supply current (VCC2)	I_{CC2}		500	mA
Receive RF input power	P_{IN_LNA}		+10	dBm
Transmit RF input power	P_{IN_PA}		+10	dBm
Antenna port load VSWR (Note 2)			10:1	–
Operating case temperature	T_C	–40	+85	°C
Junction temperature	T_J		+150	°C
Storage case temperature	T_{STG}	–40	+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.

Note 2: Antenna port load VSWR is limited by voltage. An open load condition will not damage 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 4. SKY65346-11 Recommended Operating Conditions

Parameter	Symbol	Minimum	Typical	Maximum	Units
LNA supply voltage (VCC1)	V_{CC1}	2.7	3.3	3.7	V
PA supply voltage (VCC2)	V_{CC2}	2.7	3.3	3.7	V
Digital supply voltage (VDD)	V_{DD}	2.7	3.3	3.6	V
Digital input voltage, logic 0 (CTL1, CTL2, CTL3)	V_{CTL}	0		0.2	V
Digital input voltage, logic 1 (CTL1, CTL2, CTL3)	V_{CTL}	V_{DD} – 0.2	V_{DD}	3.6	V
Receive RF input power (ANT1, ANT2)	P_{IN_RX}			–10	dBm
Transmit RF input power (RFIO)	P_{IN_TX}	–10	–6	–3	dBm
LNA external bias resistor	R_{BIAS1}	3.3	4.7	33	kΩ
PA external bias resistor	R_{BIAS2}	3.3	12	33	kΩ
915 MHz ISM band frequency range	FB915	902	915	928	MHz

Table 5. SKY65346-11 DC Electrical Specifications (Note 1) (Note 2)
(VCC1 = VCC2 = VDD = 3.3 V, T_C = –40 to +85 °C, f= 928 MHz, CW Input, Unless Otherwise Noted)

Parameter	Symbol	Test Condition	Min	Typical	Max	Units
Quiescent current, receive mode (Note 3)	I_{Q_RX}		5.0	7.2	10.0	mA
Operating current, receive mode (Note 3)	I_{OP_RX}		5.0	7.1	10.0	mA
Quiescent current, transmit mode (Note 3)	I_{Q_TX}		70	80	90	mA
Operating current, transmit mode (Note 3)	I_{OP_TX}	P_{IN} = –6 dBm		236	300	mA
Quiescent current, receive bypass mode (Note 3)	I_{Q_RXB}			75		µA
Quiescent current, shutdown mode (Note 3) (Note 4)	I_{Q_SD}			0.025		µA
Digital input current (Note 4): Logic 1 Logic 0	 I_H I_L			 33 0		 µA µA

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

Note 2: Parameters are characterized under the conditions noted here and production tested under nominal temperature and voltage conditions with guard-banded limits.

Note 3: Total module power supply current.

Note 4: Not production tested.

Table 6. SKY65346-11 Electrical Specifications: LNA_IN to RFIO Receive Path (Note 1) (Note 2) (Note 3)
(VCC1 = VCC2 = VDD = 3.3 V, T_C = –40 to +85 °C, f= 928 MHz, CW Input, Unless Otherwise Noted)

Parameter	Symbol	Test Condition	Min	Typical	Max	Units
Small signal gain	G_{LNA}		10.5	13.5	15.5	dB
Noise Figure	NF_{LNA}	100 kHz bandwidth		1.7	2.4	dB
1 dB input compression point	$IP1dB_{LNA}$	1 dB gain compression	–13.0	–11.3		dBm
3rd order input intercept point	$IIP3_{LNA}$	400 kHz spacing, P_{IN} = –30 dBm/tone	+6.0	+7.5		dBm
Input return loss	$\|S11\|_{LNA}$		10	38		dB
Output return loss	$\|S22\|_{LNA}$		10	16		dB
Non-harmonic spurious (Note 4) (Note 5)	P_{SPUR_LNA}	VSWR 10:1, all phases			–50	dBm
LNA_IN to TSW_TX isolation	ISO_{TSW}		9	14		dB

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

Note 2: Parameters are characterized under the conditions noted here and production tested under nominal temperature and voltage conditions with guard-banded limits.

Note 3: Receive mode control voltage logic: CTL1, CTL2, and CTL3 = 10xb (refer to Table 2).

Note 4: Parameter is characterized under the conditions listed in this Table, but is not production tested.

Note 5: Measurement performed with P_{IN} = –30 dBm and spectrum analyzer RBW = 100 kHz for frequencies < 1 GHz or RBW = 1 MHz for frequencies from 1 GHz to 10 GHz. Reported spurious maximum value is the noise floor of the spectrum analyzer.

Table 7. SKY65346-11 Electrical Specifications: LNA_IN to RFIO Receive Path – Bypass Mode (Note 1) (Note 2) (Note 3) (VCC1 = VCC2 = VDD = 3.3 V, T_C = –40 to +85 °C, f= 928 MHz, CW Input, Unless Otherwise Noted)

Parameter	Symbol	Test Condition	Min	Typical	Max	Units
Loss	L_{BYP}			2.3	3.0	dB
1 dB input compression point (Note 4)	$IP1dB_{BYP}$	1 dB gain compression		+20		dBm
3rd order input intercept point	$IIP3_{BYP}$	400 kHz spacing, P_{IN} = –10 dBm/tone	+16	+20		dBm
Input return loss	$\|S11\|_{BYP}$		9.5	11.0		dB
Output return loss	$\|S22\|_{BYP}$		7.0	8.3		dB

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

Note 2: Parameters are characterized under the conditions noted here and production tested under nominal temperature and voltage conditions with guard-banded limits.

Note 3: Receive mode control voltage logic: CTL1, CTL2, and CTL3 = 11xb (refer to Table 2).

Note 4: Parameter is characterized under the conditions listed in this Table, but is not production tested.

Table 8. SKY65346-11 Electrical Specifications: ANT1/ANT2 to ASW_RX Receive Path (Note 1) (Note 2) (Note 3) (VCC1 = VCC2 = VDD = 3.3 V, T_C = –40 to +85 °C, f= 928 MHz, CW Input, Unless Otherwise Noted)

Parameter	Symbol	Test Condition	Min	Typical	Max	Units
Switch loss	L_{ANT}			0.8	1.0	dB
1 dB input compression point (Note 4)	$IP1dB_{ANT}$	1 dB gain compression		+30		dBm
3rd order input intercept point	$IIP3_{ANT}$	400 kHz spacing, P_{IN} = –10 dBm/tone	+47	+50		dBm
Input return loss	$\|S11\|_{ANT}$		10	14		dB
Output return loss	$\|S22\|_{ANT}$		10	14		dB
ANT1 to ANT2 isolation	ISO_{ANT}		20.5	23.0		dB

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

Note 2: Parameters are characterized under the conditions noted here and production tested under nominal temperature and voltage conditions with guard-banded limits.

Note 3: Receive mode control voltage logic: CTL1, CTL2, and CTL3 = 1xxb (refer to Table 2).

Note 4: Parameter is characterized under the conditions listed in this Table, but is not production tested.

Table 9. SKY65346-11 Electrical Specifications: PA_IN to ANT1/ANT2 Transmit Path (Note 1) (Note 2) (Note 3)
(VCC1 = VCC2 = VDD = 3.3 V, T_C = –40 to +85 °C, f= 928 MHz, CW Input, Unless Otherwise Noted)

Parameter	Symbol	Test Condition	Min	Typical	Max	Units
PA small signal gain	G_{TX}		32.0	34.1	37.5	dB
PA saturated output power	P_{SAT}			+26.3		dBm
PA output power	P_{OUT}	P_{IN} = –6 dBm	+24.0	+25.3		dBm
Power Added Efficiency	PAE	P_{IN} = –6 dBm		43.5		%
2nd harmonic	$2f_0$	P_{IN} = –6 dBm		–43	–30	dBc
3rd harmonic	$3f_0$	P_{IN} = –6 dBm		–54	–50	dBc
4th harmonic	$4f_0$	P_{IN} = –6 dBm		–62	–58	dBc
5th harmonic	$5f_0$	P_{IN} = –6 dBm		–80	–60	dBc
Input return loss	$\|S11\|_{TX}$		10	11		dB
Output return loss	$\|S22\|_{TX}$		7	10		dB
Noise Figure	NF_{TX}	100 kHz bandwidth		5.3	7.0	dB
Non-harmonic spurious (Note 4)	P_{SPUR_TX}	VSWR 6:1, all phases, P_{IN} = –6 dBm/tone			–50	dBm

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

Note 2: Parameters are characterized under the conditions noted here and production tested under nominal temperature and voltage conditions with guard-banded limits.

Note 3: Transmit mode control voltage logic: CTL1, CTL2, and CTL3 = 01xb (refer to Table 2).

Note 4: Parameter is characterized under the conditions listed in this Table, but is not production tested. Measurement performed with spectrum analyzer RBW = 100 kHz for frequencies < 1 GHz or RBW = 1 MHz for frequencies from 1 GHz to 10 GHz.

Table 10. SKY65346-11 Electrical Specifications: RFIO to TSW_TX Transmit Path (Note 1) (Note 2) (Note 3)
(VCC1 = VCC2 = VDD = 3.3 V, T_C = –40 to +85 °C, f= 928 MHz, CW Input, Unless Otherwise Noted)

Parameter	Symbol	Test Condition	Min	Typical	Max	Units
Loss	L_{TSW}			1.5	3.0	dB
1 dB Output Compression Point (Note 4)	$OP1dB_{TSW}$	1 dB gain compression		+20		dBm
3rd Order Output Intercept Point	$OIP3_{TSW}$	400 kHz spacing, P_{IN} = –10 dBm/tone	+27	+32		dBm
Input return loss	$\|S11\|_{TSW}$			9.4		dB
Output return loss	$\|S22\|_{TSW}$			10		dB

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

Note 2: Parameters are characterized under the conditions noted here and production tested under nominal temperature and voltage conditions with guard-banded limits.

Note 3: Transmit mode control voltage logic: CTL1, CTL2, and CTL3 = 01xb (refer to Table 2).

Note 4: Parameter is characterized under the conditions listed in this Table, but is not production tested.

Typical Performance Characteristics

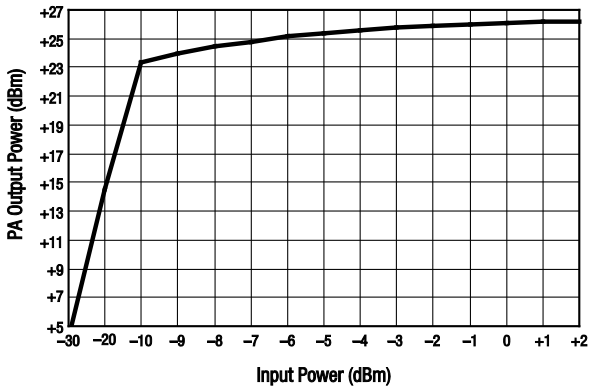


Figure 3. PA Output Power vs Input Power
(V_{CC} = 3.3 V, T_C = +25 °C, Frequency = 928 MHz)

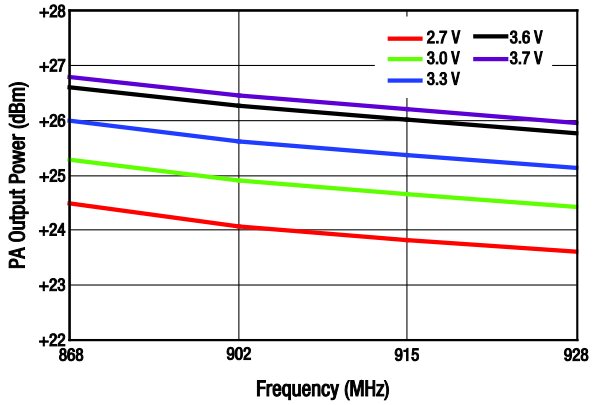


Figure 4. PA Output Power vs Frequency Over V_{CC}
(T_C = +25 °C, P_{IN} = –6 dBm)

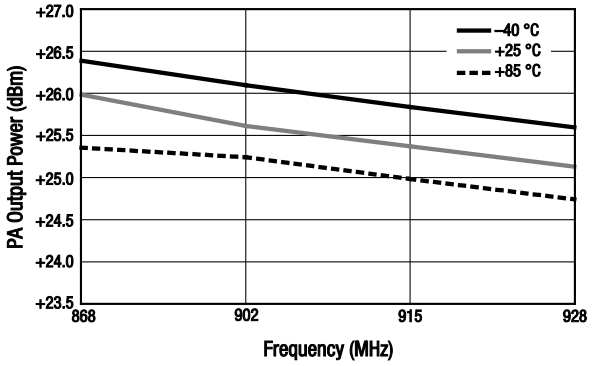


Figure 5. PA Output power vs Frequency Over Temperature
(V_{CC} = 3.3 V, P_{IN} = –6 dBm)

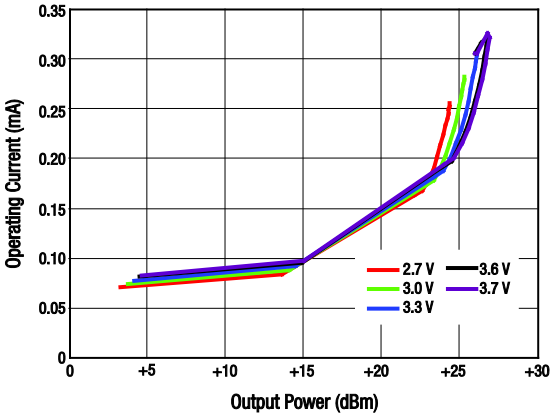


Figure 6. Transmit Operating Current vs Output Power Over V_{CC}
(T_C = +25 °C, Frequency = 928 MHz)

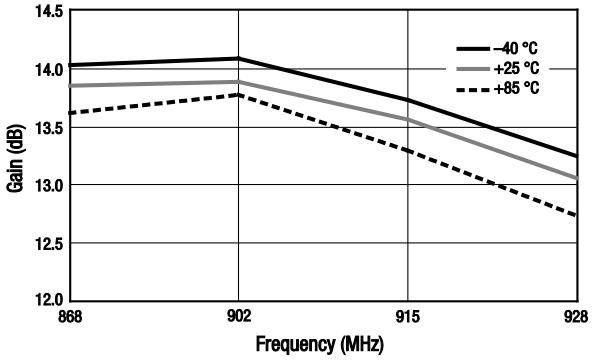


Figure 7. LNA Gain vs Frequency Over Temperature
(V_{CC} = 3.3 V)

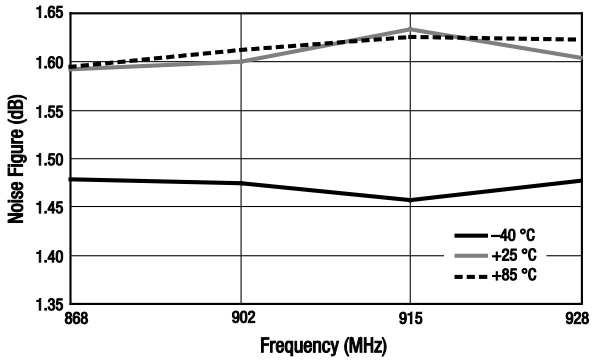


Figure 8. LNA Noise Figure vs Frequency Over Temperature
(V_{CC} = 3.3 V)

Evaluation Board Description

The SKY65346-11 Evaluation Board is used to test the performance of the SKY65346-11 FEM. An Evaluation Board schematic diagram is provided in Figure 9. An assembly drawing for the Evaluation Board is shown in Figure 10 and the layer detail is provided in Figure 11.

Circuit Design Configurations

The following design considerations are general in nature and must be followed regardless of final use or configuration:

1. Paths to ground should be made as short as possible.
2. The ground pads of the SKY65346-11 have special electrical and thermal grounding requirements. These pads are the main thermal conduit for heat dissipation. Since the circuit board acts as the heat sink, it must shunt as much heat as possible from the device. Therefore, design the connection to the ground pads to dissipate the maximum wattage produced by the circuit board. Multiple vias to the grounding layer are required.
3. Two external output bypass capacitors (10 nF and 100 pF) are required on pin 23 (VCC2). The same two capacitor values are also required on pin 9 (VCC1). The capacitors should be placed in parallel between the supply line and ground.
4. Pins 9 and 23 (VCC1 and VCC2, respectively) may be connected together at the supply.

***NOTE**: A poor connection between the slug and ground increases junction temperature (T_J), which reduces the lifetime of the device.*

Package Dimensions

The PCB layout footprint for the SKY65346-11 is provided in Figure 12. Typical case markings are shown in Figure 13. Package dimensions for the 26-pin MCM are shown in Figure 14, and tape and reel dimensions and provided in Figure 15.

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 SKY65346-11 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 the Skyworks Application Note, *PCB Design & 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. For packaging details, refer to the Skyworks Application Note, *Tape and Reel Information – RF Modules*, document number 101568.

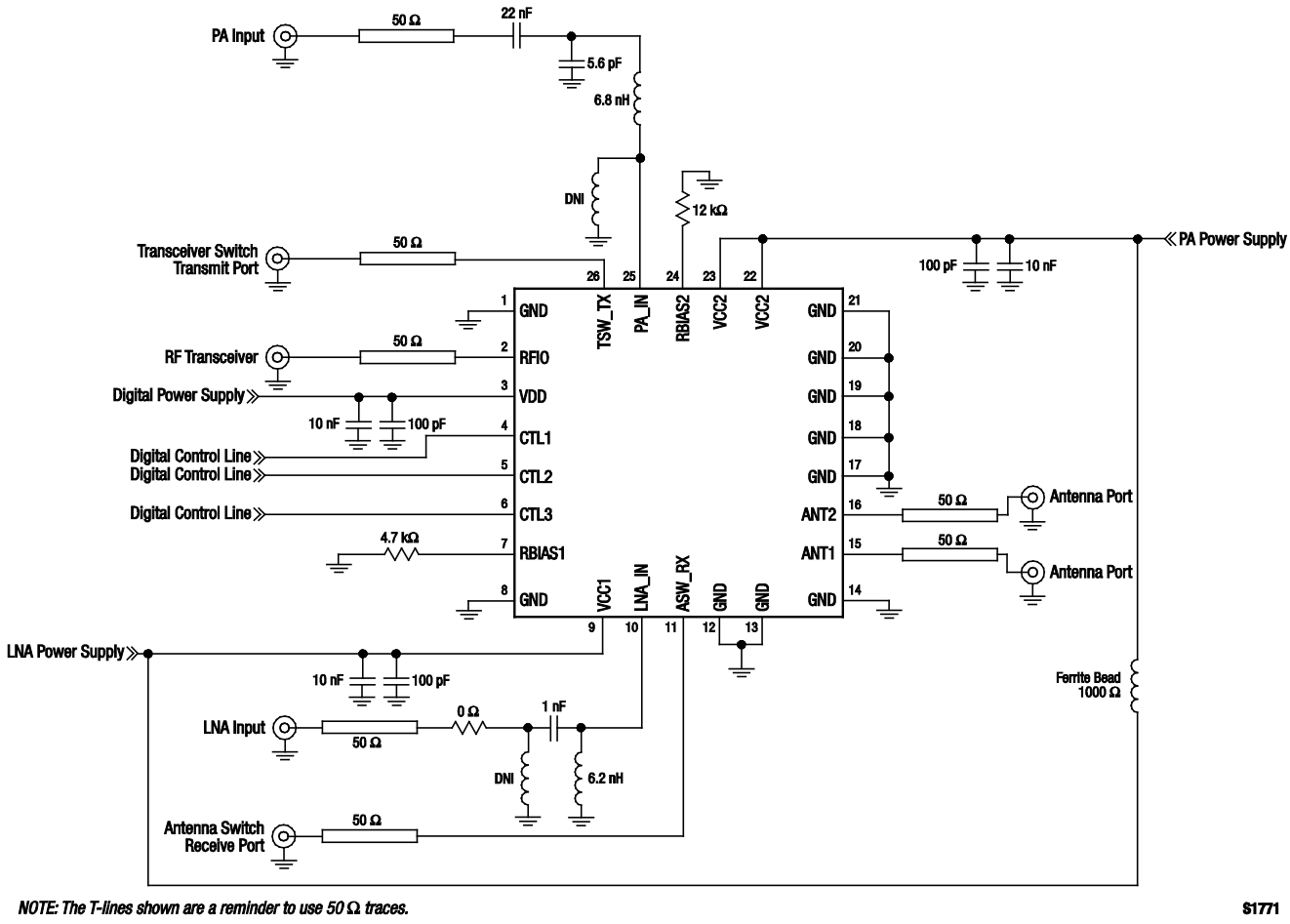


Figure 9. SKY65346-11 Evaluation Board Schematic

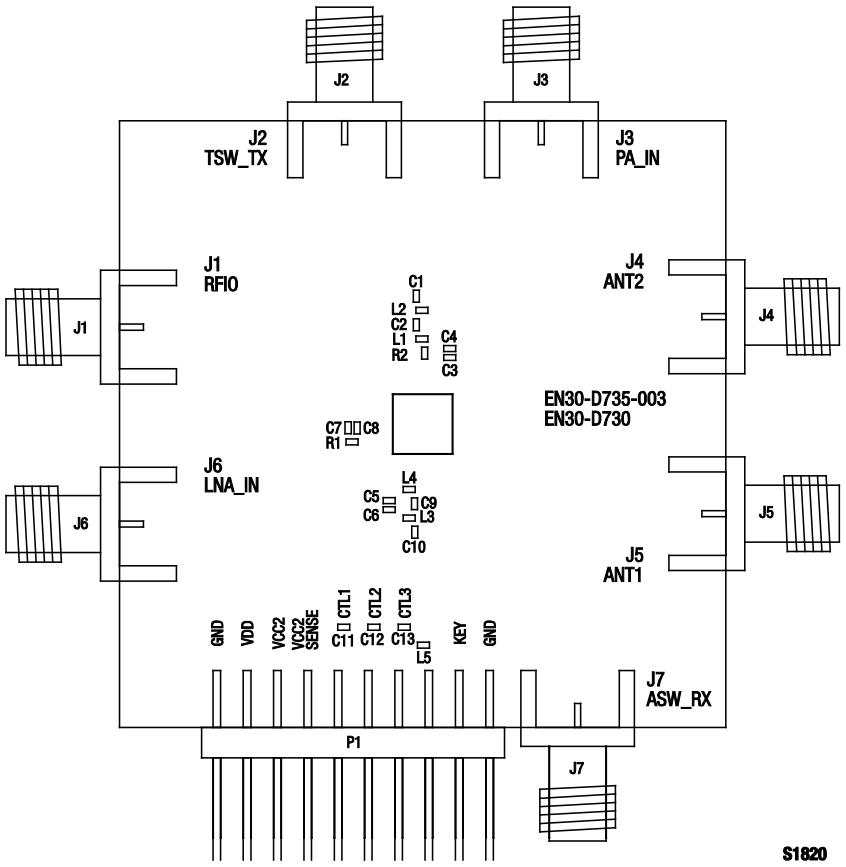
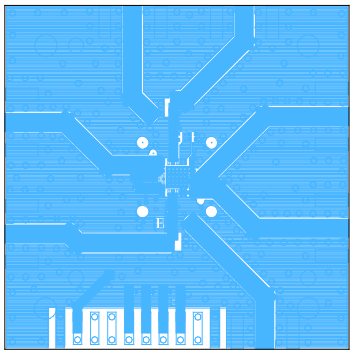
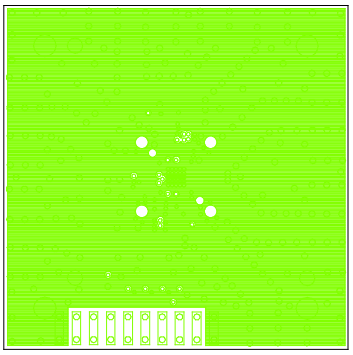


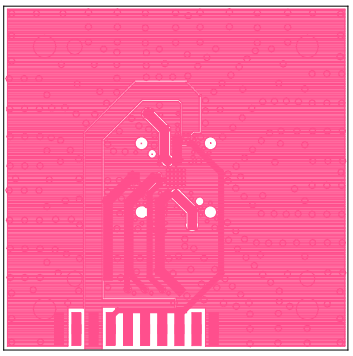
Figure 10. SKY65346-11 Evaluation Board Assembly Diagram



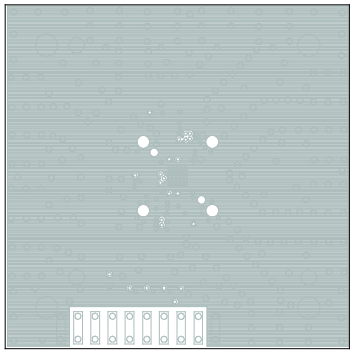
Layer 1: Top – Metal



Layer 1: Solder Mask



Layer 2: Ground



Layer 4: Solid Ground Plane

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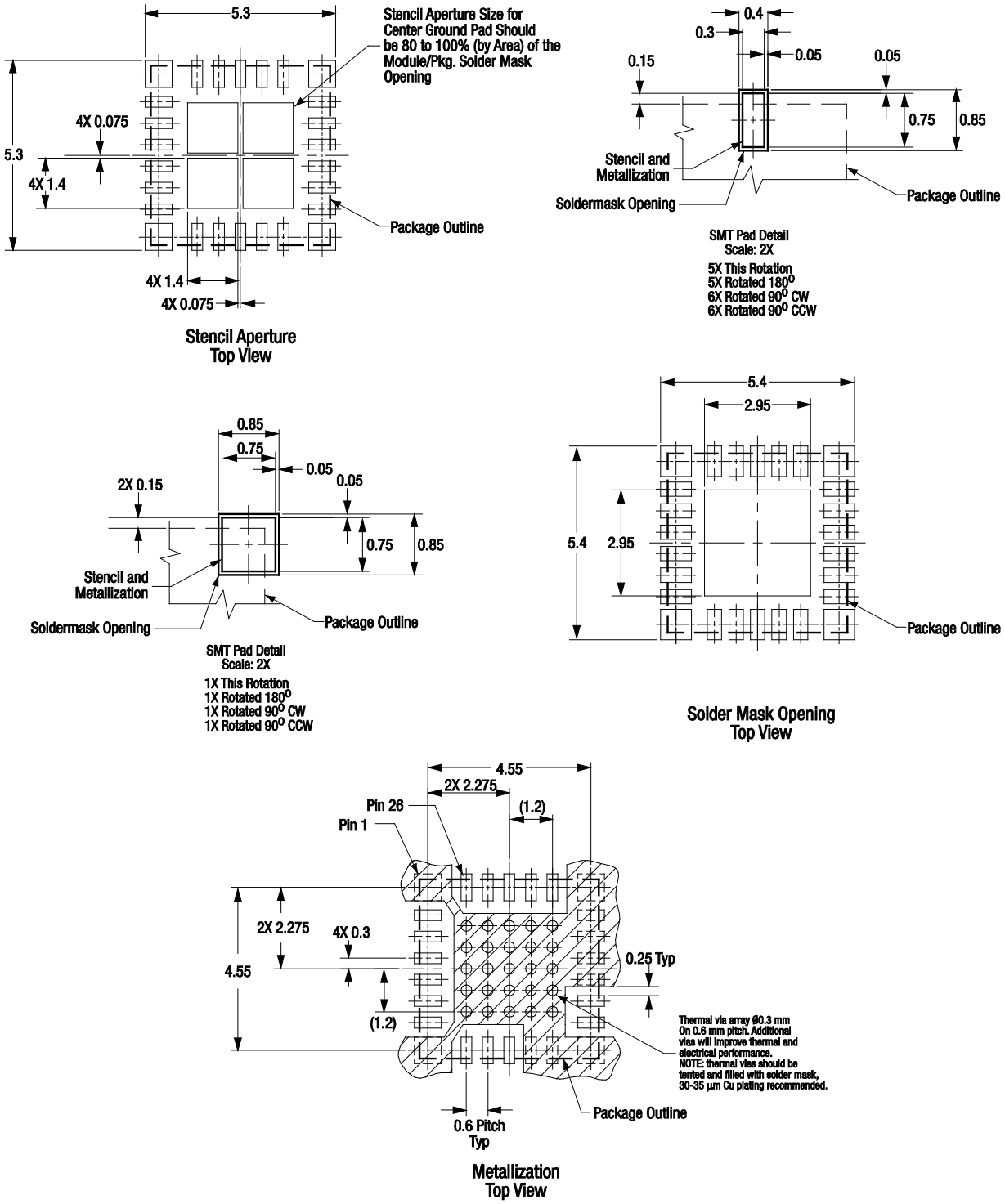
Figure 11. SKY65346-11 Evaluation Board Layer Detail

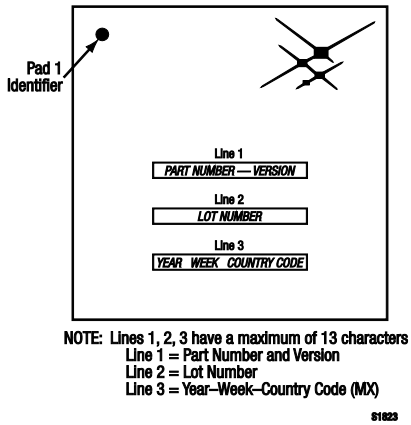


Note: The cross-hatched area represents the merger of the center ground pad +10 individual I/O ground pads. All I/O ground pads should have at least one via connected to internal ground planes for optimum electrical performance.

All dimensions are in millimeters

S1822

Figure 12. SKY65346-11 PCB Layout Footprint



NOTE: Lines 1, 2, 3 have a maximum of 13 characters
Line 1 = Part Number and Version
Line 2 = Lot Number
Line 3 = Year–Week–Country Code (MX)

S1623

Figure 13. Tyical Case Markings (Top View)

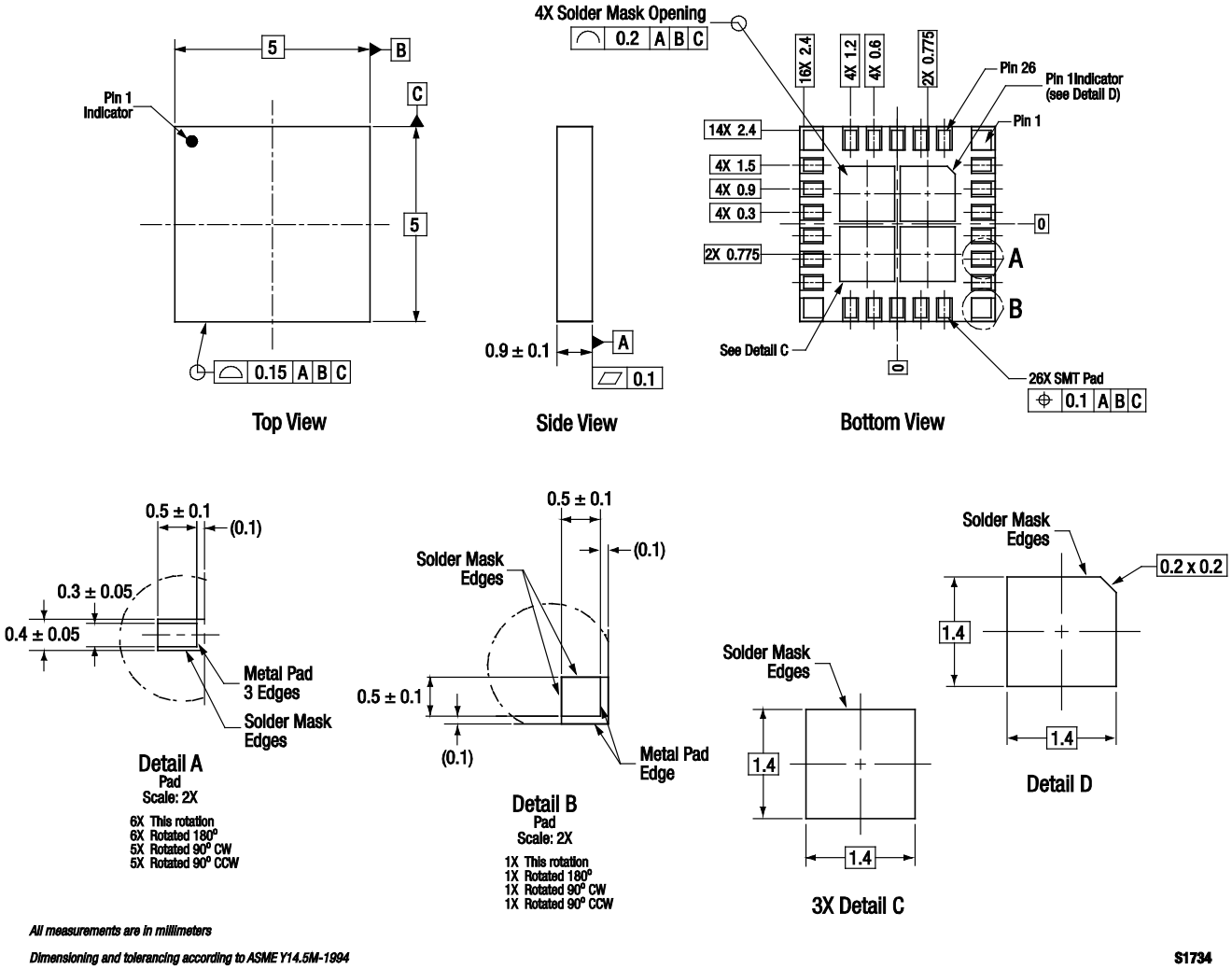
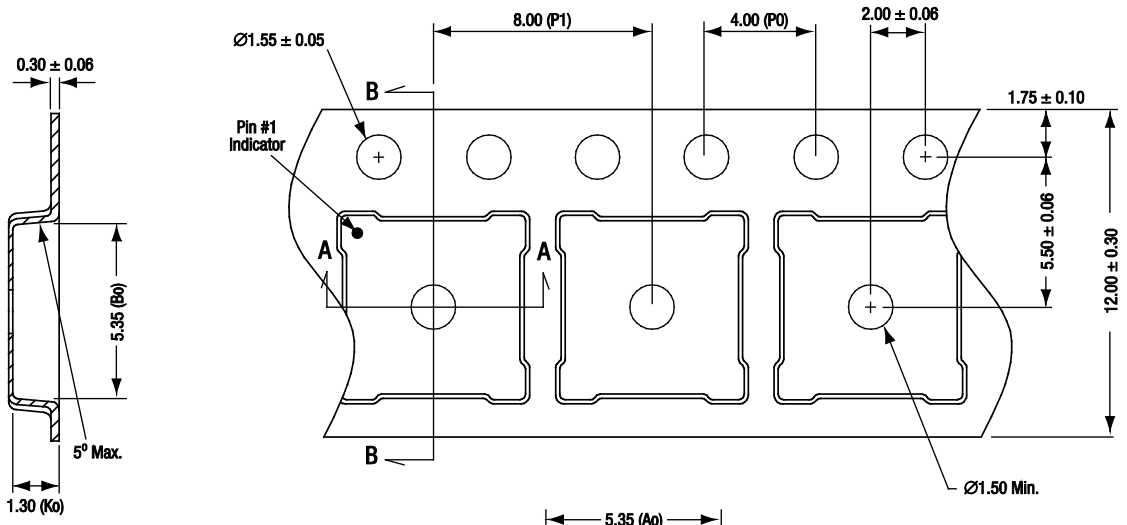


Figure 14. SKY65346-11 26-Pin MCM Package Dimensions



Notes:

1. *Carrier tape: black conductive polystyrene*
2. *Cover tape material: transparent conductive PSA*
3. *Cover tape size: 9.3 mm width*
4. *ESD surface resistivity is ≤1 x 10^{10} Ohms/Square according to EIA, JEDIC TNR specification.*
5. *P_0/P_1 10 pitches cumulative tolerance on tape: ±0.20 mm*
6. *A and B measurement points are 0.30 mm from bottom pocket.*
7. *All dimensions are in millimeters*

S461a

Figure 15. SKY65346-11 Tape and Reel Dimensions

Ordering Information

Model Name	Manufacturing Part Number	Evaluation Board Part Number
SKY65346-11 900 MHz T/R FEM	SKY65346-11	EN30-D735-003

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