DATA SHEET

SKY77928-21 SkyLiTE™ Tx-Rx Front-End Module for Quad-Band GSM / GPRS / EDGE, w/ 16 Linear TRx Switch Ports, Dual-Band TD-SCDMA, TDD LTE Band 39 – Dual Antenna

Applications

- Cellular handsets encompassing Quad-Band GSM/EDGE, Dual-Band TD-SCDMA, and TDD LTE
  - Class 4 GSM850/900
  - Class 1 DCS1800/PCS1900
  - Class 12 GPRS multi-slot operation
  - Linear EDGE operation
  - TD-SCDMA Bands 34/39
  - TDD LTE Band 39
- Carrier Aggregation (CA) with dual antenna

Features

- Small, low profile package
  - 5.5 mm x 5.5 mm x 0.75 mm
  - 44-pad configuration
- MIPI® RFFE control with dual-standard support
  - User-selectable register mappings
  - Linear or VRAMP-based GMSK power control
- RF ports internally matched to 50 Ω w/ zero DC offset
- High GMSK Efficiency (inclusive of coupler and diplexer)
  - 34% GSM850 34% DCS1800
  - 34% GSM900 34% PCS1900
- Tx harmonics below –40 dBm
- Supports APT, buck DC-DC supply
- 16 low loss/high linearity/high isolation TRx switch ports with excellent cross-band flexibility
- RF input switching to external 3G/4G path
- Three directional couplers: LB/MB/HB
- Downlink inter-band CA support with L+M/H diplexer and separate HB switch/antenna with ultra-low loss and superb linearity
- Noise suppression notch filter for WiFi coexistence
- Built-in IEC-compliant antenna ESD protection
- High impedance control inputs and low standby current
- Current limiting and overvoltage ruggedness
- Power control circuitry built-in for improved TRP variation
- Supports Uplink Carrier Aggregation in Band 39 (35 MHz)

Description

The SKY77928-21 SkyLiTE™ Tx-Rx Front-End Module (FEM) offers a complete Power Amplifier (PA) and switching solution for advanced 2G/3G/4G cellular handsets with dual antenna.

Two PAs support quad-band GSM, GPRS, EDGE multi-slot operation and TD-SCDMA and TDD LTE transmission. The low band (LB) PA transmits in the GSM850/900 bands. The mid-band (MB) PA covers DCS1800, PCS1900, TD-SCDMA bands 34/39, and TDD LTE band 39. The FEM facilitates flexible broadband RF switch-through by means of outward switching of the LB/MB PA RF inputs and 16 transmit/receive (TRx) antenna switch ports covering all 3G/4G bands from 700 MHz through 2300-2700 MHz. In support of downlink inter-band Carrier Aggregation (CA), the TRx ports are partitioned into three independent switch blocks comprising 7 LB, 5 MB and 4 HB ports with strong M/H cross-band support. Each switch block includes a directional coupler that may be monitored on the CPL port with selectable forward or reverse directionality. A diplexer and a second antenna port provide flexible simultaneous L+M/HB reception required for downlink CA.

The SKY77928-21 includes a full set of features for state-of-the-art performance and minimal phone board complexity. The Heterojunction Bipolar Transistor (HBT) PA blocks are fabricated in Gallium Arsenide (GaAs). The HBT, switches, controller die, and passive components are mounted on a multi-layer laminate substrate. A plastic overmold encapsulates the entire assembly.

A new multi-standard CMOS controller provides PA band/mode selection and bias control, including the Mobile Industry Processor Interface (MIPI) RFFE logic and switch decoder circuitry. The controller supports selection of the GMSK envelope control technology by either linear RF amplification or analog VRAMP. A distinct MIPI register mapping included in this Data Sheet provides for each of these control paradigms, including associated approaches to PA mode, power output and switch control.

Selecting the linear GMSK operation standard disables VRAMP input, so all PA biasing depends only on MIPI mode selection. The transmitted envelope is then a linear function of RF input. Selecting VRAMP-enabled operation, the PA controller provides VRAMP control of the GMSK envelope and reduces sensitivity to input drive, temperature, power supply, and process variations. Skyworks' Finger-Based Integrated Power Amplifier Control (FB-iPAC) minimizes output power variation into mismatch. In EDGE and TD-SCDMA / TDD LTE linear modes, VRAMP voltage and MIPI-based bias settings jointly optimize PA linearity and efficiency.

Skyworks Green™ products are compliant with all applicable legislation and are halogen-free. For additional information, refer to Skyworks *Definition of Green*™, document number SQ04-0074.

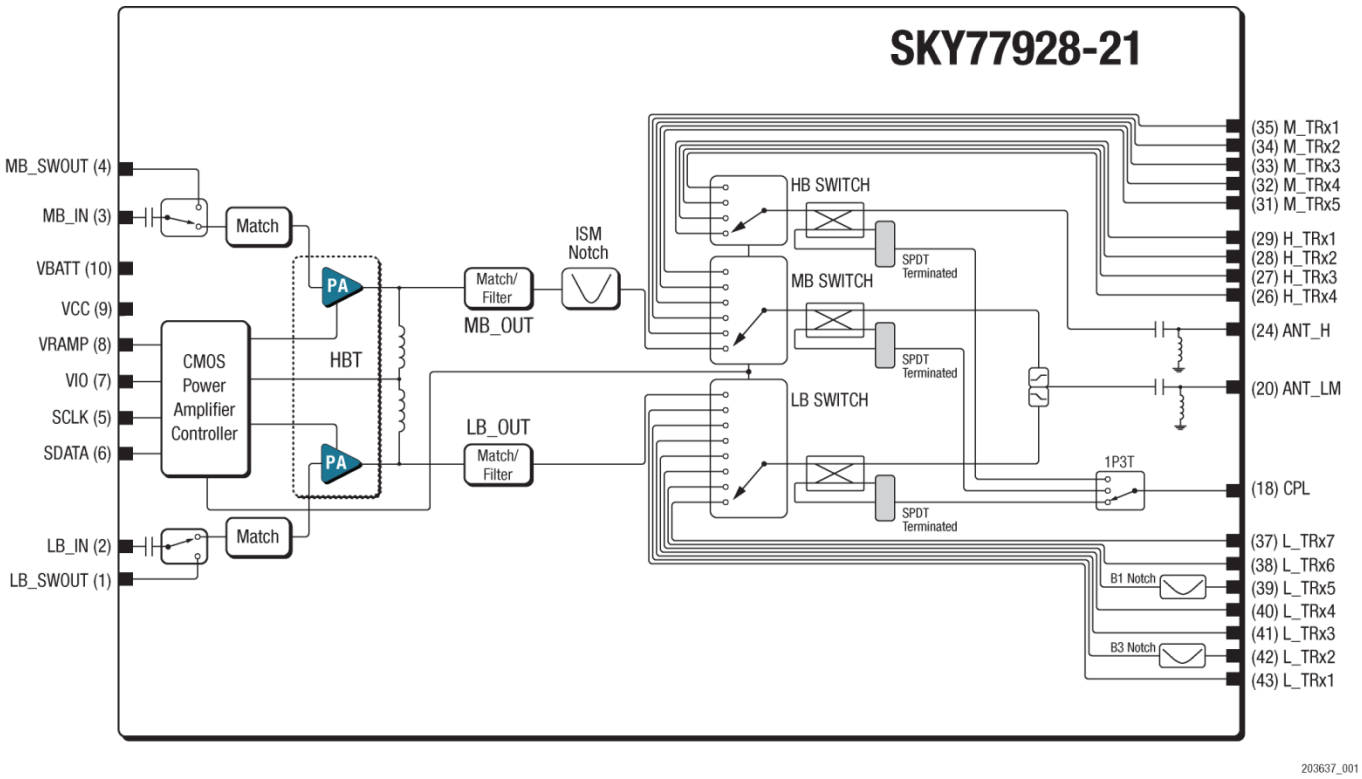


FIGURE 1. SKY77928-21 FUNCTIONAL BLOCK DIAGRAM

Electrical Specifications

The following tables list the electrical specifications of the SKY77928-21 Front-End Module. Table 1 lists the absolute maximum ratings and Table 2 lists the recommended operating conditions. Table 5 through Table 14 provide the electrical specifications of the SKY77928-21 for GMSK, EDGE, TD-SCDMA, and TDD LTE transmission and TRx port modes including control logic descriptions for the various modes.

The SKY77928-21 is a static-sensitive electronic device and should not be stored or operated near strong electrostatic fields. Detailed information on device dimensions, pad descriptions, packaging and handling can be found in later sections of this data sheet.

Table 1. Absolute Maximum Ratings[1]

Parameter		Symbol	Min	Nominal	Max	Unit
Input Power		P_{IN}	—	—	15	dBm
Supply Voltage ≤ 1 µs (measured to GND)		V_{BATT}	–1.2[2]	—	6	V
		V_{CC}	–0.5	—	6[3]	
DC Continuous During Burst[4]		I_{BATT}	—	—	2.9	A
GMSK Burst Duty Cycle		D_B	—	—	50	%
Voltage Standing Wave Ratio		VSWR	—	—	20:1	V
Power Control Voltage		V_{RAMP}	–0.3	—	3.0	V
MIPI Supply Voltage		VIO	—	—	2.0	V
MIPI Data and Clock Voltage		V_{MIPI}	—	—	2.0	V
Temperatures	Operating	T_{CASE}	–30	—	+100	°C
	Storage	T_{STG}	–40	—	+150	
Moisture Sensitivity Level		MSL	—	—	3	
Reflow Solder Temperature (J-STD-020B)		T_{SOLDER}	260	—	—	°C

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 at a time and all other parameters set at or below their nominal value.*

2 *Pulsed at –1.2 V for 100 µs.*

3 *Applies when VCC and VBATT are tied together.*

4 *Applied voltage must be current-limited to specified range.*

Table 2. SKY77928-21 Recommended Operating Conditions[1]

Unless otherwise specified: 50 Ω system; terminate all RF ports with 50 Ω during test.

Parameter		Symbol	Min	Typ[2]	Max	Unit
Supply Voltage[3]	GMSK	V_{BATT}	3.0	3.5	4.6	V
	EDGE/TD-SCDMA/TDD LTE		3.0	3.6	4.6	
		V_{CC}	3.0	—	4.6	
GMSK Input Power – V_{RAMP}-Based Operation		P_{IN}	0	3	6	dBm
Operating Case Temperature[4]	GMSK/EDGE 1–4 Slots (12.5%–50% duty cycle)[5]	T_{CASE}	–20	+25	+85	°C
	TD-SCDMA/TDD LTE		–20	+25	+85	

1 *Extreme Test Conditions (ETC) are defined by the applicable min/max values of the parameters.*

2 *Nominal Test Condition (NTC) is defined by the applicable typical values.*

3 *V_{BATT} and V_{CC} should be connected unless DC/DC is used and V_{CC} can be separately supplied.*

4 *Case Operating Temperature refers to the temperature at the GROUND PAD on the underside of the package.*

5 *Max. output power must be reduced by 6 dB to support 3-slot and 4-slot operation.*

Table 3. SKY77928-21 Interface Specifications

Unless otherwise specified: ETC per Table 2.

Parameter	Symbol	Conditions	Min	Typ	Max	Units
APT Supply Voltage	V_{BATT}		0.5	—	3.4	V
PA Supply Current (on V_{BATT})	I_{BATT}		0	—	2.9	A
GMSK/EDGE Burst Duty Cycle	D_B		12.5	—	50	%
Resistance of V_{RAMP}	$R_{\_VRAMP}$	DC resistance to ground	5	—	—	MΩ
Capacitance of V_{RAMP}	$C_{\_VRAMP}$	Capacitance to ground	—	—	2	pF
MIPI Supply Voltage	VIO		1.65	1.8	1.95	V
MIPI Signal Levels	V_{MIPI_LOW}		0		0.2 x VIO	
	V_{MIPI_HIGH}		0.8 x VIO		VIO	
Power Control Voltage	V_{RAMP}	Required for operation up to P_{RATED}	0.2	—	1.6	V
Standby Current	$I_{\_STANDBY}$	Standby mode NTC VIO = 0 V	—	7	20	µA
TRx Mode Current	$I_{\_TRx}$	Any TRx Mode	—	250	400	µA

Table 4. SKY77928-21 Linear GMSK/EDGE Power Modes -- Recommended Maximum Operating Power

Unless otherwise specified, values are used as each Power Mode's Test Condition

Band	Waveform	Power Mode	P_{RATED}	Unit
LB	GMSK	High Power Mode (HPM)	33.5	dBm
		Medium Power Mode (MPM)	29.0	
		Low Power Mode (LPM)	23.0	
		Ultra-Low Power Mode (ULPM)	15.0	
	EDGE	Medium Power Mode (MPM)	27.5	
		Low Power Mode (LPM)	22.0	
		Ultra-Low Power Mode (ULPM)	16.0	
HB	GMSK	High Power Mode (HPM)	31.0	
		Medium Power Mode (MPM)	28.0	
		Low Power Mode (LPM)	24.0	
		Ultra-Low Power Mode (ULPM)	16.0	
	EDGE	Medium Power Mode (MPM)	26.5	
		Low Power Mode (LPM)	22.0	
		Ultra-Low Power Mode (ULPM)	16.0	

Table 5-1. SKY77928-21 ELECTRICAL SPECIFICATIONS – GMSK/EDGE Low Band (Linear GMSK Operation)

Unless otherwise specified: Conditions NTC per Table 2; Duty Cycle 25%;
POUT = PRATED per "Power Modes" Table 4 at NTC, then varies with gain

Parameter	Symbol	Waveform/ Bias Mode	Condition	Min	Typ	Max	Units
Operating Frequency Range				824		915	MHz
PSAT	PSAT_GMSK	GMSK HPM	PIN = 9 dBm, NTC	33.7	34.2		dBm
PSAT Degraded	PSAT_GMSK_ETC	GMSK HPM	PIN = 9 dBm, ETC	31.5			dBm
Power Added Efficiency, saturated	PAE_GMSK_SAT	GMSK HPM	POUT = PSAT, PIN = 9 dBm		36		%
Power Added Efficiency	PAE_GMSK	GMSK HPM			34		
		GMSK MPM			20		
		GMSK LPM			10		
		GMSK ULPM			4		
Gain	GAIN_GMSK	GMSK HPM		28.0	31.0	32.0	dB
		GMSK MPM		28.0	30.5	33.0	
		GMSK LPM		24.0	26.5	29.0	
		GMSK ULPM		14.0	16.5	19.0	
	GAIN_EDGE	EDGE MPM		30.0	32.0	34.0	
		EDGE LPM		27.75	29.5	31.25	
		EDGE ULPM		17.25	19.0	20.75	
Gain Compression		GMSK HPM	Gain(PRATED – 10 dB) – Gain(PRATED – 1 dB)			1	dB
Gain Change Over Temperature		GMSK HPM	ETC, except VBATT = Vcc = 3.5 V	–2.3		1.3	dB
		GMSK MPM		–2.0		1.2	
		GMSK LPM		–2.4		1.5	
		GMSK ULPM		–2.5		2.5	
Gain Change Over Voltage		GMSK HPM	ETC, except T = 25 °C	–1.0		1.2	dB
		GMSK MPM		–0.5		1.0	
		GMSK LPM		–0.5		1.0	
		GMSK ULPM		–0.5		1.0	
PAE	PAE_EDGE	EDGE MPM			16		%

Table 5-2. SKY77928-21 ELECTRICAL SPECIFICATIONS – GMSK/EDGE Low Band (Linear GMSK Operation)

Unless otherwise specified: Conditions NTC per Table 2; Duty Cycle 25%;
POUT = PRATED per "Power Modes" Table 4 at NTC, then varies with gain

Parameter	Symbol	Waveform/ Bias Mode	Condition	Min	Typ	Max	Units
Output Noise Power		ALL	NTC, Rx = 747 MHz to 757 MHz			–84	dBm/100 kHz
			NTC, Rx = 757 MHz to 762 MHz			–84	
			NTC, Rx = 869 MHz to 894 MHz			–84	
			NTC, Rx = 925 MHz to 935 MHz			–80	
			NTC, Rx = 935 MHz to 960 MHz			–83	
			NTC, Rx = 1805 MHz to 1880 MHz			–90	
			NTC, Rx = 1930 MHz to 1990 MHz			–90	
Harmonics	$2fo$-$13fo$	GMSK ALL	ETC $P_{OUT} \leq P_{RATED}$			–33	dBm
Input VSWR	$VSWR_{IN}$	ALL				2.8:1	
Stability	S	ALL	VSWR <= 12:1			–36	dBm
Ruggedness	Ru	HPM	All Load Phases	15:1			
Switching Transients	SWT_{400}	GMSK HPM	400 kHz offset ETC P_{IN} adjusted for Temperature			–28	dBm/30kHz
		GMSK MPM				–28	
		GMSK LPM				–28	
		GMSK ULPM				–28	
ACPR (M-ORFS, No Predistortion)	$ACPR_{200}$	EDGE MPM	200 kHz offset ETC except $V_{BATT} \geq 3.2$ V P_{IN} adjusted for Temperature			–35.5	dBc/30 kHz
		EDGE LPM				–35.5	
		EDGE ULPM				–35.5	
	$ACPR_{400}$	EDGE MPM	400 kHz offset ETC except $V_{BATT} \geq 3.2$ V P_{IN} adjusted for Temperature			–58	
		EDGE LPM				–58	
		EDGE ULPM				–58	
	$ACPR_{600}$	EDGE MPM	600 kHz offset ETC except $V_{BATT} \geq 3.2$ V PIN adjusted for Temperature			–65	
		EDGE LPM				–65	
		EDGE ULPM				–65	
EVM (No Predistortion)	EVM_{rms}	EDGE MPM	ETC except $V_{BATT} \geq 3.2$ V P_{IN} adjusted for Temperature		2	4	%
		EDGE LPM			2	4	
		EDGE ULPM			2	4	

Table 6-1. SKY77928-21 Electrical Specifications – GMSK Low Band (VRAMP-Based Operation)

Unless otherwise specified: PRATED = 33.3 dBm; ETC per Table 2.

GSM850/900 GMSK Mode							
Parameter		**Symbol**	**Conditions**	**Min**	**Typ**	**Max**	**Unit**
Frequency Range	GSM850	f_0	—	824	—	849	MHz
	GSM900			880	—	915	
Supply Current		IBATT	—	—	—	2.9	A
Power Added Efficiency	GSM850	PAE	POUT = PRATED NTC Duty cycle = 1:8	—	34	—	%
	GSM900			—	34	—	
Harmonics		$2f_0$ to $13f_0$	BW = 3 MHz 5 dBm ≤ Cal-POUT ≤ PRATED VRAMP = Cal-VRAMP[1]	—	–40	–33	dBm
Output Power		POUT_MAX_NTC	NTC, PIN = 0 dBm, VRAMP = 1.65 V	—	34.2	—	dBm
		POUT_MAX_ETC	VBATT = 3.0 V, PIN = 0 dBm, VRAMP = 1.65 V	31	—	—	
Input VSWR		ΓIN	POUT ≤ PRATED	—	—	2.8:1	
Isolation		ISO_PDSD	PIN ≤ 6 dBm Isolation Mode VRAMP ≤ 0.1 V	—	–60	–51	dBm
		ISO_PESE	NTC, LB GMSK/VRAMP Tx Mode PIN ≤ 6 dBm VRAMP ≤ 0.1 V	—	—	–15	
Mode Switching Time		T_MODE_GMSK	Time from EDGE to GMSK mode transition to application of GMSK RF input drive to meet forward isolation PESE			2	µs

Table 6-2. SKY77928-21 Electrical Specifications – GMSK Low Band (Vramp-Based Operation)

Unless otherwise specified: PRATED = 33.3 dBm; ETC per Table 2.

GSM850/900 *GMSK Mode*						
Parameter	**Symbol**	**Conditions**	**Min**	**Typ**	**Max**	**Unit**
Stability	S	All combinations of the following parameters: 5 dBm ≤ POUT ≤ PRATED Load VSWR = 12:1, all phase angles	No parasitic oscillation > –36 dBm			
Load Mismatch	Load	All combinations of the following parameters: 5 dBm ≤ POUT ≤ PRATED Load VSWR = 20:1, all phase angles.	No module damage or permanent degradation			
Noise Power	PNOISE_850	ƒ_Rx = 869 MHz to 894 MHz POUT = PRATED NTC RBW = 100 kHz	—	—	–83	dBm
	PNOISE_900	ƒ_Rx = 935 MHz to 960 MHz POUT = PRATED NTC RBW = 100 kHz	—	—	–83	
		ƒ_Rx = 925 MHz to 935 MHz POUT = PRATED NTC RBW = 100 kHz	—	—	–79	
		ƒ_Rx =1805 MHz to 1880 MHz POUT = PRATED NTC RBW = 100 kHz	—	—	–86	
	PNOISE_750	ƒ_Rx = 734 MHz to 757 MHz POUT = PRATED NTC RBW = 100 kHz			–83	
	PNOISE_ISM	ƒ_Rx = 2400 MHz to 2500 MHz POUT = PRATED NTC RBW = 100 kHz			–106	

[1] *Cal-VRAMP = VRAMP at POUT = Cal-POUT, NTC*

Table 7-1. SKY77928-21 Electrical Specifications – EDGE Low Band (VRAMP-Based Operation)

Unless otherwise specified: VRAMP = 1.45 V; PRATED = 27.5 dBm; ETC per Table 2.

GSM850/900 EDGE Mode							
Parameter		**Symbol**	**Conditions**	**Min**	**Typ**	**Max**	**Unit**
Frequency Range	GSM850	f_0	—	824	—	849	MHz
	GSM900			880	—	915	
Output Power		POUT_EDGE	NTC Gain / ACPR / EVM in specification	27.5	—	—	dBm
		POUT_EDGE_EX	Gain / ACPR / EVM in specification	26.0	—	—	
Gain		G_NOM_850	POUT = PRATED NTC	30.0	31.5	33.0	dB
		G_NOM_900		30.0	31.5	33.0	
		G_EX_850	POUT = POUT_EDGE, POUT_EDGE_EX	28.0	—	34.5	
		G_EX_900		28.5	—	34.5	
Power Added Efficiency	GSM850	PAE_GSM850	POUT = PRATED NTC Duty cycle = 1:8	—	16	—	%
	GSM900	PAE_GSM900		—	16	—	
Harmonics		$2f_0$ to $15f_0$	BW = 3 MHz 5 dBm ≤ POUT ≤ POUT_EDGE, POUT_EDGE_EX	—	–45	–36	dBm
Input VSWR		Γ_{IN}	POUT ≤ PRATED	—	—	2.8:1	
ACPR		ACPR_200	POUT = POUT_EDGE, POUT_EDGE_EX Bandwidth = 30 kHz	—	–37.5	–35.5	dBc
		ACPR_400		—	–64.0	–60.0	
		ACPR_600		—	–75.0	–70.0	
EVM		EVM_RMS	POUT = POUT_EDGE, POUT_EDGE_EX	—	—	3.5	%
Bias Switching Time		T_ON_EDGE	Rx to Tx transition time from final MIPI command and 90% VRAMP to 0.5 db RF settling.	—	—	1	µs

Table 7-2. SKY77928-21 Electrical Specifications – EDGE Low Band (V_{RAMP} -Based Operation)

Unless otherwise specified: V_{RAMP} = 1.45 V; P_{RATED} = 27.5 dBm; ETC per Table 2.

GSM850/900 EDGE Mode						
Parameter	**Symbol**	**Conditions**	**Min**	**Typ**	**Max**	**Unit**
Stability	S	All combinations of the following parameters: 5 dBm ≤ P_{OUT} ≤ P_{RATED} Load VSWR = 12:1, all phase angles	No parasitic oscillation > –36 dBm			
Load Mismatch	Load	All combinations of the following parameters: 5 dBm ≤ P_{OUT} ≤ P_{RATED} Load VSWR = 20:1, all phase angles.	No module damage or permanent degradation			
Noise Power	P_{NOISE_850}	f_Rx = 869 MHz to 894 MHz P_{OUT} ≤ P_{RATED} NTC RBW = 100 kHz	—	—	–83	dBm
	P_{NOISE_900}	f_Rx = 935 MHz to 960 MHz P_{OUT} ≤ P_{RATED} NTC RBW = 100 kHz	—	—	–83	
		f_Rx = 925 MHz to 935 MHz P_{OUT} ≤ P_{RATED} NTC RBW = 100 kHz	—	—	–82	
		f_Rx = 1805 MHz to 1880 MHz P_{OUT} ≤ P_{RATED} NTC RBW = 100 kHz	—	—	–86	
	P_{NOISE_750}	f_Rx = 734 MHz to 757 MHz P_{OUT} ≤ P_{RATED} NTC RBW = 100 kHz	—	—	–83	
	P_{NOISE_ISM}	f_Rx = 2400 MHz to 2500 MHz P_{OUT} ≤ P_{RATED} NTC RBW = 100 kHz	—	—	–106	

Table 8-1. SKY77928-21 Electrical Specifications – GMSK/EDGE Mid-Band (Linear GMSK Operation)

Unless otherwise specified: Conditions NTC per Table 2; Duty Cycle 25%;
POUT = PRATED per "Power Modes" Table at NTC, then varies with gain

Parameter	Symbol	Waveform/ Bias Mode	Condition	Min	Typ	Max	Units
Operating Frequency Range				1710		1910	MHz
PSAT	PSAT_GMSK	GMSK HPM	PIN = 6 dBm, NTC	31.2	32.0		dBm
PSAT Degraded	PSAT_GMSK_ETC	GMSK HPM	PIN = 6 dBm, ETC	29.0			dBm
Power Added Efficiency, saturated	PAE_GMSK_SAT	GMSK HPM	POUT = PSAT, PIN = 6 dBm		35		%
Power Added Efficiency	PAE_GMSK	GMSK HPM			32		
		GMSK MPM			22		
		GMSK LPM			16		
		GMSK ULPM			6		
Gain	GAIN_GMSK	GMSK HPM		27.5	30.0	32.5	dB
		GMSK MPM		26.0	28.5	31.0	
		GMSK LPM		23.5	26.0	28.5	
		GMSK ULPM		20.0	22.5	25.0	
	GAIN_EDGE	EDGE MPM		30.25	32.0	33.75	
		EDGE LPM		24.75	26.5	28.25	
		EDGE ULPM		20.75	22.5	24.25	
Gain Compression		GMSK HPM	Gain(PRATED – 10 dB) – Gain(PRATED – 1 dB)			1.2	dB
Gain Change Over Temperature		GMSK HPM	ETC, except VBATT = VCC = 3.5 V	–2.5		1.4	dB
		GMSK MPM		–2.5		1.5	
		GMSK LPM		–2.4		1.7	
		GMSK ULPM		–2.5		1.8	
Gain Change Over Voltage		GMSK HPM	ETC, except T = 25 °C	–1.2		1.8	dB
		GMSK MPM		–1.0		0.9	
		GMSK LPM		–0.9		1.3	
		GMSK ULPM		–0.8		1.5	
PAE	PAE_EDGE	EDGE MPM			17		%

Table 8-2. SKY77928-21 ELECTRICAL SPECIFICATIONS – GMSK/EDGE Mid-Band (Linear GMSK Operation)

Unless otherwise specified: Conditions NTC per Table 2; Duty Cycle 25%;
POUT = PRATED per "Power Modes" Table at NTC, then varies with gain

Parameter	Symbol	Waveform/ Bias Mode	Condition	Min	Typ	Max	Units
Output Noise Power		ALL	NTC, Rx = 747 MHz to 757 MHz			–93	dBm/100kHz
			NTC, Rx = 757 MHz to 762 MHz			–93	
			NTC, Rx = 869 MHz to 894 MHz			–93	
			NTC, Rx = 925 MHz to 935 MHz			–90	
			NTC, Rx = 935 MHz to 960 MHz			–90	
			NTC, Rx = 1805 MHz to 1880 MHz			–81	
			NTC, Rx = 1930 MHz to 1990 MHz			–82	
Harmonics	$2fo$-$13fo$	GMSK ALL	ETC, Pout <= Prated			–33	dBm
Input VSWR	$VSWR_{IN}$	ALL				3:1	
Stability	S	ALL	VSWR <= 12:1			–36	dBm
Ruggedness	Ru	HPM	All Load Phases	15:1			
Switching Transients	SWT_{400}	GMSK HPM	400 kHz offset ETC P_{IN} adjusted for Temperature			–28	dBm/30kHz
		GMSK MPM				–28	
		GMSK LPM				–28	
		GMSK ULPM				–28	
ACPR (M-ORFS, no pre-distortion)	$ACPR_{200}$	EDGE MPM	200 kHz offset ETC except $V_{BATT} \geq 3.2$ V P_{IN} adjusted for Temperature			–35.5	dBc/30kHz
		EDGE LPM				–35.5	
		EDGE ULPM				–35.5	
	$ACPR_{400}$	EDGE MPM	400 kHz offset ETC except $V_{BATT} \geq 3.2$ V P_{IN} adjusted for Temperature			–58	
		EDGE LPM				–58	
		EDGE ULPM				–58	
	$ACPR_{600}$	EDGE MPM	600 kHz offset ETC except $V_{BATT} \geq 3.2$ V P_{IN} adjusted for Temperature			–65	
		EDGE LPM				–65	
		EDGE ULPM				–65	
EVM (no pre–distortion)	EVM_{RMS}	EDGE MPM	ETC except $V_{BATT} \geq 3.2$ V P_{IN} adjusted for Temperature		2	4	%
		EDGE LPM			2	4	
		EDGE ULPM			2	4	

Table 9-1. SKY77928-21 Electrical Specifications – GMSK Mid-Band (V_{RAMP}-Based Operation)

Unless otherwise specified: P_{RATED} = 30.8 dBm; ETC per Table 2.

GSM1800/1900 GMSK Mode								
Parameter		**Symbol**	**Conditions**	**Min**	**Typ**	**Max**	**Unit**
Frequency Range	DCS1800	f_0	—	1710	—	1785	MHz
	PCS1900		—	1850	—	1910	
Power Added Efficiency		$PAE_{DCS1800}$	$P_{OUT} = P_{RATED}$ NTC Duty cycle = 1:8	—	34	—	%
		$PAE_{PCS1900}$		—	34	—	
Harmonics		$2f_0$ to $7f_0$	BW = 3 MHz 0 dBm ≤ Cal-P_{OUT} ≤ P_{RATED} V_{RAMP} = Cal- V_{RAMP}[1]	—	–40	–33	dBm
Output Power		$P_{OUT\_MAX\_NTC}$	NTC P_{IN} = 0 dBm V_{RAMP} = 1.65 V	—	31.8	—	dBm
		$P_{OUT\_MAX\_ETC}$	V_{BATT} = 3.0 V P_{IN} = 0 dBm V_{RAMP} = 1.65 V	28.8	—	—	
Input VSWR		Γ_{IN}	$P_{OUT} \leq P_{RATED}$	—	—	3:1	
Isolation		ISO_{PDSD}	$P_{IN} \leq$ 6 dBm Isolation Mode $V_{RAMP} \leq$ 0.1 V	—	–60	–51	dBm
		ISO_{PESE}	NTC HB GMSK/V_{RAMP} Tx Mode $P_{IN} \leq$ 6 dBm $V_{RAMP} \leq$ 0.1 V	—	—	–15	
Mode Switching Time		T_{MODE_GMSK}	Time from EDGE to GMSK mode transition to application of GMSK RF input drive to meet forward isolation PESE	—	—	2	µs

Table 9-2. SKY77928-21 Electrical Specifications – GMSK Mid-Band (V_{RAMP}-Based Operation)

Unless otherwise specified: P_{RATED} = 31.0 dBm; ETC per Table 2.

GSM1800/1900 GMSK Mode						
Parameter	**Symbol**	**Conditions**	**Min**	**Typ**	**Max**	**Unit**
Stability	S	All combinations of the following parameters: 0 dBm ≤ P_{OUT} ≤ P_{RATED} Load VSWR = 12:1, all phase angles	No parasitic oscillation >–36 dBm			
Load Mismatch	Load	All combinations of the following parameters: 0 dBm ≤ P_{OUT} ≤ P_{RATED} Load VSWR = 20:1, all phase angles.	No module damage or permanent degradation			
Noise Power	P_{NOISE_1800}	f_Rx = 1805 MHz to 1880 MHz P_{OUT} ≤ P_{RATED} NTC RBW = 100 kHz	—	—	–81	dBm
		f_Rx = 925 MHz to 960 MHz P_{OUT} ≤ P_{RATED} NTC RBW = 100 kHz	—	—	–84	
	P_{NOISE_1900}	f_Rx = 1930 MHz to 1990 MHz P_{OUT} ≤ P_{RATED} NTC RBW = 100 kHz	—	—	–81	
		f_Rx = 869 MHz to 894 MHz P_{OUT} ≤ P_{RATED} NTC RBW = 100 kHz	—	—	–84	
	P_{NOISE_750}	f_Rx = 734 MHz to 757 MHz P_{OUT} ≤ P_{RATED} NTC RBW = 100 kHz	—	—	–83	
	P_{NOISE_ISM}	f_Rx = 2450 MHz to 2500 MHz P_{OUT} ≤ P_{RATED} NTC RBW = 100 kHz	—	—	–106	

[1] *Cal-V_{RAMP} = V_{RAMP} at P_{OUT} = Cal-P_{OUT}, NTC*

Table 10-1. SKY77928-21 Electrical Specifications – EDGE Mid-Band (V_{RAMP}-Based Operation)

Unless otherwise specified: V_{RAMP} = 1.55 V; P_{RATED} = 26.5 dBm; ETC per Table 2.

GSM1800/1900 EDGE Mode								
Parameter		**Symbol**	**Conditions**	**Min**	**Typ**	**Max**	**Unit**
Frequency Range	DCS1800	f_O	—	1710	—	1785	MHz
	PCS1900			1850	—	1916	
Output Power		P_{OUT_EDGE}	NTC Gain / ACPR / EVM / in specification	26.5	—	—	dBm
		$P_{OUT\_EDGE\_EX}$	Gain / ACPR / EVM / in specification	25.0	—	—	
Gain		G_{NOM_1800}	P_{OUT} = P_{RATED} NTC	30.0	32.0	34.0	dB
		G_{NOM_1900}		30.5	32.5	34.5	
		G_{EX_1800}	P_{OUT} = P_{OUT_EDGE}, $P_{OUT\_EDGE\_EX}$	28.0	—	35.0	
		G_{EX_1900}		27.5	—	36.0	
Power Added Efficiency		$PAE_{DCS1800}$	V_{BATT} = 3.6 V P_{OUT} = P_{RATED} NTC Duty cycle = 1:8	—	17	—	%
		$PAE_{PCS1900}$		—	17	—	
Harmonics		$2f_0$ to $7f_0$	BW = 3 MHz 0 dBm ≤ P_{OUT} ≤ P_{OUT_EDGE}, $P_{OUT\_EDGE\_EX}$	—	–45	–36	dBm
Input VSWR		Γ_{IN}	P_{OUT} ≤ P_{RATED}	—	—	3:1	
ACPR		$ACPR_{200}$	P_{OUT} = P_{OUT_EDGE}, $P_{OUT\_EDGE\_EX}$ Bandwidth = 30 kHz	—	–37.5	–35.5	dBc
		$ACPR_{400}$		—	–64.0	–59.0	
		$ACPR_{600}$		—	–75.0	–70.0	
EVM		EVM_{RMS}	P_{OUT} = P_{OUT_EDGE}, $P_{OUT\_EDGE\_EX}$	—	—	3.5	%
Mode Switching Time		T_{ON_EDGE}	Rx to Tx transition time from final MIPI command and 90% V_{RAMP} to 0.5 dB RF settling	—	—	1	µs

Table 10-2. SKY77928-21 Electrical Specifications – EDGE Mid-Band (VRAMP-Based Operation)

Unless otherwise specified: VRAMP = 1.55 V; PRATED = 26.5 dBm; ETC per Table 2.

GSM1800/1900 EDGE Mode						
Parameter	**Symbol**	**Conditions**	**Min**	**Typ**	**Max**	**Unit**
Stability	S	All combinations of the following parameters: 0 dBm ≤ POUT ≤ PRATED Load VSWR = 12:1, all phase angles	No parasitic oscillation >–36 dBm			
Load Mismatch	Load	All combinations of the following parameters: 0 dBm ≤ POUT ≤ PRATED Load VSWR = 20:1, all phase angles	No module damage or permanent degradation			
Noise Power	PNOISE_1800	ƒ_Rx = 1805 MHz to 1880 MHz POUT ≤ PRATED NTC RBW = 100 kHz	—	—	–80	dBm
		ƒ_Rx = 925 MHz to 960 MHz POUT ≤ PRATED NTC RBW = 100 kHz	—	—	–84	
	PNOISE_1900	ƒ_Rx = 1930 MHz to 1990 MHz POUT ≤ PRATED NTC RBW = 100 kHz	—	—	–80	
		ƒ_Rx = 869 MHz to 894 MHz POUT ≤ PRATED NTC RBW = 100 kHz	—	—	–84	
	PNOISE_750	ƒ_Rx = 734 MHz to 757 MHz POUT ≤ PRATED NTC RBW = 100 kHz	—	—	–83	
	PNOISE_ISM	ƒ_Rx = 2450 MHz to 2500 MHz POUT ≤ PRATED NTC RBW = 100 kHz	—	—	–106	

Table 11. SKY77928-21 Electrical Specifications – TD-SCDMA Band 39

Unless otherwise specified: MPM (Linear GMSK/EDGE Operation); VRAMP = 1.6 V (VRAMP-Based Operation); ETC per Table 2.

TD-SCDMA Band 39 (1880–1920 MHz)							
Parameters		**Symbol**	**Condition**	**Min**	**Typ**	**Max**	**Unit**
Output Power		POUT_TD_NOM	NTC	24.5	—	—	dBm
		POUT_TD_EX		23.5			
Gain	High Power	GMPM_TD_NOM	POUT = POUT_TD_NOM	29.75	31.5	33.25	dB
		GMPM_EX	POUT = POUT_TD_EX	26.5		34.0	
	Ultra-Low Power	GULPM	POUT = –5 dBm ULPM or VRAMP = 0.17 V	—	14.0	18.5	
Power Added Efficiency		PAEMPM	POUT = POUT_TD_NOM	—	12	—	%
Low Power Mode Current		IBATT_LPM	VRAMP = 0.17 V POUT = 0 dBm NTC		55		mA
Adjacent Channel Leakage power Ratio[1]	1.6 MHz offset	ACLR1.6	POUT_TD_NOM	—	–47	–42	dBc
			POUT_TD_EX	—	—	–38	
	3.2 MHz offset	ACLR3.2	POUT_TD_NOM, POUT_TD_EX	—	–64	–60	
Error Vector Magnitude[1]		EVM_RMS	POUT_TD_NOM	—	2	3	%
			POUT_TD_EX	—	—	3	
Spectral Emissions Margin		SEM1–SEM3	POUT = POUT_TD_NOM Margin to ETSI SEM mask	5			dB
Harmonic Suppression[1]		$f_0$2–$f_0$6	POUT ≤ POUT_TD_NOM, POUT_TD_EX, RBW = 1 MHz	—	—	–36	dBm
Tx Noise in Rx Bands[1]	DCS Rx		f_Rx = 1805 MHz to 1850 MHz, POUT = POUT_TD_NOM NTC, RBW = 100 kHz	—	—	–81	dBm
Input Voltage Standing Wave Ratio		VSWR_IN	—	—	—	3:1	—
Rise / Fall Time		TONDC	TRx Mode to TDD LTE Tx, from MIPI command and >90% VRAMP to 0.5 dB RF settling	—	—	10	µs
		TOFFDC	TDD LTE Tx to TRx Mode, from MIPI command or <10% VRAMP to 30 dB gain drop	—	—	10	
Stability		S	VSWR = 12:1 All phases, RBW = 1 MHz	—	—	–36	dBm
Ruggedness - no damage		Ru	All phases, time = 10 seconds	20:1	—	—	

[1] *Measured using ETSI TS 125.102 UL reference measurement channel (12.2 kbps), 16% duty cycle.*

Table 12. SKY77928-21 Electrical Specifications – TD-SCDMA Band 34

Unless otherwise specified: MPM (Linear GMSK/EDGE Operation); VRAMP = 1.6 V (VRAMP-Based Operation); ETC per Table 2.

TD-SCDMA Band 34 (2010–2025 MHz)							
Parameters		**Symbol**	**Condition**	**Min**	**Typ**	**Max**	**Unit**
Output Power		$P_{OUT\_TD\_NOM}$	NTC	24.5	—	—	dBm
		$P_{OUT\_TD\_EX}$		23.5	—	—	
Gain	High Power	$G_{MPM\_TD\_NOM}$	$P_{OUT} = P_{OUT\_TD\_NOM}$	29.0	31.0	33.0	dB
		G_{MPM_EX}	$P_{OUT} = P_{OUT\_TD\_EX}$	25.0	—	35.0	
	Ultra-Low Power	G_{ULPM}	P_{OUT} = –5 dBm ULPM or V_{RAMP} = 0.17 V	—	13.0	17.0	
Power Added Efficiency		PAE_{MPM}	$P_{OUT} = P_{OUT\_TD\_NOM}$	—	12	—	%
Low Power Mode Current		I_{BATT_LPM}	V_{RAMP} = 0.17 V P_{OUT} = 0 dBm NTC		55		mA
Adjacent Channel Leakage power Ratio[1]	1.6 MHz offset	ACLR1.6	$P_{OUT\_TD\_NOM}$	—	–44	–40	dBc
			$P_{OUT\_TD\_EX}$	—	—	–38	
	3.2 MHz offset	ACLR3.2	$P_{OUT\_TD\_NOM}$, $P_{OUT\_TD\_EX}$	—	–62	–58	
Error Vector Magnitude[1]		$EVM_{\_RMS}$	$P_{OUT\_TD\_NOM}$	—	2	3	%
			$P_{OUT\_TD\_EX}$	—	—	3	
Spectral Emissions Margin		SEM1–SEM3	$P_{OUT} = P_{OUT\_TD\_NOM}$ Margin to ETSI SEM mask	5			dB
Harmonic Suppression[1]		$f_0 2–f_0 6$	$P_{OUT} \le P_{OUT\_TD\_NOM}$, $P_{OUT\_TD\_EX}$, RBW = 1 MHz	—	—	–36	dBm
Tx Noise in Rx Bands[1]	DCS Rx		f_Rx = 1805 MHz to 1880 MHz, $P_{OUT} = P_{OUT\_TD\_NOM}$ NTC, RBW = 100 kHz	—	—	–81	dBm
Input Voltage Standing Wave Ratio		$VSWR_{\_IN}$	—	—	—	3:1	—
Rise / Fall Time		T_{ON}DC	TRx Mode to TDD LTE Tx, from MIPI command and >90% VRAMP to 0.5 dB RF settling	—	—	10	µs
		T_{OFF}DC	TDD LTE Tx to TRx Mode, from MIPI command or <10% VRAMP to 30 dB gain drop	—	—	10	
Stability		S	VSWR = 12:1 All phases, RBW = 1 MHz	—	—	–36	dBm
Ruggedness - no damage		Ru	All phases, time = 10 seconds	20:1	—	—	

[1] *Measured using ETSI TS 125.102 UL reference measurement channel (12.2 kbps), 16% duty cycle.*

Table 13. SKY77928-21 Electrical Specifications – TDD LTE Band 39

Unless otherwise specified: MPM (Linear GMSK/EDGE Operation); VRAMP = 1.2 V (VRAMP-Based Operation); ETC per Table 2.

TDD LTE Band 39 (1880–1920 MHz)							
Parameters		**Symbol**	**Condition**	**Min**	**Typ**	**Max**	**Unit**
Output Power[1]		POUT_TDLTE_NOM	NTC	25.0	—	—	dBm
		POUT_TDLTE_EX		24.0	—	—	
Gain[1]	High Power	GMPM_TDLTE_NOM	POUT = POUT_TDLTE_NOM	28.0	29.0	32.0	dB
		GMPM_TDLTE_EX	POUT = POUT_TDLTE_EX	25.5	—	33.5	
	Ultra-Low Power	GULPM	POUT = –5 dBm ULPM or VRAMP = 0.19 V	—	15.0	18.5	
Power Added Efficiency		PAEMPM	POUT = POUT_TDLTE_NOM	—	13	—	%
Low Power Mode Current		IBATT_LPM	ULPM or VRAMP = 0.19 V POUT = 0 dBm NTC		58		mA
Adjacent Channel Leakage power Ratio[1]		EUTRA_ACLR1	POUT = POUT_TDLTE_NOM	—	–42	—	dBc
			POUT = POUT_TDLTE_EX	—	—	–36	
		UTRA_ACLR1	POUT = POUT_TDLTE_NOM	—	–42	—	
			POUT = POUT_TDLTE_EX	—	—	–38	
		UTRA_ACLR2	POUT = POUT_TDLTE_NOM	—	–48	—	
			POUT = POUT_TDLTE_EX	—	—	–42	
Error Vector Magnitude[1]		EVM_RMS	POUT = POUT_TDLTE_NOM	—	2	3	%
			POUT = POUT_TDLTE_EX	—	—	3	
Spectral Emissions Margin		SEM1–SEM9	POUT = POUT_TDLTE_NOM Margin to ETSI SEM mask	5			dB
Harmonic Suppression[2]	Second	$f_0$2	POUT ≤ POUT_TDLTE_NOM, POUT_TDLTE_EX, RBW = 1 MHz	—	—	–36	dBm
	Third	$f_0$3		—	—	–46	
Tx Noise in Rx Bands[3]	ISM Band	PNOISE_TDLTE_ISM	f_Rx = 2450 to 2500 MHz, POUT = POUT_TDLTE_NOM – MPR, NTC, RBW = 100 kHz	—	—	–106	dBm
	Band 34 Rx	PNOISE_TDLTE_B34	f_Rx = 2010 to 2025 MHz, POUT = POUT_TDLTE_NOM – MPR, NTC, RBW = 100 kHz	—	—	–75	
Input Voltage Standing Wave Ratio		VSWR_IN	—	—	—	3:1	—
Rise / Fall Time		TONDC	TRx Mode to TDD LTE Tx, from MIPI command and >90% VRAMP to 0.5 dB RF settling	—	—	10	µs
		TOFFDC	TDD LTE Tx to TRx Mode, from MIPI command or <10% VRAMP to 30 dB gain drop	—	—	10	
Stability		S	VSWR = 12:1 All phases, RBW = 1 MHz	—	—	–36	dBm
Ruggedness - no damage		Ru	All phases, time = 10 seconds	20:1	—	—	

[1] Performance is measured using UL reference measurement channel, 10 MHz. QPSK, 12RB, per ETSI TS 136.101 (Release 12, section A.2.3.2.1-4a).

[2] Harmonic suppression is measured using UL reference measurement channel, 1.4 MHz, QPSK, 1RB, per ETSI TS 136.01 (Release 12, section A.2.3.2.1-1).

[3] Noise is measured using UL reference measurement channel, 20 MHz, QPSK, 100 RB, per ETSI TS 136.101 (Release 12, section A.2.3.1.1)

Table 14-1. SKY77928-21 Electrical Specifications – TRx Ports

Unless otherwise specified: any TRx Mode; Tested CW; ETC per Table 2.

Ports L_TRx1 to L_TRx7, Ports M_TRx1 to M_TRx5, Ports H_TRx1 to H_TRx4							
Parameter		**Symbol**	**Conditions**	**Min**	**Typ**	**Max**	**Unit**
Frequency Range		f_{TRx}		699		2690	MHz
Insertion Loss		Rx_{IL_LLB}	699 MHz to 850 MHz, NTC, L_TRx1–L_TRx7		1.10	1.40	dB
		Rx_{IL_ULB}	850 MHz to 960 MHz, NTC, L_TRx1–L_TRx7		1.25	1.55	
		Rx_{IL_LMB}	1400 MHz to 1700 MHz, NTC, M_TRx1–M_TRx5		1.40	1.70	
		Rx_{IL_UMB}	1710 MHz to 2400 MHz, NTC, M_TRx1–M_TRx5		1.10	1.40	
		Rx_{IL_HMB}	2500 MHz to 2700 MHz, NTC, M_TRx1–M_TRx5		1.20	1.50	
		Rx_{IL_LHB}	1400 MHz to 1700 MHz, NTC, H_TRx1–H_TRx4		0.50	0.75	
		Rx_{IL_MHB}	1710 MHz to 2170 MHz, NTC, H_TRx1–H_TRx4		0.55	0.80	
		Rx_{IL_HHB}	2300 MHz to 2690 MHz NTC, H_TRx1 to H_TRx4		0.65	0.90	
TRx Mode VSWR[1]		$VSWR_{TRx}$	NTC, Applies where insertion loss is specified		1.5:1		VSWR
Active-to-Inactive TRx Isolation	Active TRx port to any adjacent inactive TRx port	$ISO_{ADJ\_TRx\_LB}$	699 MHz to 960 MHz (two L_TRx)	30			dB
		$ISO_{ADJ\_TRx\_MB}$	1710 MHz to 2170 MHz (two M_TRx)	25			
		$ISO_{ADJ\_TRx\_HB}$	2300 MHz to 2690 MHz (two H_TRx)	20			
	Active TRx port to any non-adjacent inactive TRx port	$ISO_{NADJ\_TRx\_LB}$	699 MHz to 960 MHz (two L_TRx)	35			
		$ISO_{NADJ\_TRx\_MB}$	1710 MHz to 2170 MHz (any two M_TRx)	30			
		$ISO_{NADJ\_TRx\_HB}$	2300 MHz to 2690 MHz (any two H_TRx)	25			
LB-MB Cross-switch Isolation[2]		$ISO_{CA\_TRx\_LB}$	699 MHz to 960 MHz	20	22		dB
		$ISO_{CA\_TRx\_MB}$	1400 MHz to 1700MHz	15	16		
			1710 MHz to 2170 MHz	25	30		
			1805 MHz to 1830 MHz (B3 Rx)[3]	38[10]	41		
			2110 MHz to 2148 Mhz (B4 Rx)[4]	41[10]	45		
		$ISO_{CA\_TRx\_HB}$	2300 MHz to 2690 MHz	30	35		
LB-HB Cross-switch Isolation[5]		$ISO_{CA\_TRx\_LH}$	699 MHz to 960 MHz and 1710 MHz to 2690 MHz	40			dB
MB-HB Cross-switch Isolation[6]		$ISO_{CA\_TRx\_MH}$	1710 MHz to 2690 MHz	26			dB
TRx Harmonics	LB	TRx_{2fo} TRx_{3fo}	NTC 50 ohm P_{IN_TRx} = +26 dBm			–75	dBm
	M/HB					–55	
	LB	TRx_{2fo} TRx_{3fo}	NTC, VSWR 5:1 at ANT port P_{IN_TRx} = +26 dBm			–70	
	M/HB					–50	
Band 13 2nd Harmonic in GPS Band		TRx_{2fo_B13}	P_{IN_TRx} = 25 dBm at 787 MHz, NTC			–85	dBm
Band 8 2nd Harmonic in Band 3		$TRx2_{2xB8}$	P_{IN} = 25 dBm L_TRx2 only NTC		–115		

Table 14-2. SKY77928-21 Electrical Specifications – TRx Ports

Unless otherwise specified: any TRx Mode; Tested CW; ETC per Table 2.

Ports L_TRx1 to L_TRx7, Ports M_TRx1 to M_TRx5, Ports H_TRx1 to H_TRx4						
Parameter	**Symbol**	**Conditions**	**Min**	**Typ**	**Max**	**Unit**
Band 12/17 3rd Harmonic in Band 1	$TRx5_{\_3xB12}$	P_{IN} = 25 dBm L_TRx5 only NTC		–125		
2nd Order Intermodulation Distortion f_IMD2 = | f_TX ± f_blocker |	IMD2	Tx Output Power = +20 dBm Blocker Power = –15 dBm NTC TRx port duplexer termination VSWR 10:1 at $f_{\_BLOCKER}$, all phases			–105	dBm
3rd Order Intermodulation Distortion f_IMD3 = 2f_TX – f_blocker	IMD3	Tx Output Power = +20 dBm Blocker Power = –15 dBm NTC TRx port duplexer termination VSWR 10:1 at $f_{\_BLOCKER}$, all phases			–105	dBm
Band 7 IMD w/ WiFi	IMD3_B7	P_TRx = +24 dBm at 2550 MHz P_blocker = +2 dBm at 2430 MHz NTC H_TRx1 to H_TRx4		–95	–88	dBm
Leakage from Tx to TRx Ports	$P_{\_TxTRx}$	Any TX Mode			0	dBm
Coupling Factor in TRx Mode[7]	$CPL_{\_TRx\_LB}$	699 to 960 MHz, L_TRx ports only NTC		–22		dB
	$CPL_{\_TRx\_MB}$	1710 to 2025 MHz, M_TRx and H_TRx ports only NTC		–22		
	$CPL_{\_TRx\_HB}$	2300 to 2690 MHz, M_TRx and H_TRx ports only NTC		–22		
Coupling Factor Variation over Output VSWR[6]	$CPL_{\_SWR\_TRx\_LB}$	699 to 960 MHz, L_TRx ports only VSWR 2.5:1 at ANT port	–0.5		0.5	dB
	$CPL_{\_SWR\_TRx\_MB}$	1710 to 2025 MHz, M_TRx and H_TRx ports only VSWR 2.5:1 at ANT port	–1.3		1.3	
	$CPL_{\_SWR\_TRx\_HB}$	2300 to 2690 MHz, M_TRx and H_TRx ports only VSWR 2.5:1 at ANT port	–0.5		0.5	
Coupling Factor Variation over Temperature[8,9]	$CPL_{\_TV\_TRx\_LB}$	699 to 960 MHz, L_TRx ports only	–0.5		0.5	dB
	$CPL_{\_TV\_TRx\_MB}$	1710 to 2025 MHz, M_TRx and H_TRx ports only	–1.0		1.0	
	$CPL_{\_TV\_TRx\_HB}$	2300 to 2690 MHz, M_TRx and H_TRx ports only	–1.0		1.0	
Turn-on Time	$T_{\_ON\_VBATT}$	From 50% V_{BATT} and VIO to 0.5 dB RF settling			20	us
TRx-to-TRx Switch Speed	$T_{\_TRxTRx}$	From MIPI command to 0.5 dB RF settling		2	5	us

1 *Based on the worst of TRx and ANT port reflection coefficients.*

2 *Any active L_TRx1-7 port to any active M_TRx1-5 port.*

3 *Only for L_TRx2. For other ports spec = 30 Min, 32 Typ.*

4 *Only for L_TRx5. For other ports spec = 33.5 Min, 38 Typ.*

5 *Any active L_TRx1-7 port to any active H_TRx1-4 port.*

6 *Any active M_TRx1-5 port to any active H_TRx1-4 port.*

7 *Defined as the ratio of CPL port to ANT port output power, driven from TRx.*

8 *Variation with respect to 50 ohm reference, forward direction only.*

9 *Variation with respect to NTC, forward direction only.*

10 *Min represents worst case data across all MHTRx ports and frequencies. Selective MHTRx ports provide better isolation.*

Table 15. SKY77927-21 Electrical Specifications– Input Switch

Unless otherwise specified: any TRx Mode; Tested CW; ETC per Table 2.

Ports LB_SWOUT and MB_SWOUT						
Parameter	**Symbol**	**Conditions**	**Min**	**Typ**	**Max**	**Unit**
Frequency Range	$f_{\_INSW}$		600		2025	MHz
Insertion Loss	LBSWOUT_IL	600 MHz to 915 MHz, NTC, LB_SWOUT		0.6	0.9	dB
	MBSWOUT_IL	1710 MHz to 2025 MHz, NTC, MB_SWOUT		1.25	1.55	

MIPI RFFE Information

Table 16. SKY77928-21 MIPI RFFE Register Map (Linear GMSK Power Control only)

Bit Position	Description	Trigger Support	R/W	Default	Notes
Register 0, Address 0x00 (Mode Control)					
[7]	Register Map & Power Control Selector	Trigger0	R/W	0	(set to 0 to select this Linear GMSK Power Control register map)
[6:3]	PA Bias Mode Control			0000	0000 = Low Band EDGE 0100 = B34/39 TD-SCDMA 0001 = High Band EDGE 0101 = B39 TDD LTE 0010 = Low Band GMSK 0011 = High Band GMSK
[2]	PA Enable			0	0 = PA Tx Disabled 1 = PA Tx Enabled
[1:0]	Power Range Mode			00	00 = High Power Mode (HPM) 01 = Mid Power Mode (MPM) 10 = Low Power Mode (LPM) 11 = Ultra-Low Power Mode (ULPM)
Register 1, Address 0x01 (RESERVED)					
[7:0]	RESERVED	Trigger0	R/W	00000000	RESERVED
Register 4, Address 0x04					
[7:6]	Input Switch Control	Trigger0	R/W	00	01 = LB Switch Out 11 = HB Switch Out 00 = Switch Off

Table 17. SKY77928-21 MIPI RFFE Register Map (VRAMP-Based Operation only)

Bit Position	Description	Trigger Support	R/W	Default	Notes		
Register 0, Address 0x00 (PA Control)							
[7]	Register Map and Power Control Selector	Trigger0	R/W	0	(set to 1 to select this VRAMP GMSK Power Control register map)		
[6]	Reserved			0	Reserved; (set to zero)		
[5]	Gain Control (linear)			0	0 = nominal gain	1 = reduced gain	
[4:0]	TxFEM Mode Control			00000	0x00 = PA off	0x0B = LB EDGE/Linear Tx	0x0F = HB EDGE/Linear Tx
					0x0A = LB GMSK/Vramp Tx	0x0E = HB GMSK/Vramp Tx	Other = Reserved (Do Not Use)
Register 1, Address 0x01 (BIAS_CTRL)							
[7:4]	PA Stage 3 Bias (DAC3)	Trigger0	R/W	0000	0000 = 250 µA	0110 = 1750 µA	1100 = 3250 µA
					0001 = 500 µA	0111 = 2000 µA	1101 = 3500 µA
					0010 = 750 µA	1000 = 2250 µA	1110 = 3750 µA
					0011 = 1000 µA	1001 = 2500 µA	1111 = 4000 µA
					0100 = 1250 µA	1010 = 2750 µA	
					0101 = 1500 µA	1011 = 3000 µA	
[3:0]	PA Stage 1-2 Bias (DAC12)			0000	0000 = 250 µA	0110 = 1750 µA	1100 = 3250 µA
					0001 = 500 µA	0111 = 2000 µA	1101 = 3500 µA
					0010 = 750 µA	1000 = 2250 µA	1110 = 3750 µA
					0011 = 1000 µA	1001 = 2500 µA	1111 = 4000 µA
					0100 = 1250 µA	1010 = 2750 µA	
					0101 = 1500 µA	1011 = 3000 µA	

Table 18-1. SKY77928-21 MIPI RFFE Register Map (Common Registers)

Bit Position	Description	Trigger Support	R/W	Default Value	Notes		
Register 2, Address 0x02 (ASM_CTRL)							
[7:4]	(RESERVED)	Trigger0	R/W	0000	Reserved (set to all zeroes)		
[3:0]	LB Switch Control		R/W	0000	0000 = Standby	0011 = L_TRx3	0110 = L_TRx6
					0001 = L_TRx1	0100 = L_TRx4	0111 = L_TRx7
					0010 = L_TRx2	0101 = L_TRx5	1111 = LB PA Out
							Other = isolation
Register 3, Address 0x03 (ASM_CTRL2)							
[7:5]	HB Switch Control	Trigger0	R/W	000	000 = Standby	010 = H_TRx2	100 = H_TRx4
					001 = H_TRx1	011 = H_TRx3	Other = isolation
[4:0]	(RESERVED)			00000	(Reserved; set to zero)		
Register 4, Address 0x04 (CPL_CTRL)							
[7:5]	(RESERVED)	Trigger0		000	(Reserved; set to zero)		
[4:3]	Coupler Mode		R/W	00	00 = Standby	10 = MB Coupler ON	
					01 = LB Coupler ON	11 = HB Coupler ON	
[2]	Coupler Directionality		R/W	0	0 = Forward	1 = Reverse	
[1:0]	Coupler Termination		R/W	00	00 = Termination A	01 = Termination B	10 = Termination C 11 = Termination D
Register 5, Address 0x05 (ASM_CTRL3)							
[7:4]	(RESERVED)		R/W	0x00	Reserved (set to zero)		
[3:0]	MB Switch Control			0000	0000 = Standby	0011 = M_TRx3	1111 = MB PA Out
					0001 = M_TRx1	0100 = M_TRx4	
					0010 = M_TRx2	0101 = M_TRx5	Other = isolation

Table 19-2. SKY77928-21 MIPI RFFE Register Map (Common Registers)

Bit Position	Description	Trigger Support	R/W	Default Value	Notes
Register 27, Address 0x1B (GROUP_ID)					
7:4	(RESERVED)	No	R/W	0000	(Reserved)
3:0	Group SID			0000	Group slave ID
Register 28, Address 0x1C (PM_TRIG)					
7:6	PWR_MODE (See Note)	No	R/W	10	00 = Normal Operation (ACTIVE) 01 = Default Register Settings 10 = Low Power (LOW POWER) 11 = Reserved
5	Trigger Mask 2			0	Trigger Enable: 0, Trigger Disable: 1
4	Trigger Mask 1			0	Trigger Enable: 0, Trigger Disable: 1
3	Trigger Mask 0			0	Trigger Enable: 0, Trigger Disable: 1
2	Trigger Register 2			0	Not supported
1	Trigger Register 1			0	(Reserved)
0	Trigger Register 0			0	1 = Latch Triggered Register Contents
Register 29, Address 0x1D (PROD_ID)					
7:0	Product ID	No	R	0x9B	Product ID
Register 30, Address 0x1E (MAN_ID)					
7:0	Manufacturer ID	No	R	0xA5	Manufacturer ID [7:0]
Register 31, Address 0x1F (USID)					
7:6	(RESERVED)	No	R/W	00	(Reserved)
5:4	Manufacturer ID (MSB)		R	01	Manufacturer ID [9:8]
3:0	User ID		R/W	1110	USID
Register 32, Address 0x20 (EXT_PROD_ID)					
7:0	EXT_PROD_ID	No	R	0x00	
Register 35, Address 0x23 (UDR_RST)					
7	SOFTWARE_RESET	No	R/W	0	
6:0	(RESERVED)			0000000	Reserved (set to zero)
Register 36, Address 0x24 (ERR_SUM)					
7	RESERVED	No	R/W	0	Reserved
6	COMMAND_FRAME_ PARITY_ERR			0	Command Sequence received with parity error – discard command. The RFFE_STATUS register shall reset after it is read.
5	COMMAND_LENGTH_ ERR			0	Command length error. The RFFE_STATUS register shall reset after it is read.
4	ADDRESS_FRAME_ PARITY_ERR			0	Address frame with parity error. The RFFE_STATUS register shall reset after it is read.
3	DATA_FRAME_PARITY _ERR			0	Data frame with parity error. The RFFE_STATUS register shall reset after it is read.
2	READ_UNUSED_REG			0	Read command to an invalid address. The RFFE_STATUS register shall reset after it is read.
1	WRITE_UNUSED_REG			0	Write command to an invalid address. The RFFE_STATUS register shall reset after it is read.
0	BID_GID_ERR			0	Read command with a BROADCAST_ID or GROUP_ID. The RFFE_STATUS register shall reset after it is read.

***NOTE**: When an RFFE Slave is initially powered up and comes out of reset, it enters LOW POWER. During LOW POWER, the device will be in Standby mode.*

Technical Information

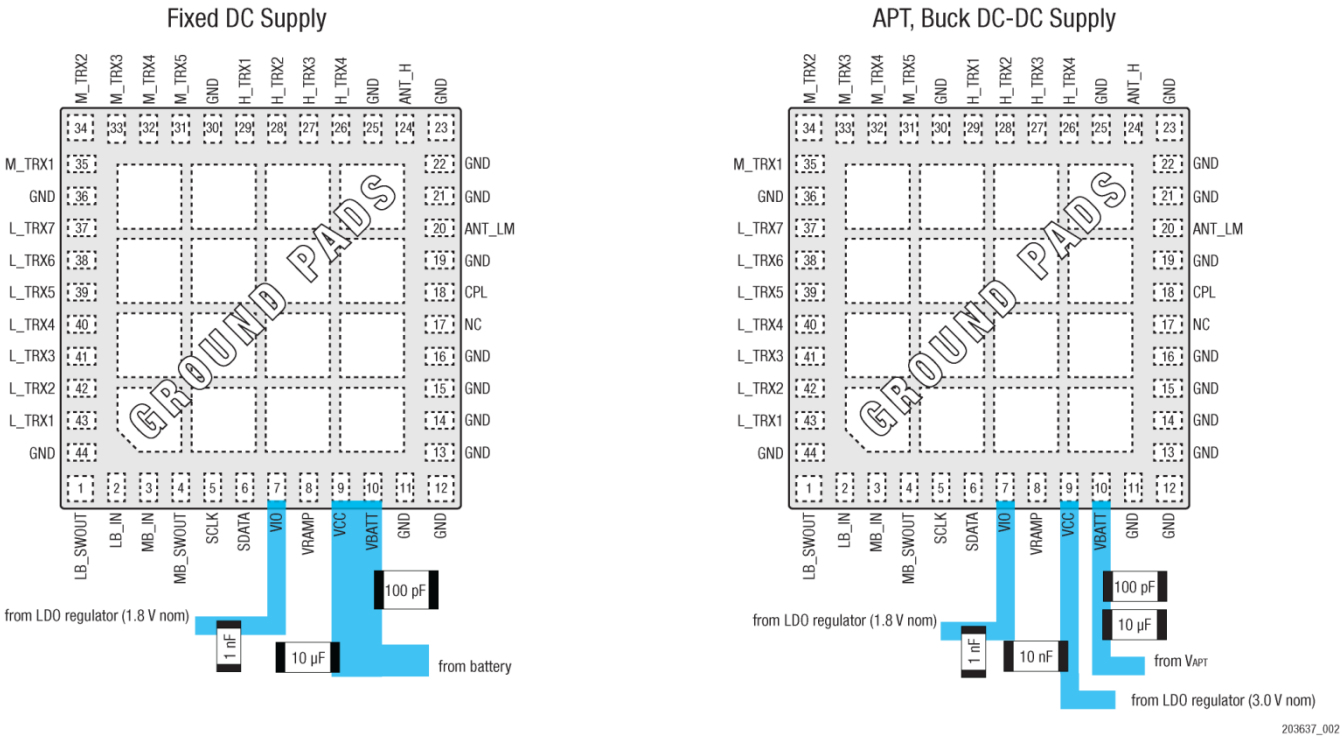


FIGURE 2. SKY77928-21 APPLICATION SCHEMATIC

Package Dimensions

The SKY77928-21 quad-band front-end module is a 5.5 mm x 5.5 mm x 0.75 mm, 44-pad, leadless package. Figure 3 is a three-view mechanical drawing of the pad configuration with layout dimensions. Figure 4 provides a recommended PCB layout footprint for the FEM to help the designer attain optimum thermal conductivity, good grounding, and minimum RF discontinuity for the 50-ohm terminals.

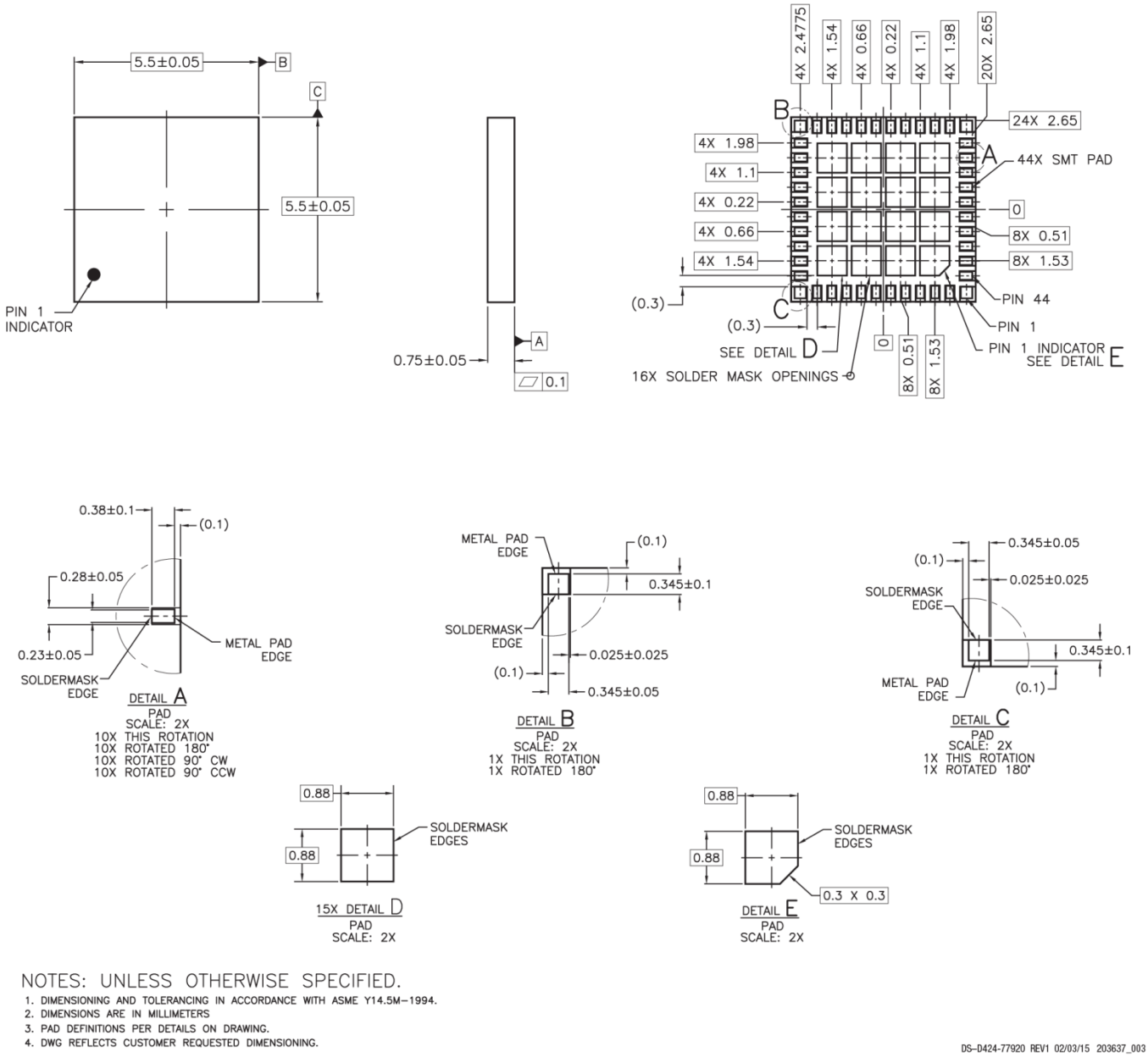


FIGURE 3. DIMENSIONAL DIAGRAM FOR 5.5 mm x 5.5 mm x 0.75 mm, 44-PAD LEADLESS PACKAGE – SKY77928-21 (ALL VIEWS)

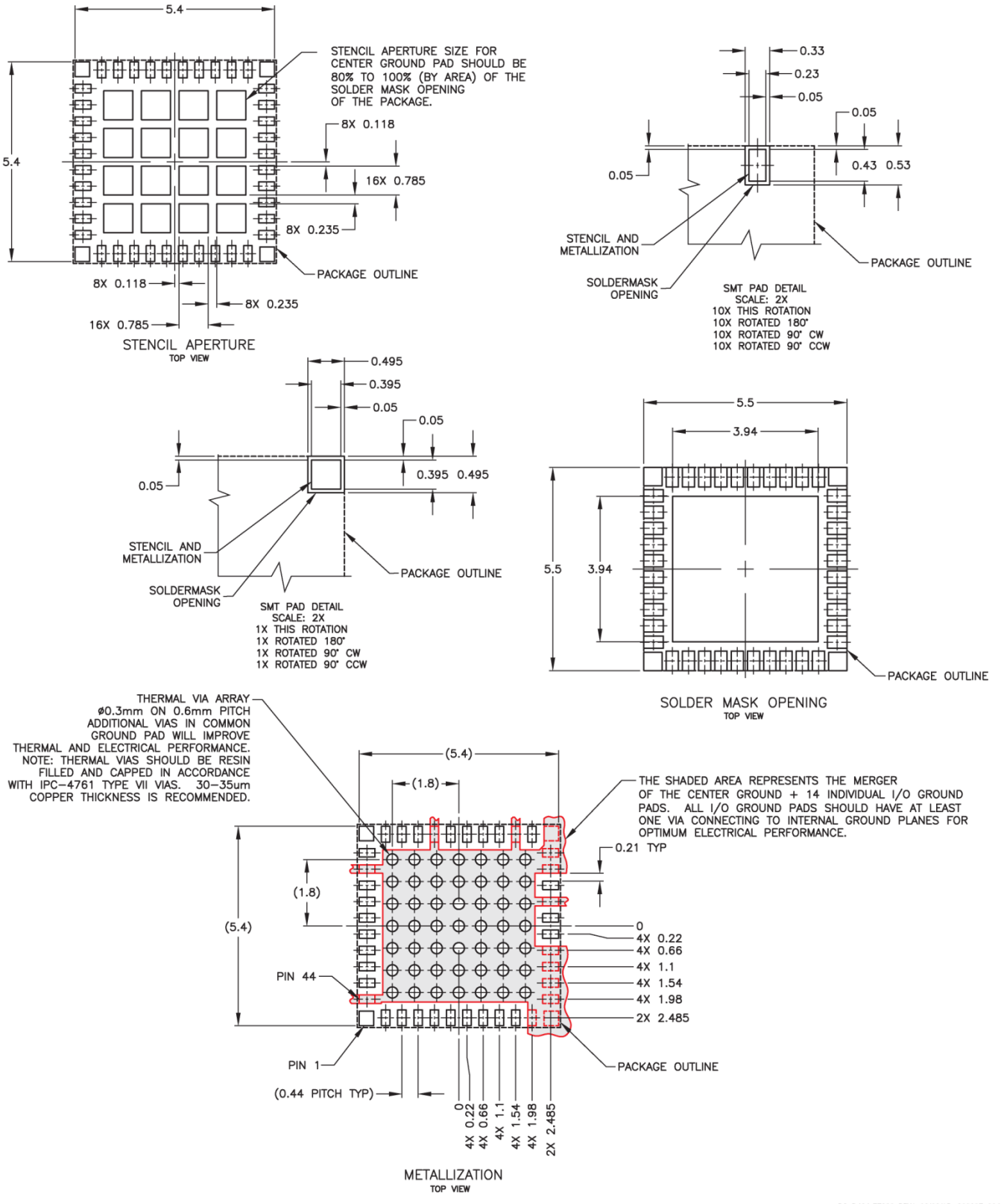
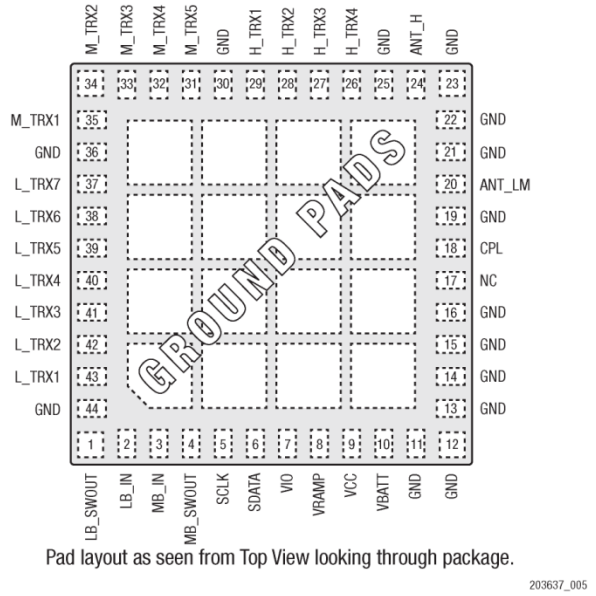


FIGURE 4. PCB LAYOUT FOR 5.5 mm x 5.5 mm, 44-PAD LEADLESS PACKAGE – SKY77928-21 SPECIFIC

Package Description

Figure 5 shows the device pad configuration and the pad numbering convention, which starts with pad 1 in the lower left and increments counter-clockwise around the package. Table 18 lists the pad names and signal descriptions. Figure 6 illustrates the typical case markings.



Pad layout as seen from Top View looking through package.

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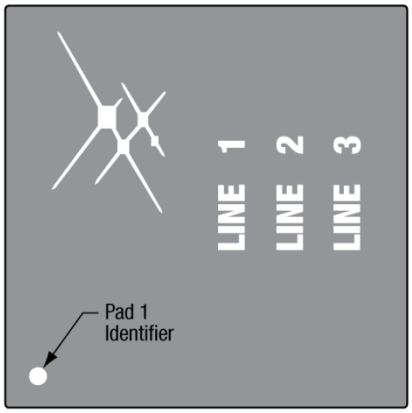
FIGURE 5. SKY77928-21 PAD CONFIGURATION (TOP VIEW)



NOTE: Lines 1, 2, 3 have a maximum of 12 characters
Line 1 = Part Number and Version
Line 2 = Lot Number
Line 3 = YEAR–WEEK–Country Code (MX)

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FIGURE 6. TYPICAL CASE MARKINGS

Table 20. SKY77928-21 Signal Descriptions

Pad[1]	Name	Description
1	LB_SWOUT	Alternate RF output path for LB_IN
2	LB_IN	RF input to LB PA or LB_SWOUT
3	MB_IN	RF input to MB PA or MB_SWOUT
4	MB_SWOUT	Alternate RF output path for MB_IN
5	SCLK	MIPI clock
6	SDATA	MIPI serial data
7	VIO	MIPI supply voltage
8	VRAMP	Controls GMSK power; EDGE, TD-SCDMA, TDD LTE bias
9	VCC	Output switch supply voltage
10	VBATT	PA supply voltage
17	NC	No connection
18	CPL	Directional coupler RF output
20	ANT_LM	RF output to antenna
24	ANT_H	RF output to antenna
26–29	H_TRx4…H_TRx1	HB TRx Switch ports
31–35	M_TRx5…M_TRx1	MB TRx Switch ports
37–43	L_TRx7…L_TRx1	LB TRx Switch ports
Ground Pad Grid		Ground Pad Grid (device underside)

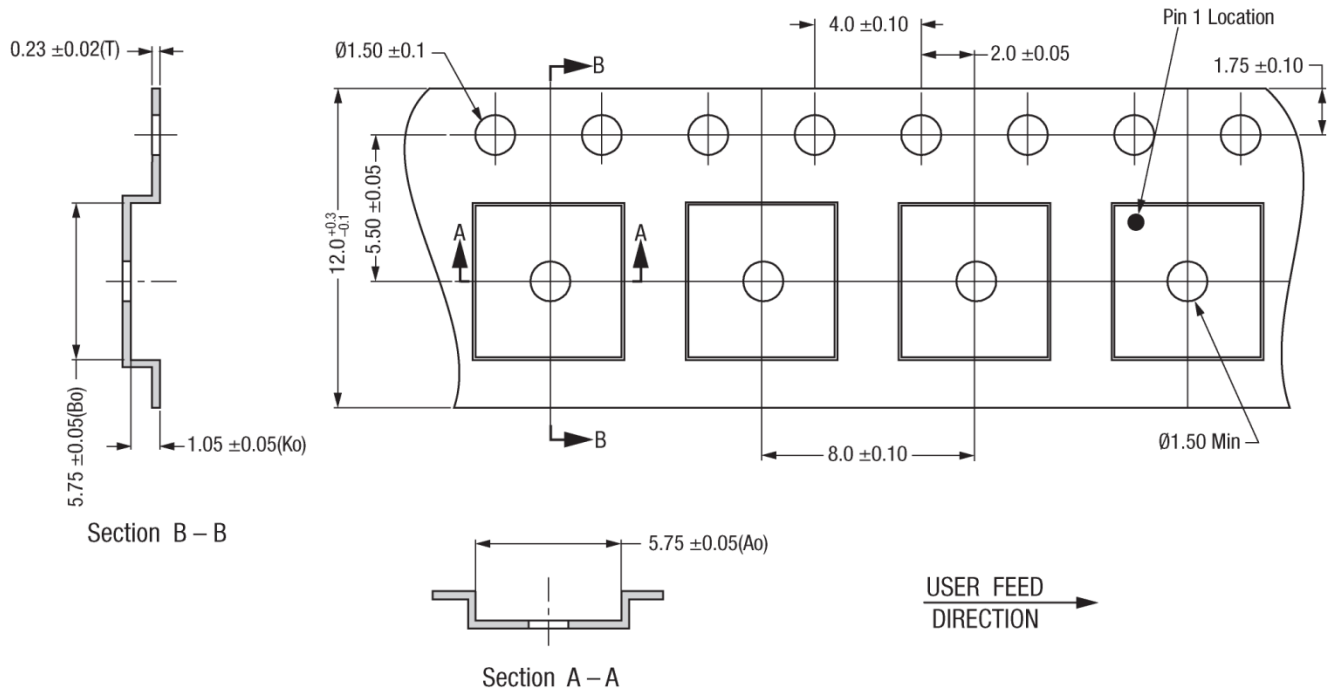
[1] *Pads 11–16, 19, 21–23, 25, 30, 36, 44 are ground pads.*

Package Handling Information

Because of its sensitivity to moisture absorption, this device package is baked and vacuum-packed prior to shipment. Instructions on the shipping container label must be followed regarding exposure to moisture after the container seal is broken, otherwise, problems relate to moisture absorption may occur when the part is subjected to high temperature during solder assembly.

The SKY77928-21 is capable of withstanding an MSL3/260 °C solder reflow. Care must be taken when attaching this product, whether it is done manually or in a production solder reflow environment. If the part is attached in a reflow oven, the temperature ramp rate should not exceed 3 °C per second; maximum temperature should not exceed 260 °C. If the part is manually attached, precaution should be taken to insure that the part is not subjected to temperatures exceeding 260 °C for more than 10 seconds. For details on attachment techniques, precautions, and handling procedures recommended by Skyworks, please refer to Skyworks Application Note: *PCB Design and SMT Assembly/Rework,* Document Number 101752. Additional information on standard SMT reflow profiles can also be found in the *JEDEC Standard J-STD-020*.

Production quantities of this product are shipped in the standard tape-and-reel format (Figure 7).



NOTES:
1. CARRIER TAPE IS BLACK CONDUCTIVE POLYSTYRENE OR POLYCARBONATE.
2. COVER TAPE IS TRANSPARENT AND CONDUCTIVE.
3. ESD SURFACE RESISTIVITY ≤ $1x10^{10}$ OHMS/SQ, PER EIA, JEDEC TAPE AND REEL SPEC.
4. 10 SPROCKET HLE PITCH CUMULATIVE TOLERANCE ON TAPE: ±0.20 mm.
5. Ao & Bo MEASURESD ON PLANE 0.30 mm ABOVE BOTTOM OF POCKET.
6. ALLOWABLE CAMBER TO BE 1/100 mm, NON-CUMULATIVE OVER 250 mm.
7. ALL DIMENSIONS ARE IN MILLIMETERS.

Carrier Tape for Body Size 5.5 x 5.5 x 0.80–1.10 mm D232-XXX(076D)

FIGURE 7. DIMENSIONAL DIAGRAM FOR CARRIER TAPE BODY SIZE 5.5 mm x 5.5 mm x 0.85–1.10 mm – MCM

Electrostatic Discharge (ESD) Sensitivity

Attention: Observe Precautions for Handling Electrostatic-Sensitive Devices.
Electrostatic Discharge (ESD) can damage this device, which must be protected from ESD at all times. 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.

To avoid ESD damage, both latent and visible, it is very important that the product assembly and test areas follow the ESD handling precautions listed below

- Personnel Grounding
  - Wrist Straps
  - Conductive Smocks, Gloves and Finger Cots
  - Antistatic ID Badges
- Protective Workstation
  - Dissipative Table Top
  - Protective Test Equipment (Properly Grounded)
  - Grounded Tip Soldering Irons
  - Solder Conductive Suckers
  - Static Sensors
- Facility
  - Relative Humidity Control and Air Ionizers
  - Dissipative Floors (less than 1,000 MΩ to GND)
  -
- Protective Packaging and Transportation
  - Bags and Pouches (Faraday Shield)
  - Protective Tote Boxes (Conductive Static Shielding)
  - Protective Trays
  - Grounded Carts
  - Protective Work Order Holders

Ordering Information

Product Name	Order Number	Evaluation Board Part Number
SKY77928-21 SkyLiTE™ Tx-Rx Front-End Module	SKY77928-21	

Revision History

Revision	Date	Description
A	August 1, 2015	Initial Release – Preliminary Information CO 1871
B	October 13, 2016	Revise: Change Data Sheet status to FINAL from PRELIMINARY; Features list (p1); Tables 1, 4–14, 18 Add: Table 15; Figure 6 CN 9949

References

Skyworks Application Note: *PCB Design and SMT Assembly/Rework Guidelines for MCM–L Packages;* Document Number 101752

Standard SMT Reflow Profiles: *JEDEC Standard J–STD–020*