DATA SHEET

SKY65045-70LF: 390–1500 MHz Low Noise Power Amplifier Driver

Applications

- UHF television
- TETRA radio
- GSM, AMPS, PCS, DCS, 2.5G, 3G
- ISM band transmitters
- Fixed WCS
- 802.16 WiMAX
- 3GPP long term evolution

Features

- Wideband frequency range: 390–1500 MHz
- Low noise figure: 1.8 dB
- High linearity: OIP3: 37.5 dBm
- Output $P_{1\ dB}$: 25 dBm
- High gain: 14 dB
- Single DC supply: 5 V
- On-chip bias circuit
- SOT-89 (4-pin 2.4 x 4.5 mm) lead (Pb)-free package (MSL1, 260 °C per JEDEC J-STD-0-20)

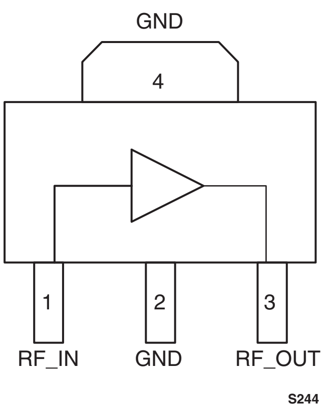
Description

Skyworks SKY65045-70LF is a high-performance, ultrawideband Power Amplifier (PA) driver with superior output power, low noise, linearity, and efficiency. The device provides a 1.6 dB Noise Figure (NF) and an output power at 1 dB compression of 25 dBm, making the SKY65045-70LF ideal for use in the driver stage of infrastructure transmit chains. The SKY65045-70LF is fabricated with Skyworks high reliability Heterojunction Bipolar Transistor (HBT) process. The device uses low-cost Surface Mount Technology (SMT) in the form of a 2.4 x 4.5 mm Small Outline Transistor (SOT-89) package.

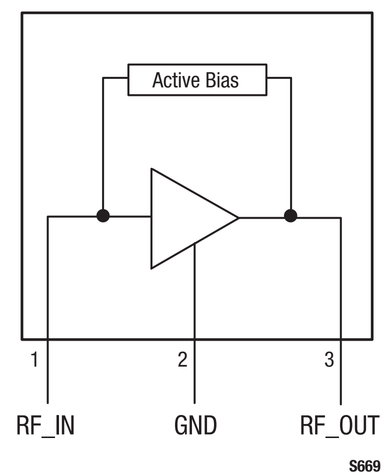
The module can operate over the temperature range of -40 °C to +85 °C. A populated evaluation board is available upon request.

NEW Skyworks offers lead (Pb)-free, RoHS (Restriction of Hazardous Substances)-compliant packaging.

Block Diagram



Functional Diagram



Electrical Specifications

V_{CC} = 5 V, Z_0 = 50 Ω, T_C = 25 °C, unless otherwise noted

Parameter	Symbol	Condition	Min.	Typ.	Max.	Unit
Test Frequency = 747 MHz						
Frequency	F		697	747	797	MHz
Small signal gain	G	P_{IN} = -15 dBm		15		dB
Input return loss	$\|S_{11}\|$	P_{IN} = -15 dBm		9		dB
Output return loss	$\|S_{22}\|$	P_{IN} = -15 dBm		8		dB
Reverse transmission loss	$\|S_{12}\|$	P_{IN} = -15 dBm		23		dB
Output power at 1 dB compression	$P_{1\ dB}$	CW		24		dBm
Operating current @ $P_{1\ dB}$	$I_{CC}\_P_{1\ dB}$	@ $P_{1\ dB}$		132		mA
Operating current	I_{CC}	Pout = 17 dBm		70		mA
Power added efficiency	PAE	@ $P_{1\ dB}$		35		%
Input 3rd order intercept point	IIP3	P_{IN}/tone = -7 dBm, ΔF = 1 MHz		29		dBm
Output 3rd order intercept point	OIP3	P_{OUT}/tone = 8 dBm, ΔF = 1 MHz		44		dBm
Noise figure	NF	Small signal		1.9		dB
Quiescent current	I_{CCQ}	No RF		47		mA
Test Frequency = 897.5 MHz						
Frequency	F		880	897.5	915	MHz
Small signal gain	G	P_{IN} = -15 dBm	13	14	16	dB
Input return loss	$\|S_{11}\|$	P_{IN} = -15 dBm		12.2	10	dB
Output return loss	$\|S_{22}\|$	P_{IN} = -15 dBm		19.5	10	dB
Reverse transmission loss	$\|S_{12}\|$	P_{IN} = -15 dBm		21	15	dB
Output power at 1 dB compression	$P_{1\ dB}$	CW	22.5	25		dBm
Operating current @ P1dB	$I_{CC}\_P_{1\ dB}$	@ $P_{1\ dB}$		133	180	mA
Operating current	I_{CC}	P_{OUT} = 17 dBm		61	90	mA
Power added efficiency	PAE	@ $P_{1\ dB}$		45		%
Output 3rd order intercept point	OIP3	P_{OUT}/tone = 17 dBm, ΔF = 1 MHz	36	37.5		dBm
Noise figure	NF	Small signal		1.8	2.4	dB
Quiescent current	I_{CCQ}	No RF		46	60	mA

Absolute Maximum Ratings

Characteristic	Value
RF output power (P_{OUT})	27 dBm
Supply voltage (V_{CC})	6 V
Supply current (I_{CC})	215 mA
Power dissipation (P_{DISS})	1.3 W
Operating case temperature (T_C)	-40 °C to +85 °C
Storage temperature (T_{ST})	-55 °C to +125 °C
Junction temperature (T_J)	150 °C

Performance is guaranteed only under the conditions listed in the specifications table and is not guaranteed under the full range(s) described by the Absolute Maximum specifications. Exceeding any of the absolute maximum/minimum specifications may result in permanent damage to the device and will void the warranty.

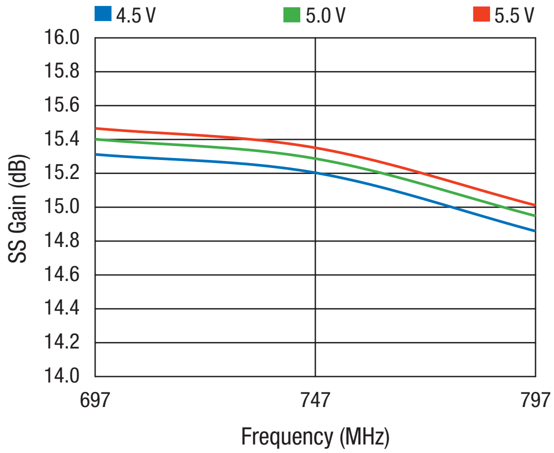
CAUTION: *Although this device is designed to be as robust as possible, ESD (Electrostatic Discharge) can damage this device. This device must be protected at all times from ESD. Static charges may easily produce potentials of several kilovolts on the human body or equipment, which can discharge without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

Recommended Operating Conditions

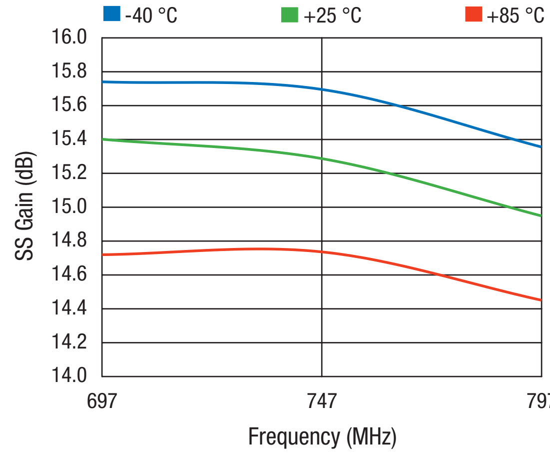
Parameter	Symbol	Min.	Typ.	Max.	Unit
Supply voltage	V_{CC}		5.0	5.5	V
Operating frequency	F_0	390		1500	MHz
Operating case temperature	T_C	-40	+25	+85	°C

Typical Performance Data

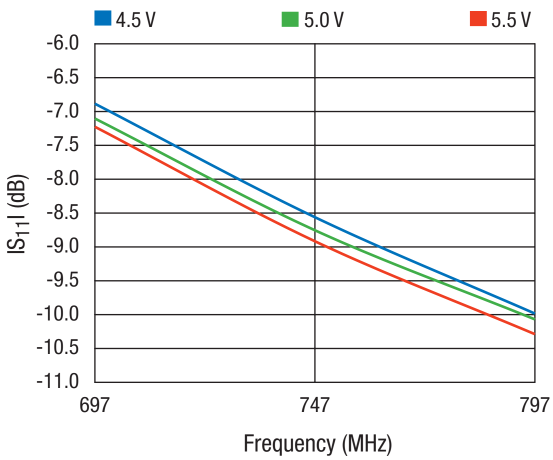
V_{CC} = 5 V, F = 747 MHz, CW, Z_0 = 50 Ω, T_C = 25 °C, unless otherwise noted



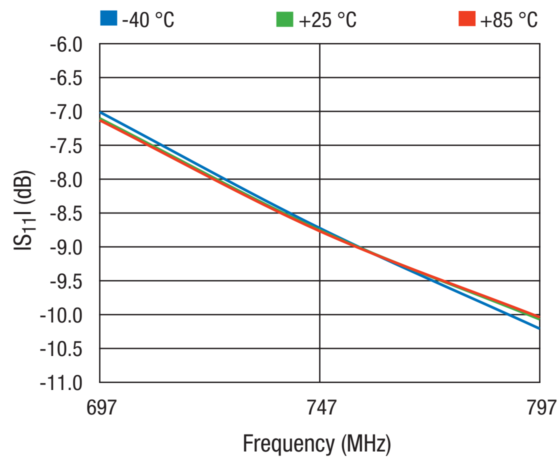
Small Signal Gain vs. Frequency Across V_{CC}



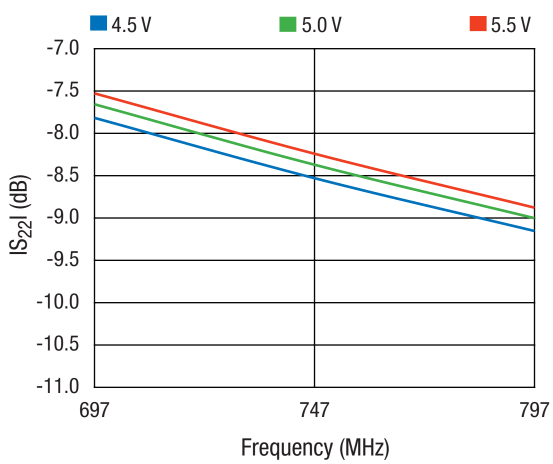
Small Signal Gain vs. Frequency Across Temperature



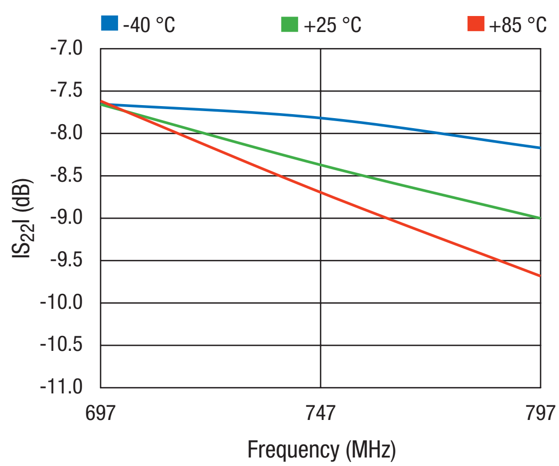
$|S_{11}|$ vs. Frequency Across V_{CC}



$|S_{11}|$ vs. Frequency Across Temperature



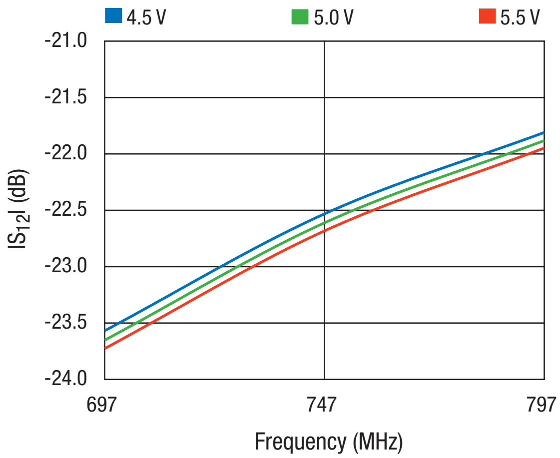
$|S_{22}|$ vs. Frequency Across V_{CC}



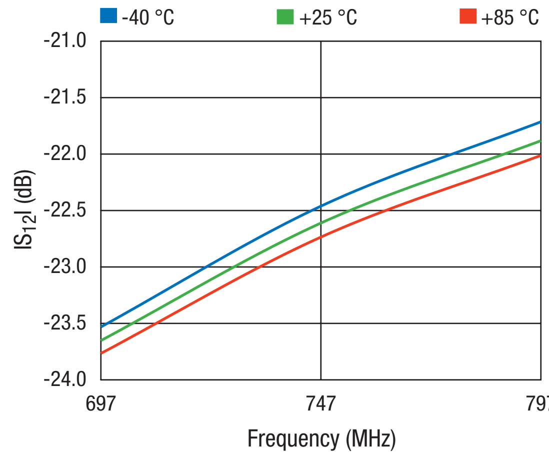
$|S_{22}|$ vs. Frequency Across Temperature

Typical Performance Data

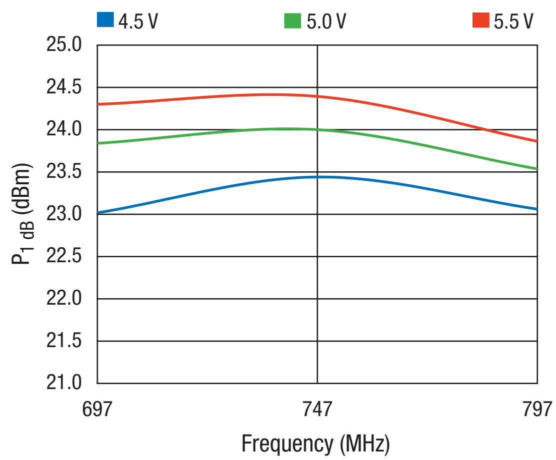
V_{CC} = 5 V, F = 747 MHz, CW, Z_0 = 50 Ω, T_C = 25 °C, unless otherwise noted



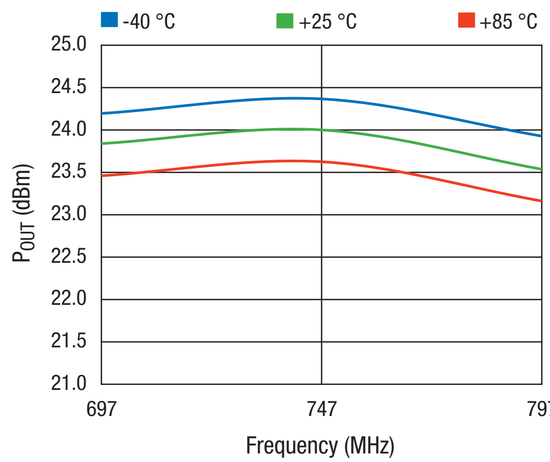
$|S_{12}|$ vs. Frequency Across V_{CC}



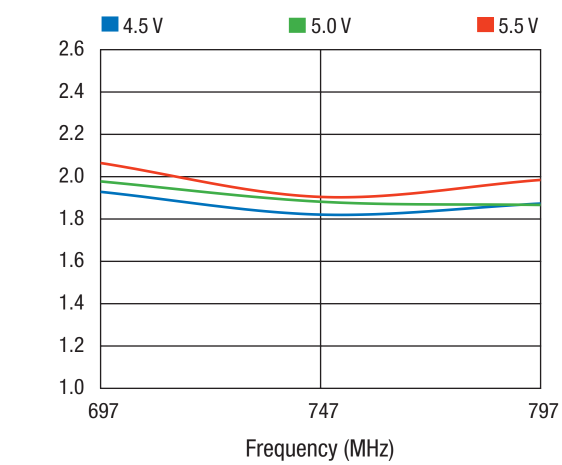
$|S_{12}|$ vs. Frequency Across Temperature



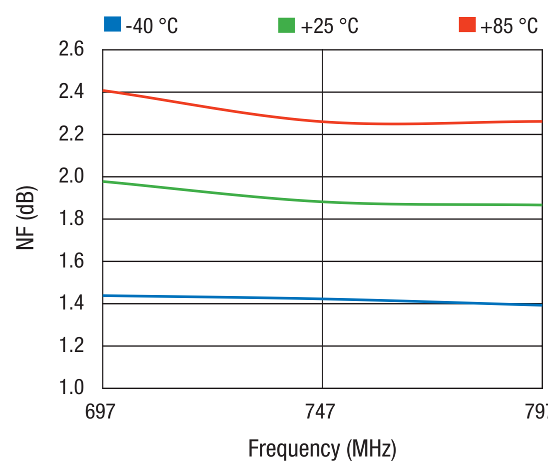
$P_{1\ dB}$ vs. Frequency Across V_{CC}



$P_{1\ dB}$ vs. Frequency Across Temperature



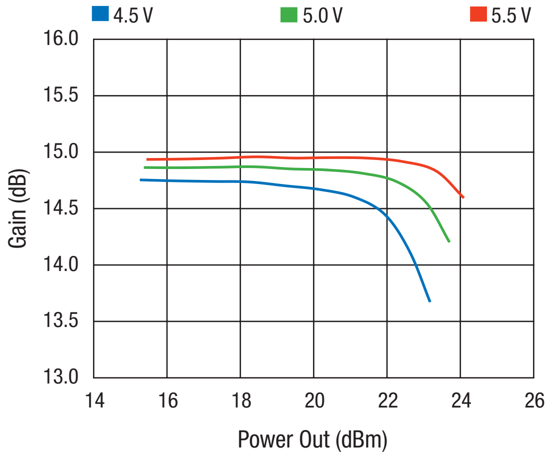
Noise Figure vs. Frequency Across V_{CC}



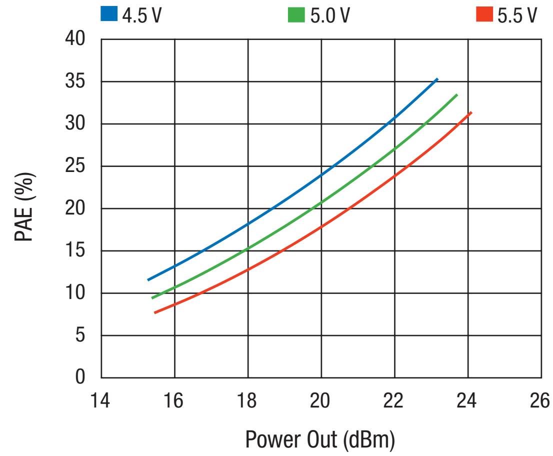
Noise Figure vs. Frequency Across Temperature

Typical Performance Data

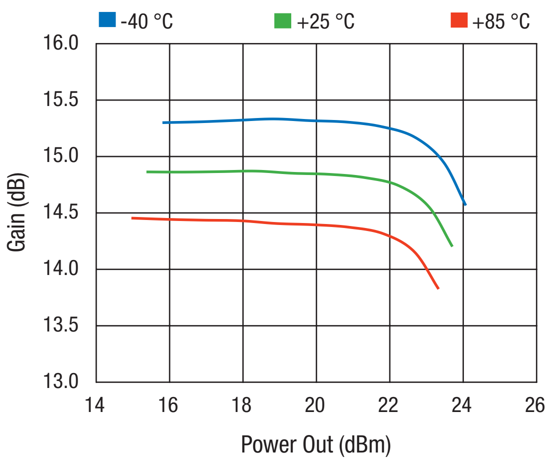
V_{CC} = 5 V, F = 747 MHz, CW, Z_0 = 50 Ω, T_C = 25 °C, unless otherwise noted



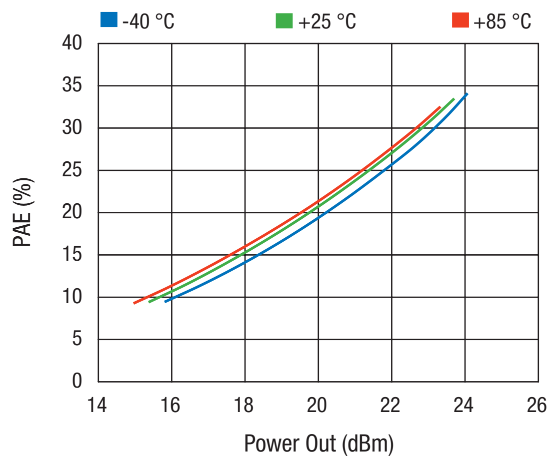
Gain vs. Power Out Across V_{CC}



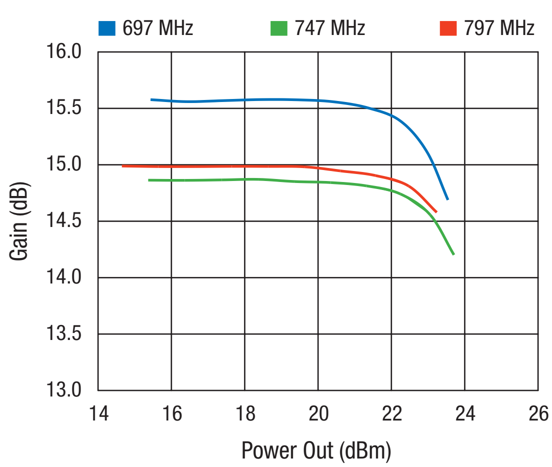
PAE vs. Power Out Across V_{CC}



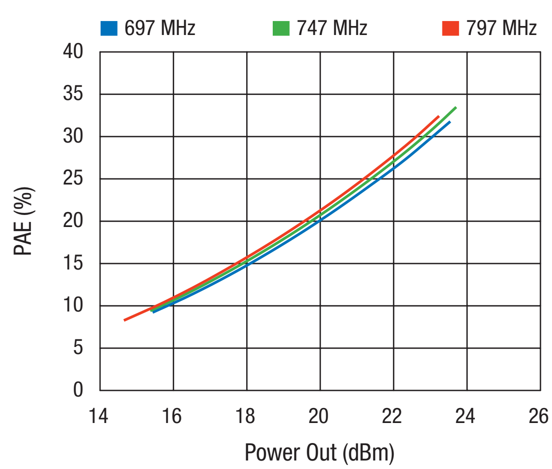
Gain vs. Power Out Across Temperature



PAE vs. Power Out Across Temperature



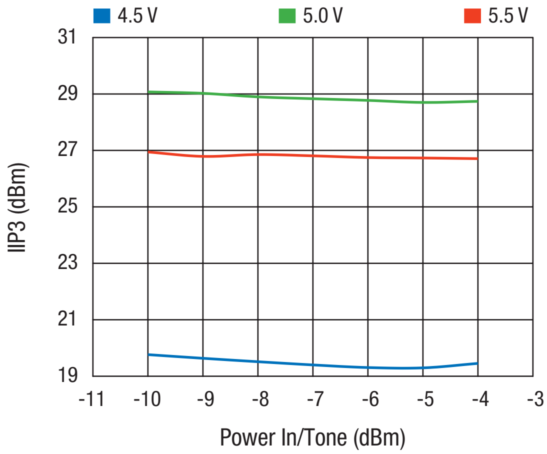
Gain vs. Power Out Across Frequency



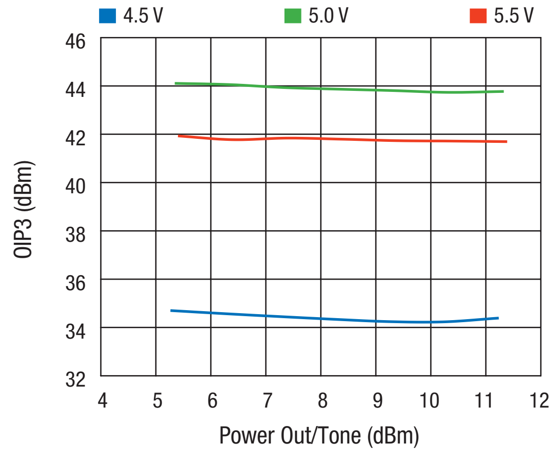
PAE vs. Power Out Across Frequency

Typical Performance Data

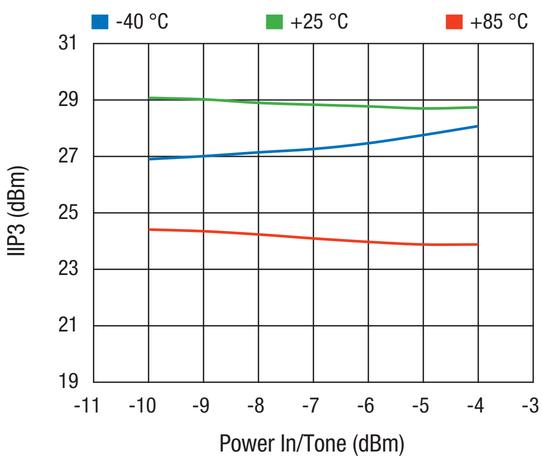
V_{CC} = 5 V, F = 747 MHz, CW, Z_0 = 50 Ω, T_C = 25 °C, unless otherwise noted



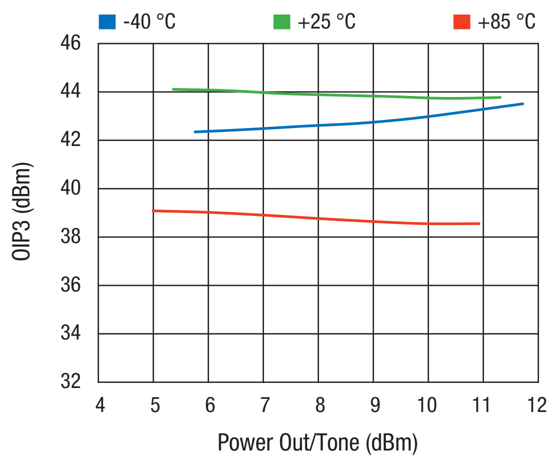
IIP3 vs. Power In/Tone Across V_{CC}



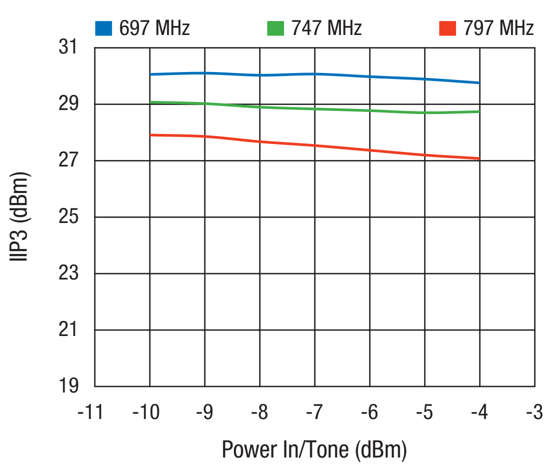
OIP3 vs. Power Out/Tone Across V_{CC}



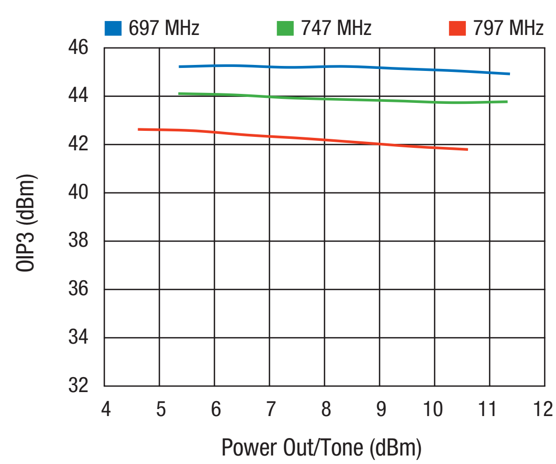
IIP3 vs. Power In/Tone Across Temperature



OIP3 vs. Power Out/Tone Across Temperature



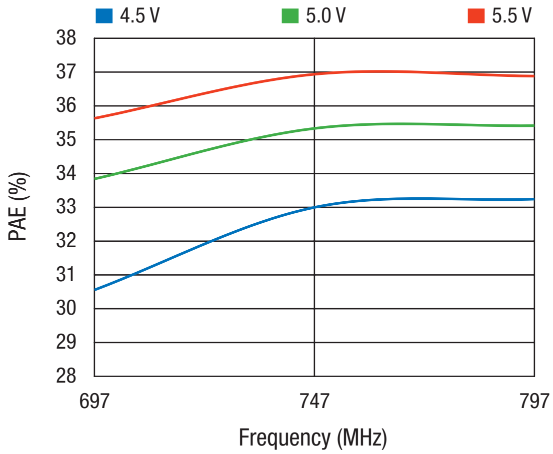
IIP3 vs. Power In/Tone Across Frequency



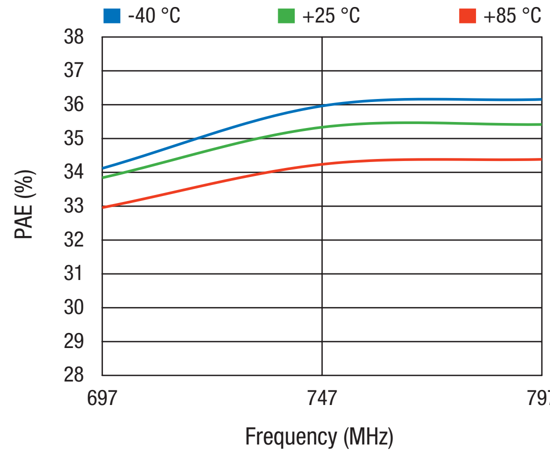
OIP3 vs. Power Out/Tone Across Frequency

Typical Performance Data

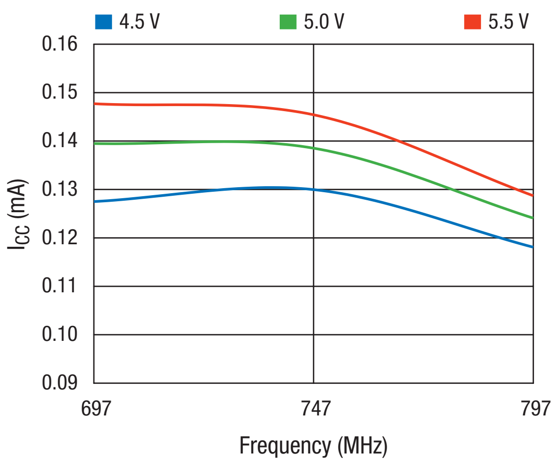
V_{CC} = 5 V, F = 747 MHz, CW, Z_0 = 50 Ω, T_C = 25 °C, unless otherwise noted



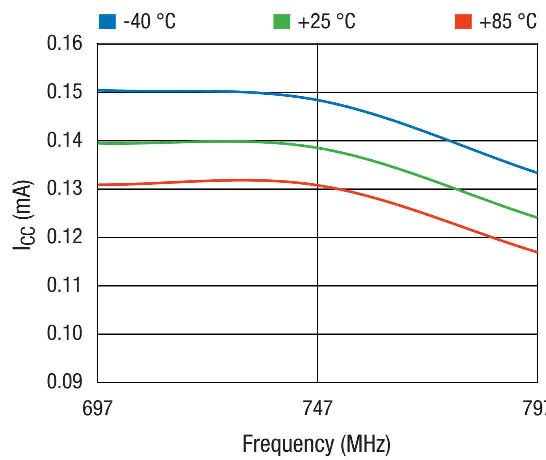
PAE @ $P_{1 dB}$ vs. Frequency Across V_{CC}



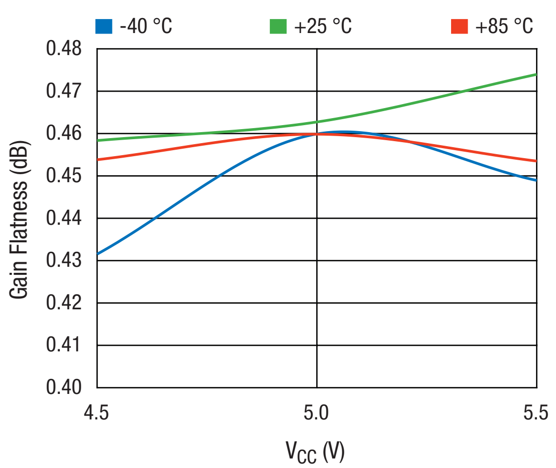
PAE @ $P_{1 dB}$ vs. Frequency Across Temperature



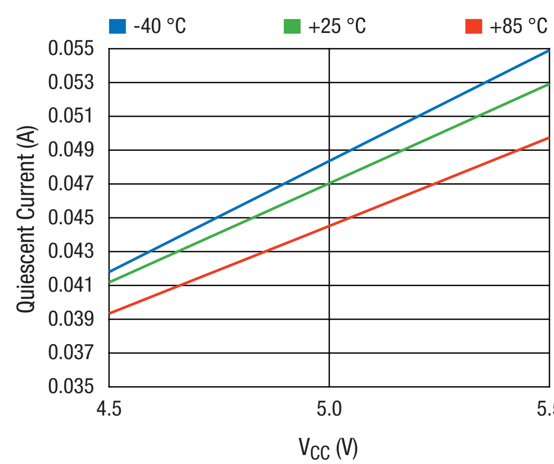
I_{CC} @ $P_{1 dB}$ vs. Frequency Across V_{CC}



I_{CC} @ $P_{1 dB}$ vs. Frequency Across Temperature



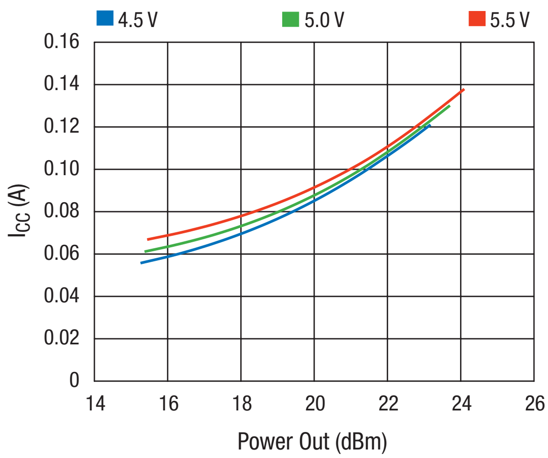
Gain Flatness vs. V_{CC} Across Temperature



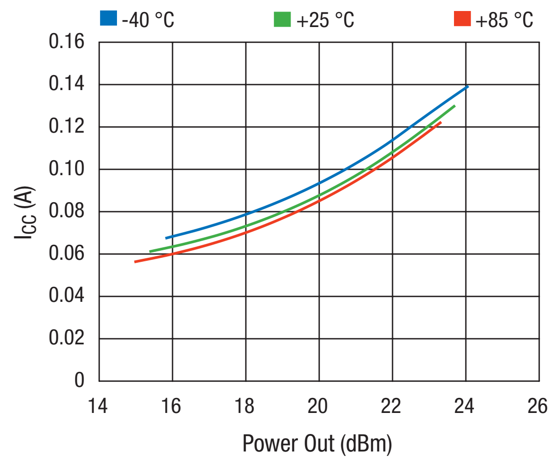
Quiescent Current vs. V_{CC} Across Temperature

Typical Performance Data

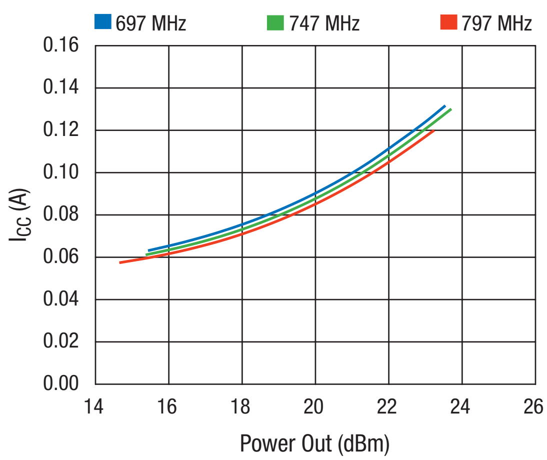
V_{CC} = 5 V, F = 747 MHz, CW, Z_0 = 50 Ω, T_C = 25 °C, unless otherwise noted



I_{CC} vs. P_{OUT} Across V_{CC}



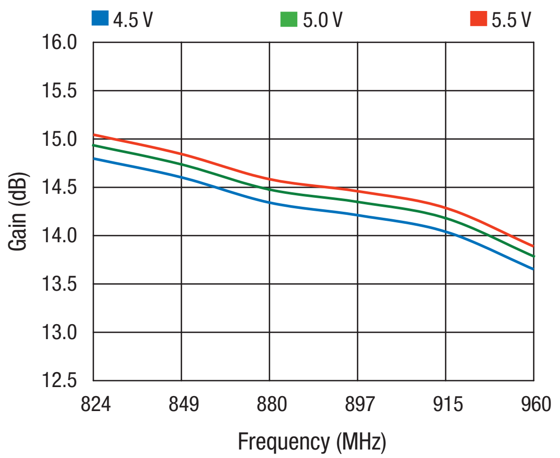
I_{CC} vs. P_{OUT} Across Temperature



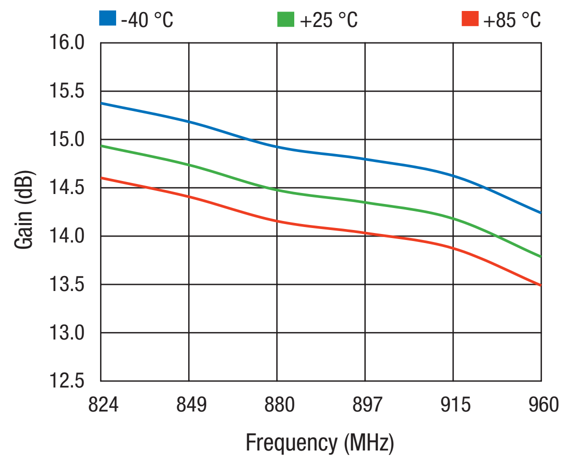
I_{CC} vs. P_{OUT} Across Frequency

Typical Performance Data

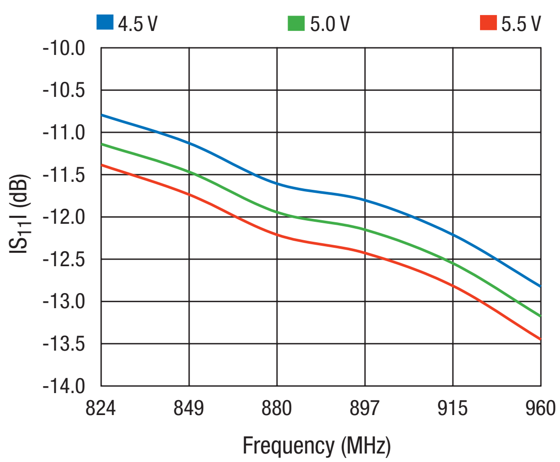
V_{CC} = 5 V, F = 897.5 MHz, CW, Z_0 = 50 Ω, T_C = 25 °C, unless otherwise noted



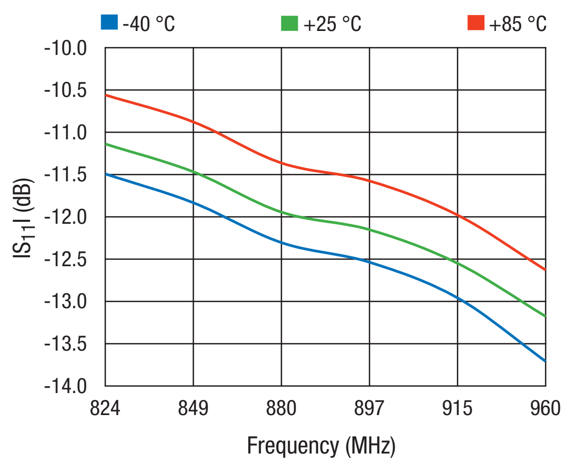
Small Signal Gain vs. Frequency Across V_{CC}



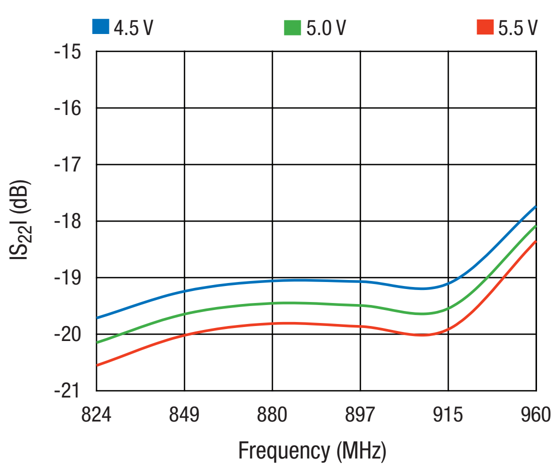
Small Signal Gain vs. Frequency Across Temperature



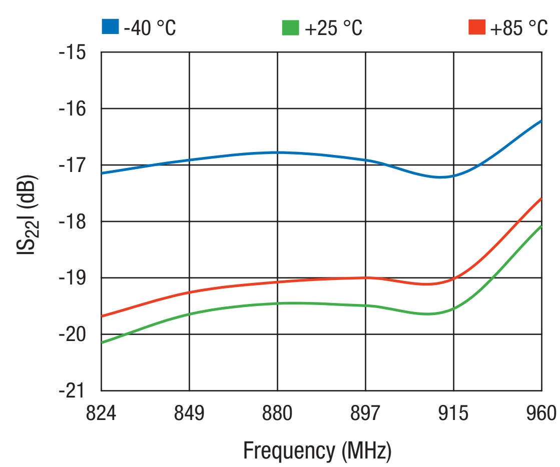
IS_{11}I vs. Frequency Across V_{CC}



IS_{11}I vs. Frequency Across Temperature



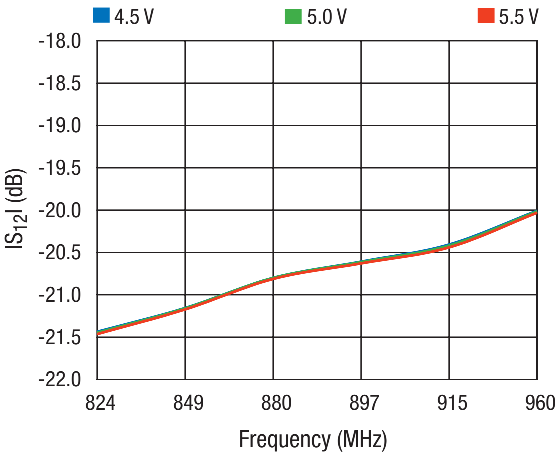
IS_{22}I vs. Frequency Across V_{CC}



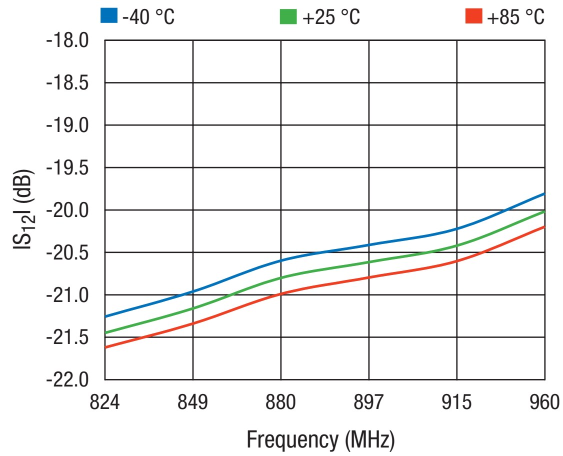
IS_{22}I vs. Frequency Across Temperature

Typical Performance Data

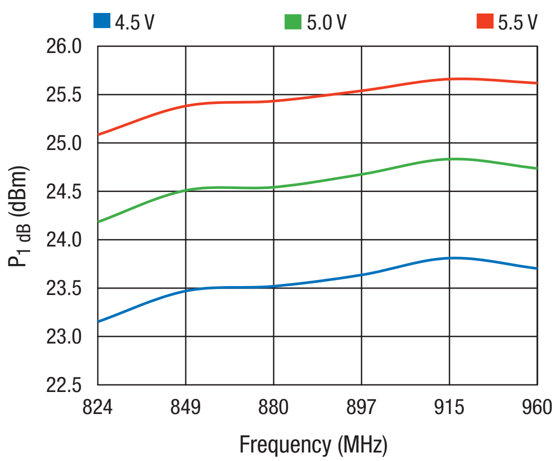
V_{CC} = 5 V, F = 897.5 MHz, CW, Z_0 = 50 Ω, T_C = 25 °C, unless otherwise noted



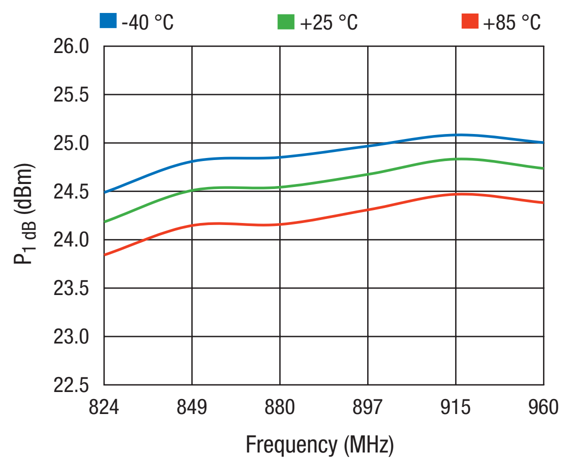
$|S_{12}|$ vs. Frequency Across V_{CC}



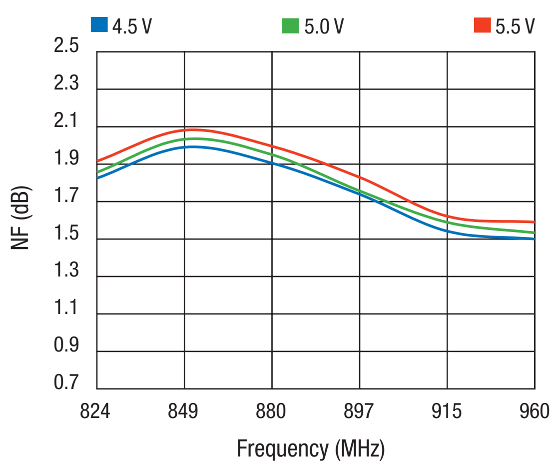
$|S_{12}|$ vs. Frequency Across Temperature



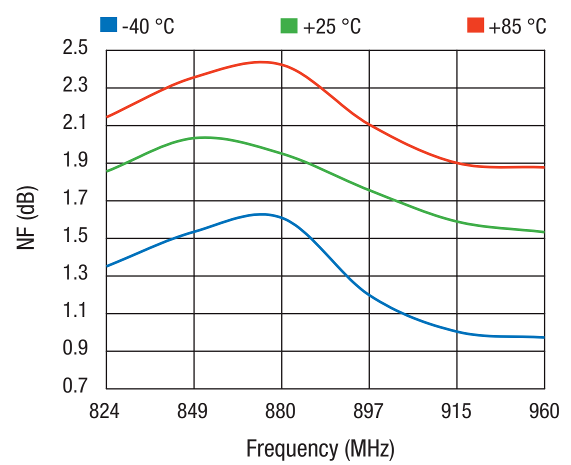
$P_{1\ dB}$ vs. Frequency Across V_{CC}



$P_{1\ dB}$ vs. Frequency Across Temperature



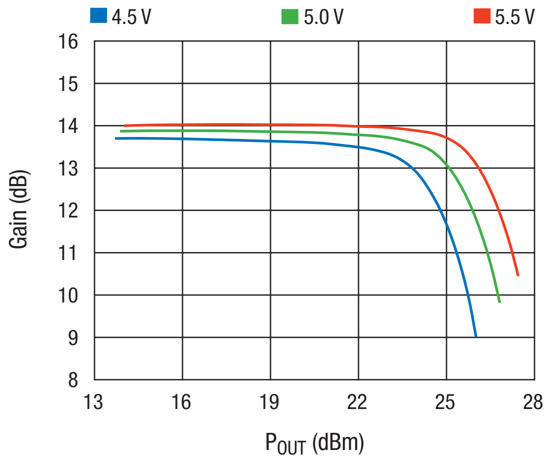
Noise Figure vs. Frequency Across V_{CC}



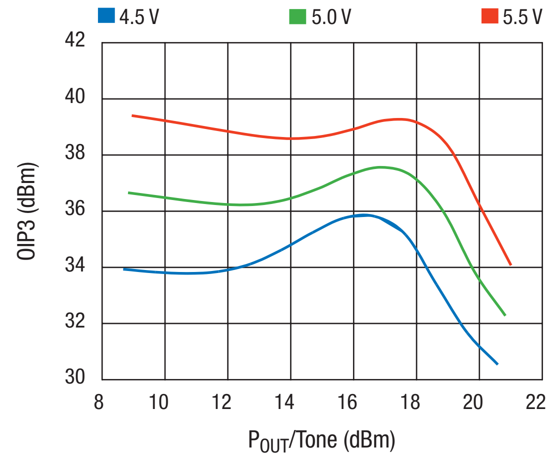
Noise Figure vs. Frequency Across Temperature

Typical Performance Data

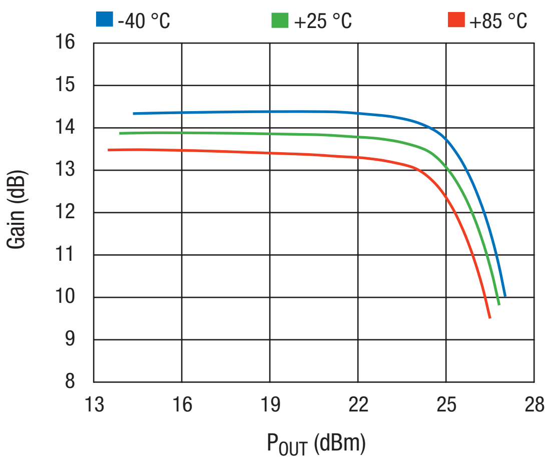
V_{CC} = 5 V, F = 897.5 MHz, CW, Z_0 = 50 Ω, T_C = 25 °C, unless otherwise noted



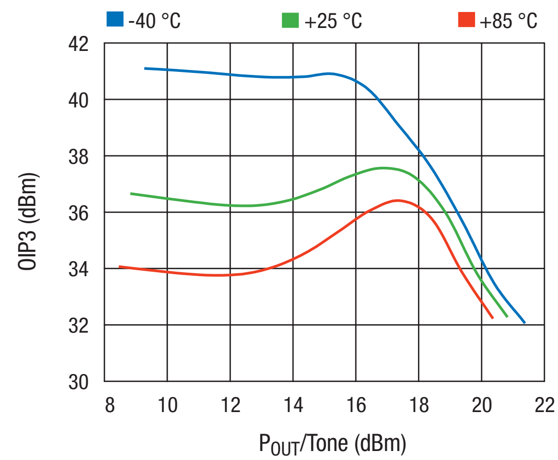
Gain vs. P_{OUT} Across V_{CC}



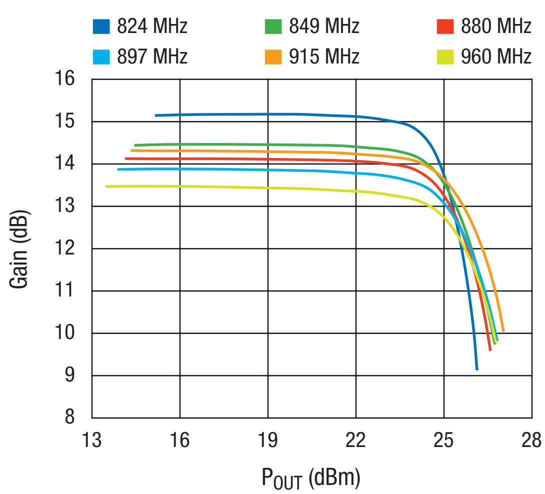
OIP3 vs. P_{OUT}/Tone Across V_{CC}



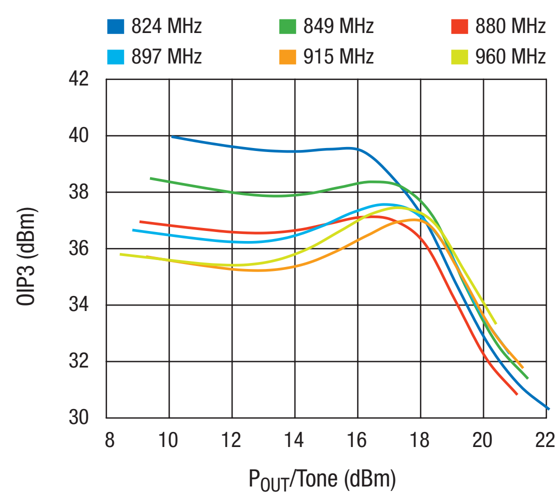
Gain vs. P_{OUT} Across Temperature



OIP3 vs. P_{OUT}/Tone Across Temperature



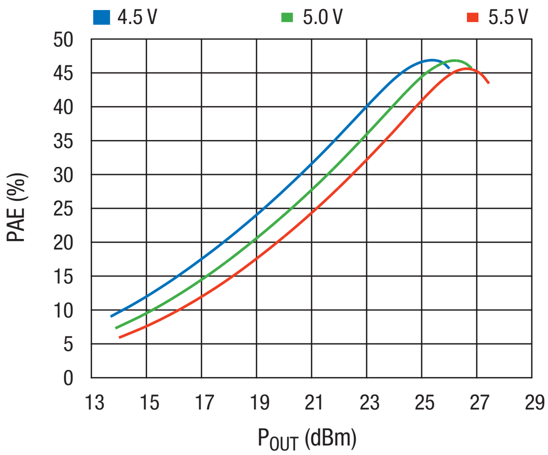
Gain vs. P_{OUT} Across Frequency



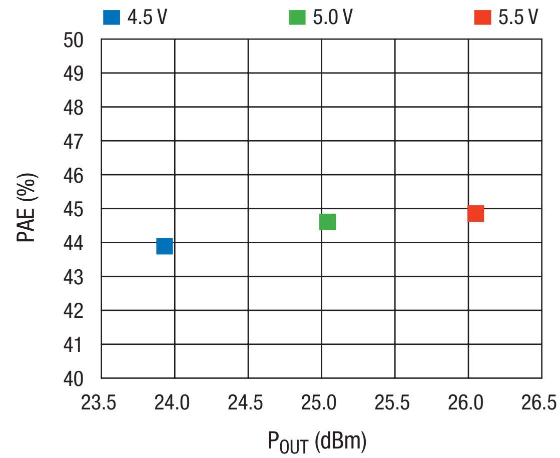
OIP3 vs. P_{OUT}/Tone Across Frequency

Typical Performance Data

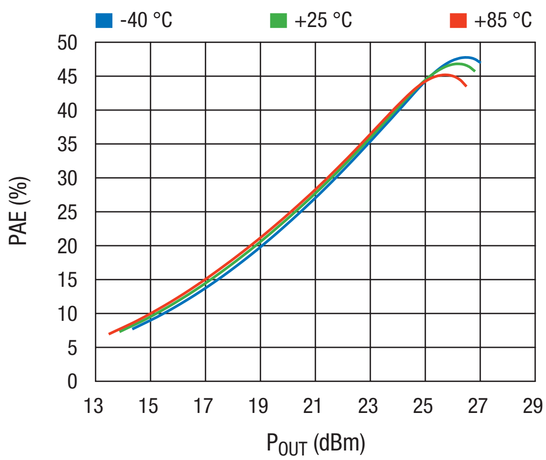
V_{CC} = 5 V, F = 897.5 MHz, CW, Z_0 = 50 Ω, T_C = 25 °C, unless otherwise noted



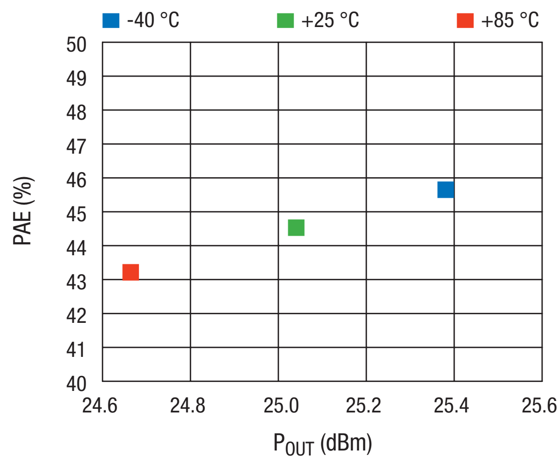
PAE vs. P_{OUT} Across V_{CC}



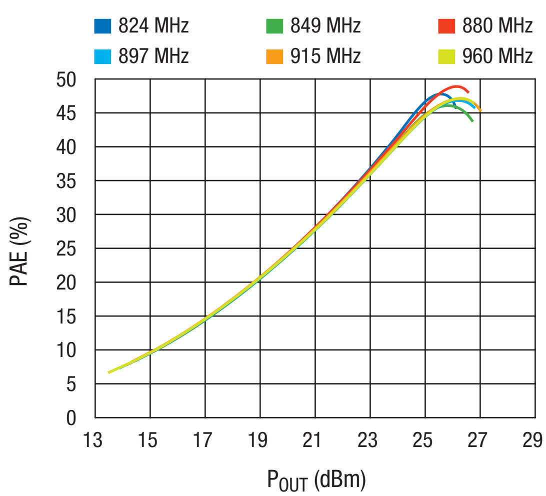
PAE @ $P_{1\ dB}$ vs. P_{OUT} Across V_{CC}



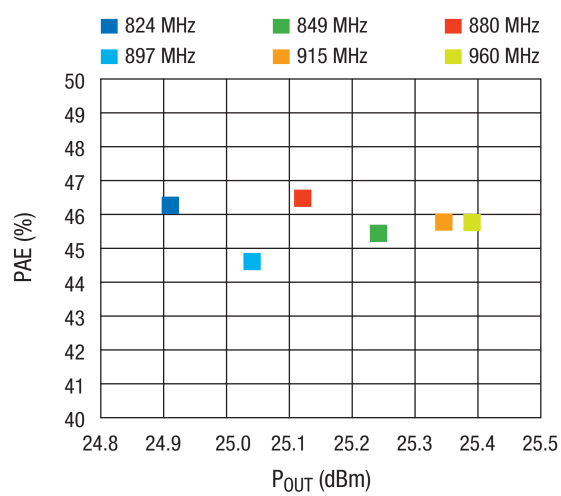
PAE vs. P_{OUT} Across Temperature



PAE @ $P_{1\ dB}$ vs. P_{OUT} Across Temperature



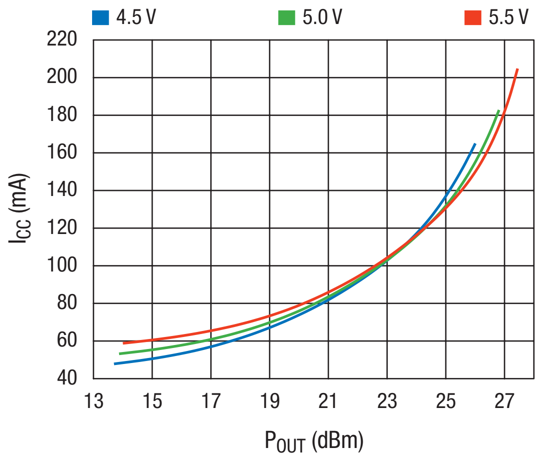
PAE vs. P_{OUT} Across Frequency



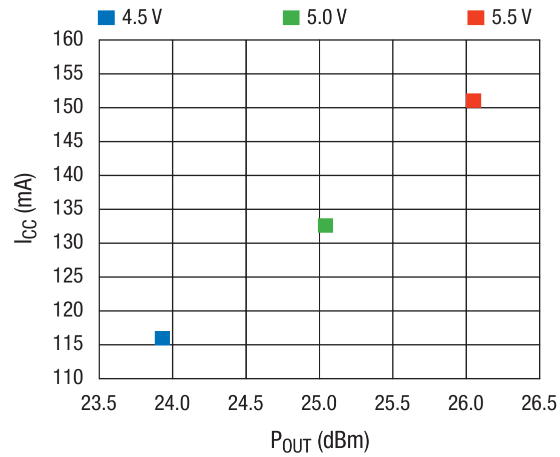
PAE @ $P_{1\ dB}$ vs. P_{OUT} Across Frequency

Typical Performance Data

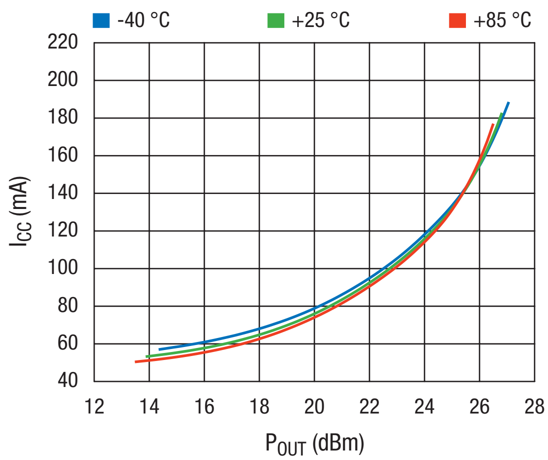
V_{CC} = 5 V, F = 897.5 MHz, CW, Z_0 = 50 Ω, T_C = 25 °C, unless otherwise noted



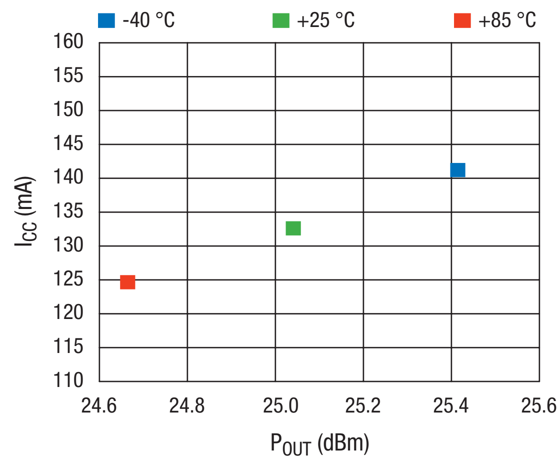
I_{CC} vs. P_{OUT} Across V_{CC}



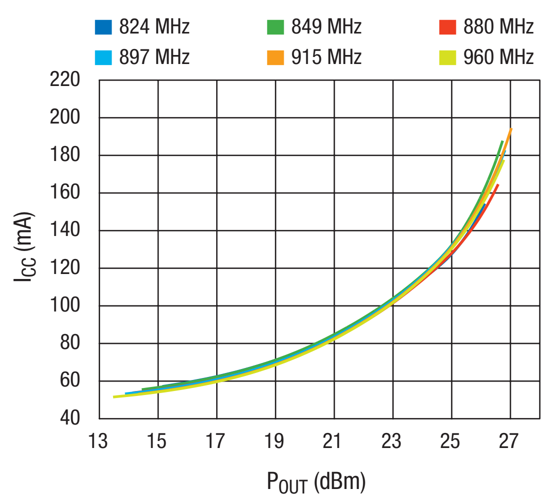
Supply Current @ $P_{1\ dB}$ vs. P_{OUT} Across V_{CC}



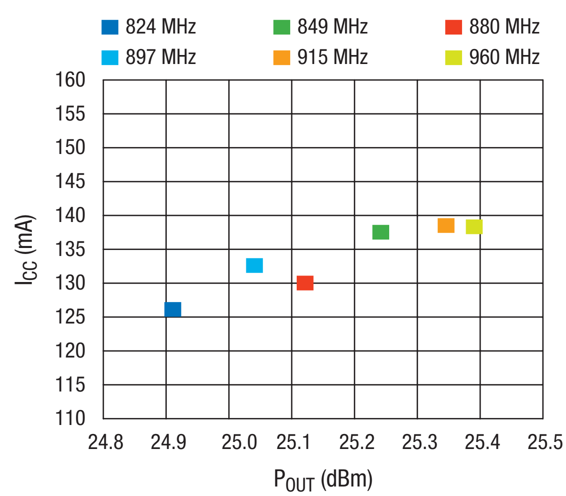
I_{CC} vs. P_{OUT} Across Temperature



Supply Current @ $P_{1\ dB}$ vs. P_{OUT} Across Temperature



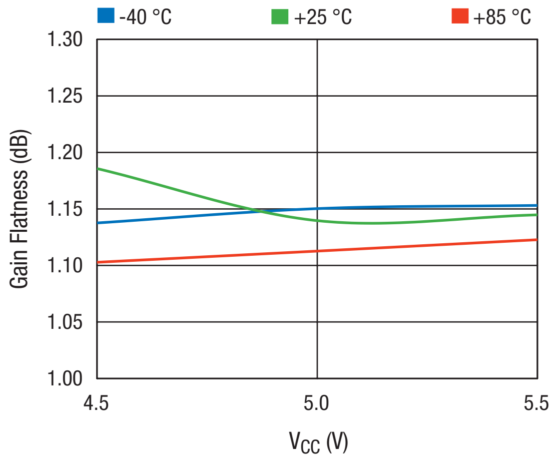
I_{CC} vs. P_{OUT} Across Frequency



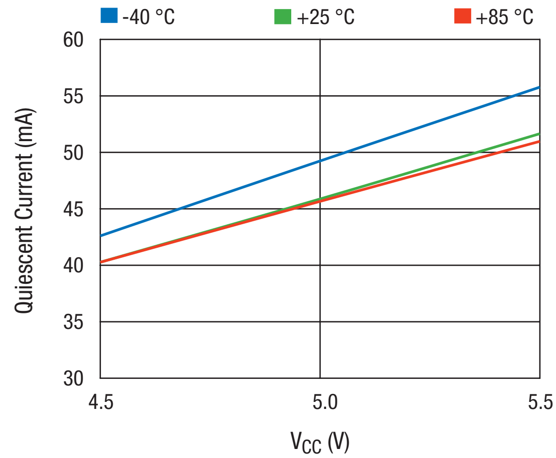
Supply Current @ $P_{1\ dB}$ vs. P_{OUT} Across Frequency

Typical Performance Data

V_{CC} = 5 V, F = 897.5 MHz, CW, Z_0 = 50 Ω, T_C = 25 °C, unless otherwise noted



Gain Flatness vs. V_{CC} Across Temperature



Quiescent Current vs. V_{CC} Across Temperature

Theory of Operation

The SKY65045-70LF is a single stage, low noise power amplifier in a low-cost surface mount package. The device operates with a single 5 V power supply connected though an RF choke (L1) to the output pin. Capacitors C7, C8 and C9 provide DC bias decoupling for V_{CC}. The bias current is set by the on-chip active bias composed of current mirror and reference voltage transistors, allowing for excellent gain tracking over temperature and voltage variations. The part is externally RF matched using surface mount components to facilitate operation over a frequency range of 390 to 1500 MHz.

Pin 1 is the RF input and Pin 3 is the RF output. External DC blocking is required on the input and output, but can be implemented as part of the RF matching circuit. Pin 2 and the package backside metal, Pin 4, provide the DC and RF ground.

Application Circuit Notes

RF In (Pin 1). Amplifier RF input pin. The amplifier requires a DC blocking capacitor as part of the external RF matching.

Ground (Pin 2). Attach the ground pin to the RF ground plane with the largest diameter and lowest inductance via that the layout will allow. Multiple small vias are also acceptable and will work well under the device if solder migration is an issue.

RF Out/V_{CC} (Pin 3). Amplifier RF output pin. The amplifier requires a DC blocking capacitor as part of the external RF matching. The amplifier collector supply voltage is supplied through an RF choke to the output at pin 3.

Center Ground (Pin 4). It is extremely important that the device paddle be sufficiently grounded for both thermal and stability reasons. Multiple small vias are acceptable and will work well under the device if solder migration is an issue.

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.

Please refer to Skyworks solder reflow application note, available at www.skyworksinc.com, for instructions on mounting the SKY65045-70LF to a printed circuit board.

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, document number 101568.

Electrostatic Discharge (ESD) Sensitivity

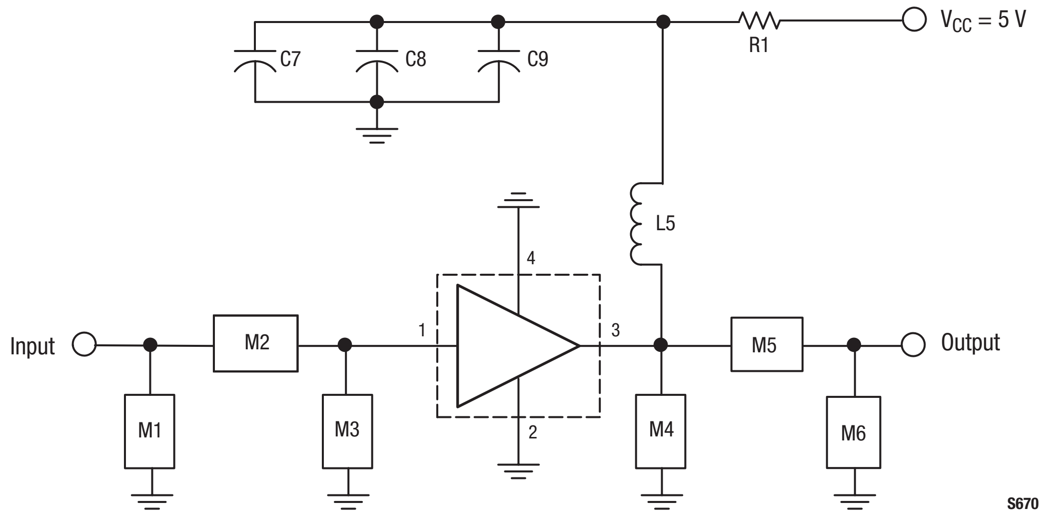
The SKY65045-70LF is a static-sensitive electronic device. Do not operate or store near strong electrostatic fields. Take proper ESD precautions.

Pin Assignments

Pin #	Name	Description
1	RF In	RF input
2	GND	Ground
3	RF Out	RF output/V_{CC}
4	GND	Center ground

Center attachment pad must have a low inductance and low thermal resistance connection to the customer's printed circuit board ground plane.

Application Circuit



Bill of Material for Evaluation Board

747 MHz

Component	Value	Units	Qty.	Size	Product Number	Manufacturer	Manufacturer's Part Number	Characteristics
R1	0	Ω	1	0603	5424R20-146	Rohm	MCR03EZHJ000	50 V, 0.063 W, ± 5%
C7	10	µF	1	0805	5404R29-076	Murata	GRM21BR60J106K	X5R, 50 V, ± 20%
C8	12	pF	1	0603	5404R23-014	Murata	GRM1885C1H120JD51D	C0G, 50 V, ± 5%
C9	DNI							
L5	3.3	nH	1	0603	5332R34-005	Taiyo-Yuden	HK16083N3S-T	± 0.3 nH, SRF 6000 MHz
M1	10	nH	1	0603	5332R34-020	Taiyo-Yuden	HK160810NJ-T	± 5%, SRF 3400 MHz
M2	4.7	pF	1	0603	5404R98-006	Murata	GRM1885C1H4R7CZ01D	C0G, 50 V, ± 0.25 pF
M3	DNI							
M4	DNI							
M5	4.7	pF	1	0603	5404R98-006	Murata	GRM1885C1H4R7CZ01D	C0G, 50 V, ± 0.25 pF
M6	10	nH	1	0603	5332R34-020	Taiyo-Yuden	HK160810NJ-T	± 5%, SRF 3400 MHz

897.5 MHz

Component	Value	Units	Qty.	Size	Product Number	Manufacturer	Manufacturer's Part Number	Characteristics
R1	0	Ω	1	0603	5424R20-146	Rohm	MCR03EZHJ000	50 V, 0.063W, ± 5%
C7	1	µF	1	0805	5404R29-070	TDK	C2012X7R1H104K	X7R, 50 V, ± 10%
C8	1000	pF	1	0603	5404R23-057	TDK	C1608C0G1H102JT	C0G, 50 V, ± 5%
C9	DNI							
L5	39	nH	1	0603	5332R34-034	Taiyo-Yuden	HK160839NJ-T	± 5%, SRF 1100 MHz
M1	DNI							
M2	10	pF	1	0603	5404R23-013	Murata	GRM39C0G100J050AD	C0G, 50 V, ± 5%
M3	2.2	pF	1	0603	5404R23-039	Murata	GRM1885C1H2R2CZ01D	C0G, 50 V, ± 0.25pF
M4	DNI							
M5	15	pF	1	0603	5404R23-015	Murata	GRM1885C1H150JD51D	C0G, 50 V, ± 5%
M6	DNI							

Evaluation Board Description

The Skyworks SKY65045-70LF Evaluation Board is used to test the performance of the SKY65045-70LF low noise power amplifier module. 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 pad of the SKY65045-70LF low noise power amplifier module has special electrical and thermal grounding requirements. This pad is 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 amplifiers. As such, design the connection to the ground pad to dissipate the maximum wattage produced to the circuit. Multiple vias to the grounding layer are required.
3. Bypass capacitors should be used on the DC supply lines. RF inductor is required on the V_{CC} supply line to block RF signal from the DC supply. See Evaluation Board schematic drawing for more details.
4. The RF lines should be well separated from each other, with solid ground in between traces, to maximize input-to-output isolation.

NOTE: *Junction temperature (T_J) of the device increases with a poor connection to the slug and ground. This reduces the lifetime of the device.*

Evaluation Board Test Procedure

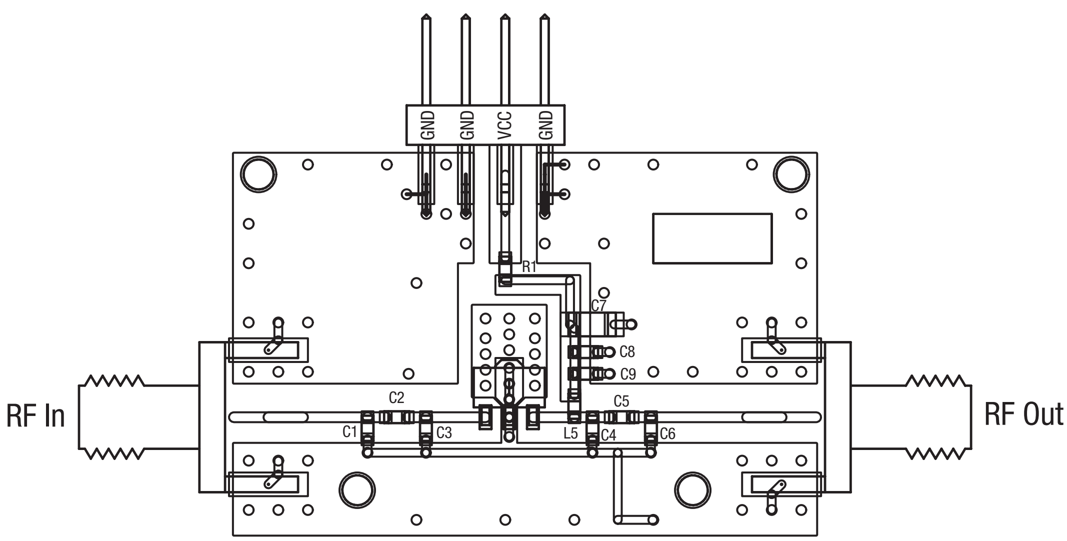
Use the following procedure to set up the SKY65045-70LF evaluation board for testing.

1. Connect a 5 V supply to V_{CC}. If available, enable the current limiting function of the power supply to 100 mA.
2. Connect a signal generator to the RF signal input port. Set it to the desired RF frequency at a power level of -15 dBm or less to the evaluation board, but do NOT enable the RF signal.
3. Connect a spectrum analyzer to the RF signal output port.
4. Enable the power supply.
5. Enable the RF signal.
6. Take measurements.

CAUTION: *If the input signal exceeds the rated power, the SKY65045-70LF Evaluation Board can be permanently damaged.*

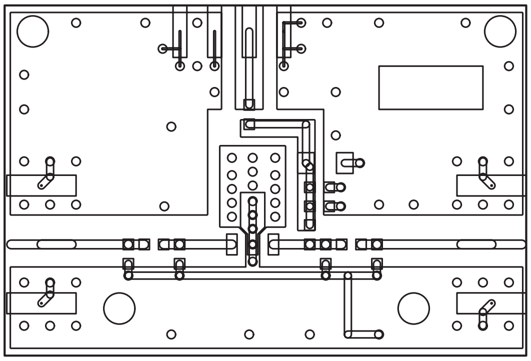
NOTE: *It is important that the V_{CC} voltage source be adjusted such that 5 V is measured at the board. The high collector currents will drop the collector voltage significantly if long leads are used. Adjust the bias voltage to compensate.*

Evaluation Board

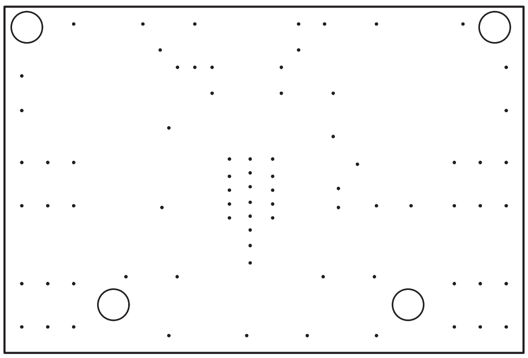


S708

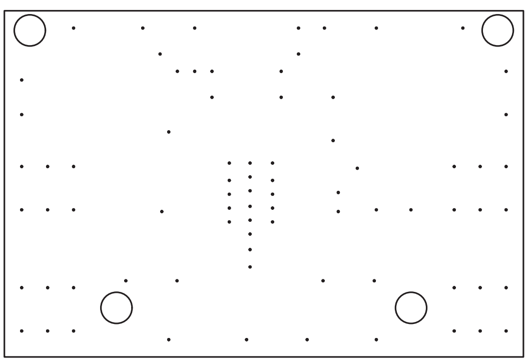
Evaluation Board Layer Detail



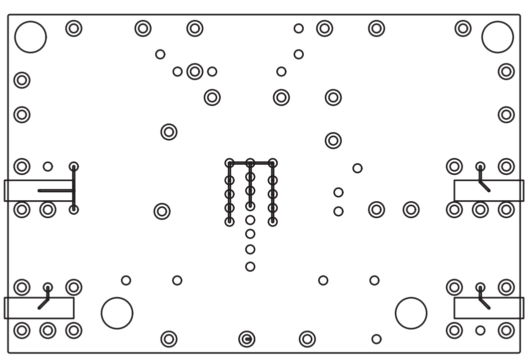
Layer 1: Top - Metal



Layer 2: Ground



Layer 3: Ground



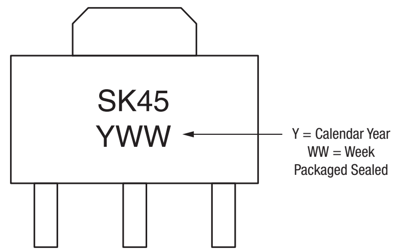
Layer 4: Solid Ground Plane

S709

Evaluation Board Stack-Up

Cross Section	Name	Thickness (mil)	Material	ε_r
	L1	1.4	Cu	–
	Lam1	12	Rogers 4003-12	3.38
	L2	1.4	Cu, 1 oz.	–
	Lam2	4	FR4-4	4.35
	L3	1.4	Cu, 1 oz.	–
	Lam3	12	FR4-12	4.35
	L4	1.4	Cu, 1 oz.	–

Branding Specifications



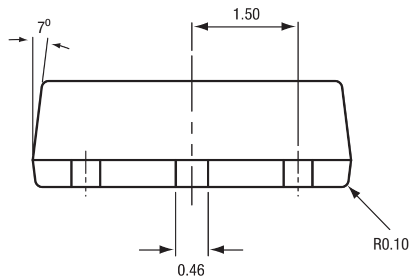
Recommended Solder Reflow Profiles

Refer to the *"Recommended Solder Reflow Profile"* Application Note.

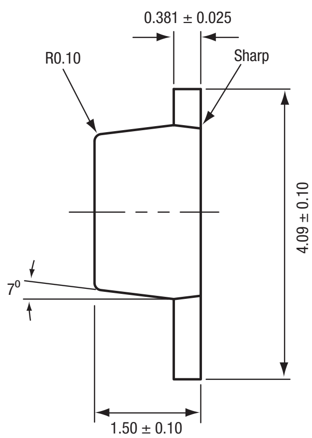
Tape and Reel Information

Refer to the *"Discrete Devices and IC Switch/Attenuators Tape and Reel Package Orientation"* Application Note.

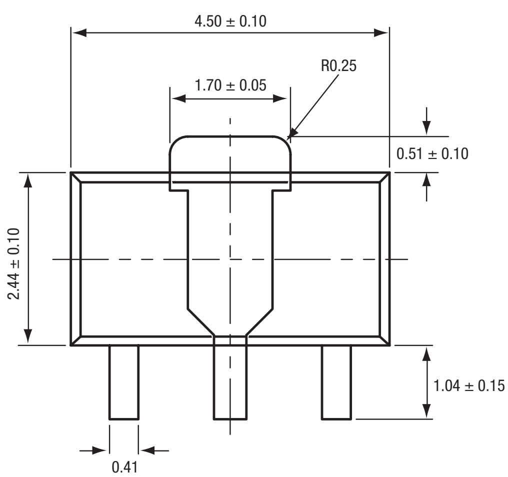
Package Dimensions



Side View



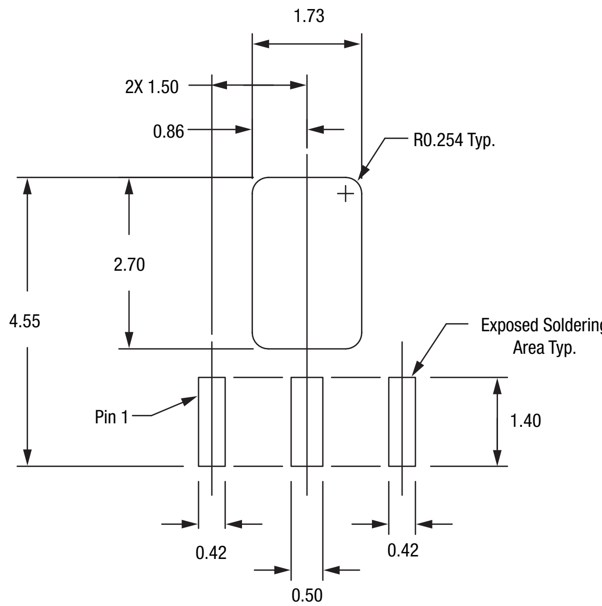
End View



Bottom View

All measurements are in millimeters

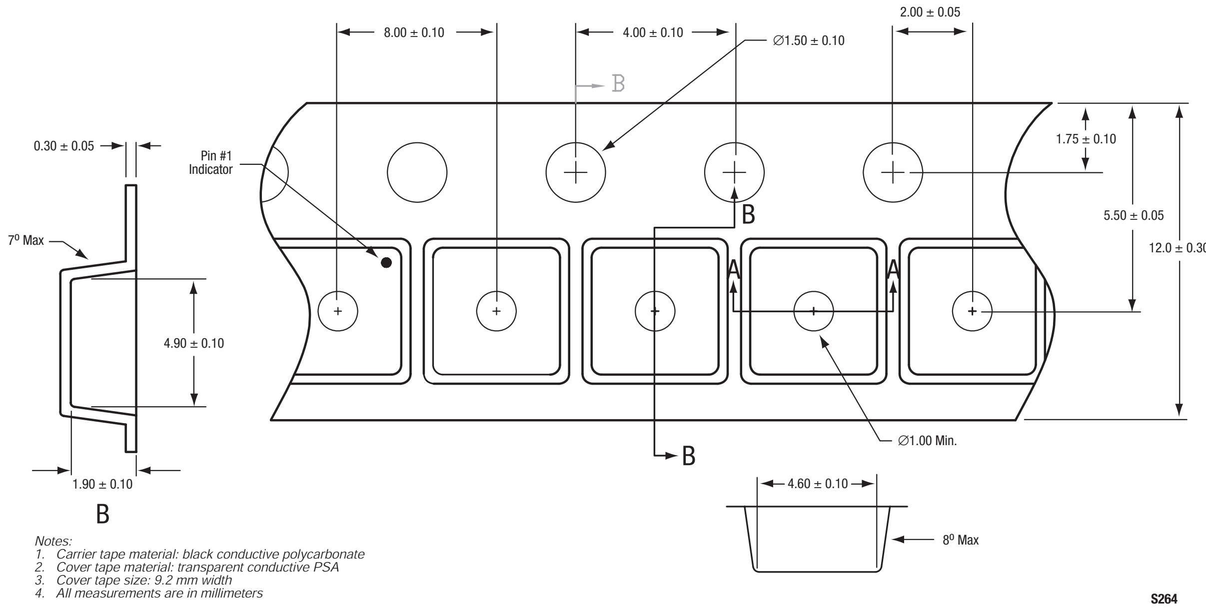
Recommended Footprint



Thru View - From Top

All measurements are in mm.

Tape and Reel Dimensions



Notes:
1. *Carrier tape material: black conductive polycarbonate*
2. *Cover tape material: transparent conductive PSA*
3. *Cover tape size: 9.2 mm width*
4. *All measurements are in millimeters*

Ordering Information

Model Name	Manufacturing Part Number	Evaluation Kit Part Number
SKY65045-70LF: 390–1500 MHz low noise power amplifier driver	SKY65045-70LF (Pb-free package)	TW17-D630-001 (747 MHz) TW17-D440-001 (897.5 MHz)