DATA SHEET

SKY65146: 3.5 V Broadband MCM Power Amplifier 806–849 MHz

Applications

- iDEN® (806–825 MHz)
- TETRA (806–825 MHz)
- TDMA (824–849 MHz)
- AMPS (824–849 MHz)
- Wireless Local Loop (WLL)

Features

- Low voltage positive bias supply (3.5 V)
- High gain 39 dB, high power: P_{SAT} 35.6 dBm
- High efficiency: PAE 51%
- Good linearity
- Dual mode operation
- Large dynamic range
- 28-pin LCC package (10 x 13.97 x 1.45 mm)
- Internal RF match
- Power down control
- Available on tape and reel
- Available lead (Pb)-free and RoHS-compliant

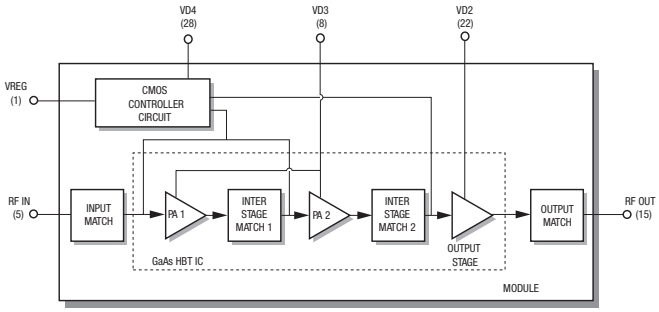
Description

The SKY65146 is a fully matched 28-pin surface mount multi-chip module (MCM) amplifier designed for Private Mobile Radio, Wireless Local Loop, and TDMA/AMPS mobile units operating in the 806-849 MHz cellular bandwidth. Microwave Monolithic Integrated Circuits (MMICs), comprised of Gallium Arsenide (GaAs) and Si CMOS, contain all active circuitry in the module, which includes on-board bias circuitry as well as the interstage matching circuit. The input and output match is realized off-chip within the module package to optimize efficiency and high power performance (P3 dB_sat ≅ 35.6 dBm) into a 50 Ω load.

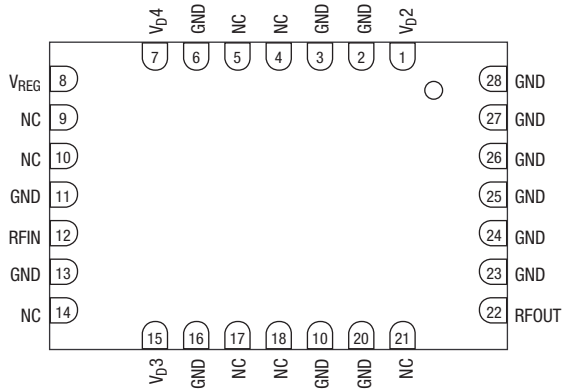
Primary bias to the SKY65146 can be supplied directly from a single cell lithiumion or other suitable battery with a nominal output of 3.5 V.

No external supply side switch is needed as typical “off” leakage is a few microamperes with full primary voltage supplied from the battery.

Block Diagram



Package Diagram



The ICs are manufactured on an advanced InGaP HBT process and on a silicon CMOS process, providing for all positive voltage DC supply operation while maintaining high efficiency and good linearity.

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.

Electrical Specifications

V_{CC} (V_D) = 3.5 V, V_{REG} = 2.75 V, Frequency = 815 MHz, T_C = 25 °C, unless otherwise specified.

Parameter	Symbol	Condition	Min.	Typ.	Max.	Unit
Frequency range	F		806		825	MHz
Gain	$\|S_{21}\|$	Small signal		38.7		dB
Power gain	Gp	P_O = 29 dBm	35.5	38.7	40	dB
Input VSWR	$\|S_{11}\|$	Small signal	12	17		
Saturated output power	$P_{3\ dB}$ SAT	Gain Comp ≤ 3 dB	35.1	35.6		dBm
Power added efficiency	PAE	$P_O = P_{3\ dB}$ SAT	47	51		%
Current @ PSAT	I_{CC} SAT	$P_O = P_{3\ dB}$ SAT		2		A
Quiescent current	I_{CCQ}	No RF signal	270	329	370	mA
Harmonic Levels	$2F_O$ $3F_O$ $4F_O$	$P_O \leq P_{3\ dB}$ SAT $P_O \leq P_{3\ dB}$ SAT $P_O \leq P_{3\ dB}$ SAT		-37 -60 -80		dBc dBc dBc
Noise power in Rx band FC + 30 MHz, BW = 18 kHz	RxBN	$P_O \leq$ 29 dBm			-85	dBm/Hz
Noise figure	NF	CW		6.8	8	dB
Stability (spurious output)	S	Output VSWR = 10:1			-36	dBm
Ruggedness - no damage	Ru	$P_O \leq$ 29 dBm	15:1			VSWR
Thermal resistance	θ_{JC}	Junction to case		19		°C/W

Recommended Operating Conditions

Parameter	Symbol	Conditions	Min.	Typ.	Max.	Unit
Supply voltage	V_{CC}		3	3.5	4.4	V
Regulation voltage	V_{REG}		2.65	2.75	2.85	V
Operating frequency	F		806		849	MHz
Continuous RMS output power	PoRMS			29	31	dBm
Operating case temperature	T_C		-40	+25	+85	°C

Absolute Maximum Ratings

Characteristic	Value
RF input power (P_{IN})	11 dBm(1)
Supply voltage (V_{CC})	6.9 V(2)
Regulated supply voltage (V_{REG})	V_{CC} V (3)
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

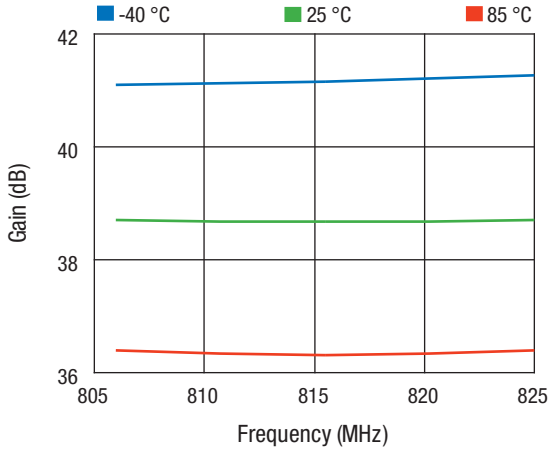
1. For pulsed operation with duty cycle < 25%.
2. When amplifier is biased off (V_{REG} = 0 V).
3. Voltage on V_{REG} pin may not exceed the applied V_{CC} voltage.

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. Each absolute maximum rating listed is an individual parameter. Biasing and driving the amplifier with more than one absolute maximum rating listed may result in permanent damage to the device. Exposure to maximum rating conditions for extended periods may reduce device reliability.

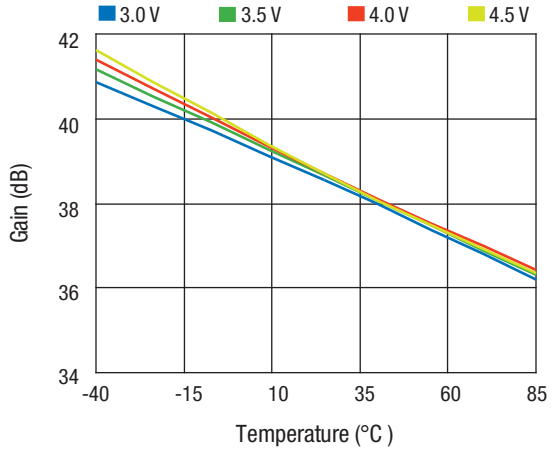
CAUTION: *Although this device is designed to be as robust as possible, ESD (Electrostatic Discharge) can damage this device. This device must be protected at all times from ESD. Static charges may easily produce potentials of several kilovolts on the human body or equipment, which can discharge without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

Typical Performance Data

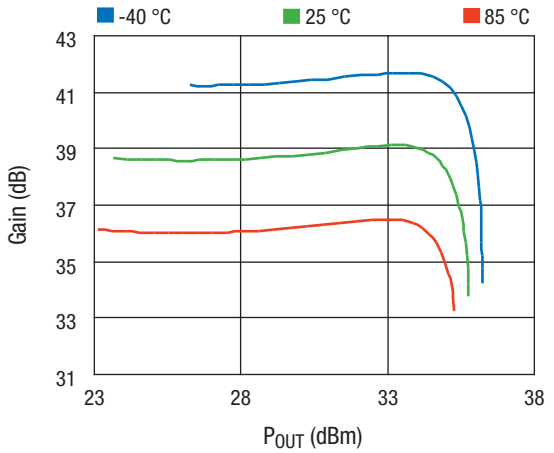
V_{CC} (V_D) = 3.5 V, V_{REG} = 2.75 V, Frequency = 815 MHz, T_C = 25 °C, unless otherwise specified.



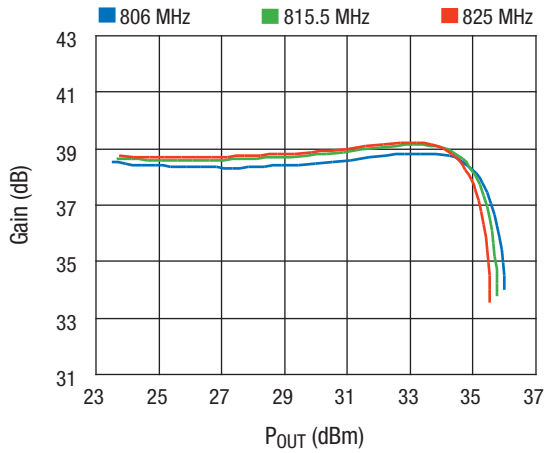
Gain vs. Frequency Across Temperature



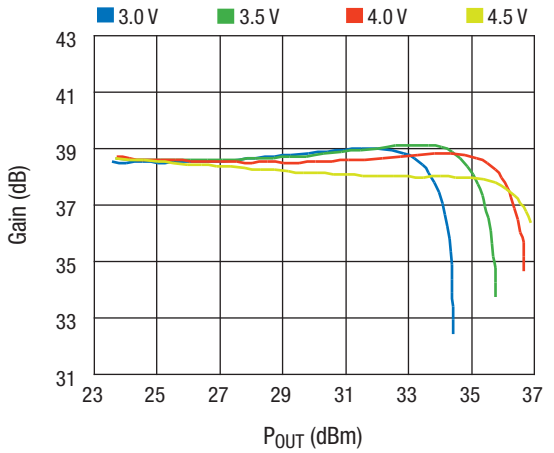
Gain vs. Temperature Across V_{CC}



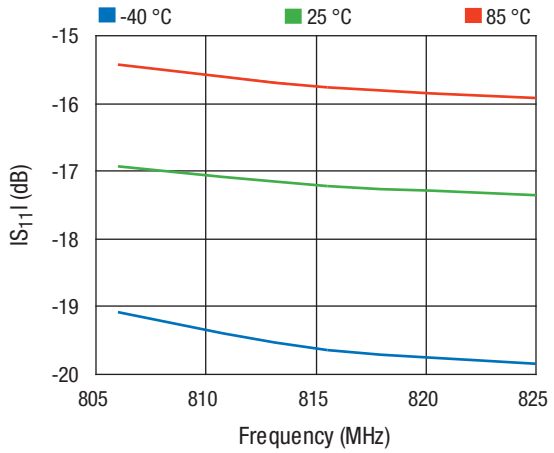
Gain vs. P_{OUT} Across Temperature



Gain vs. P_{OUT} Across Frequency



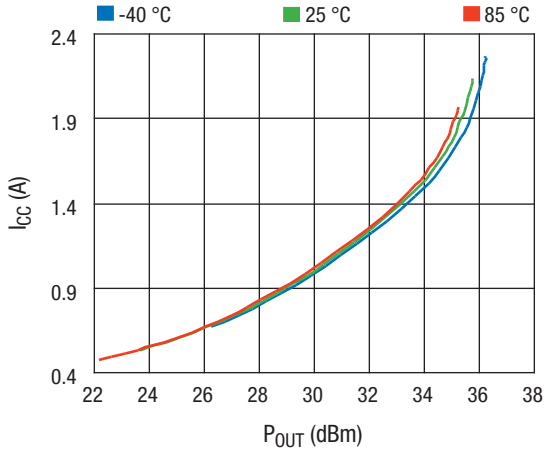
Gain vs. P_{OUT} Across V_{CC}



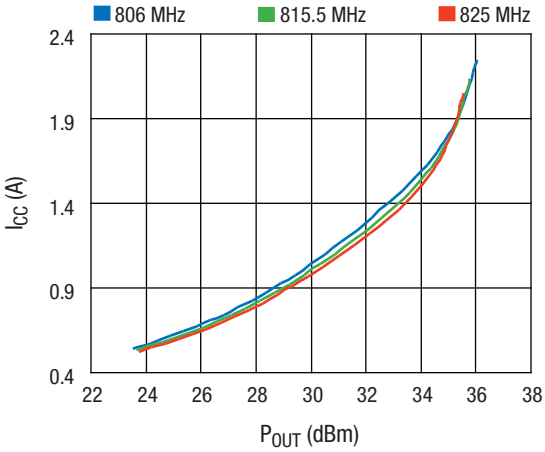
$IS_{11}I$ vs. Frequency Across Temperature

Typical Performance Data

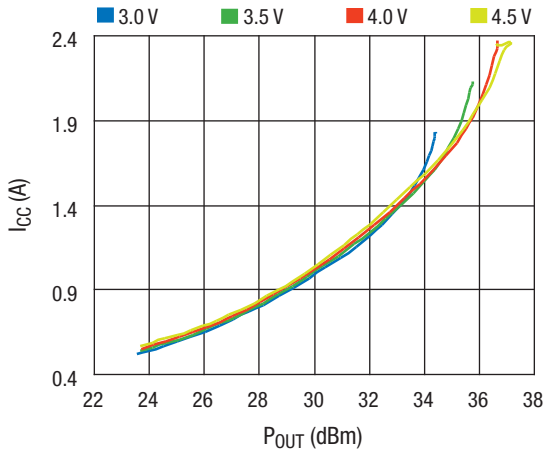
V_{CC} (V_D) = 3.5 V, V_{REG} = 2.75 V, Frequency = 815 MHz, T_C = 25 °C, unless otherwise specified.



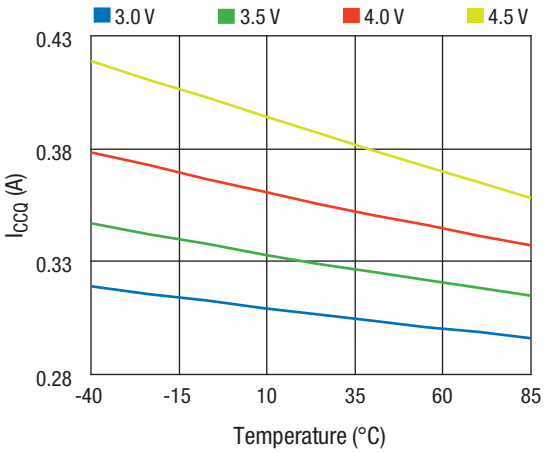
I_{CC} vs. P_{OUT} Across Temperature



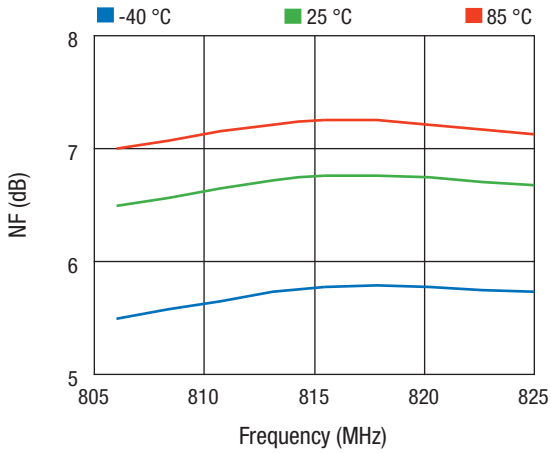
I_{CC} vs. P_{OUT} Across Frequency



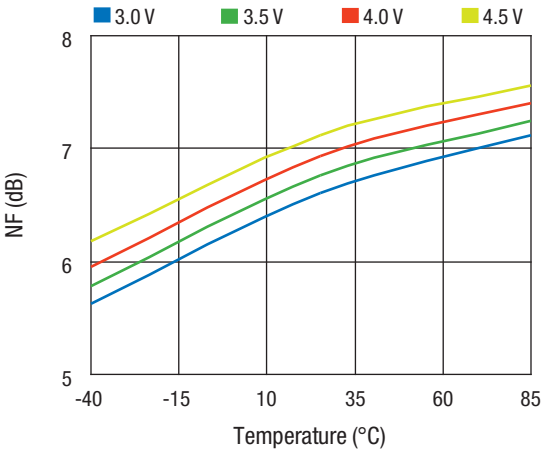
I_{CC} vs. P_{OUT} Across V_{CC}



I_{CCQ} vs. Temperature Across V_{CC}



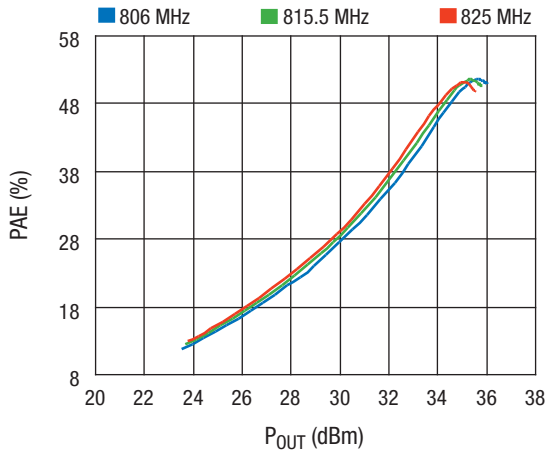
NF vs. Frequency Across Temperature



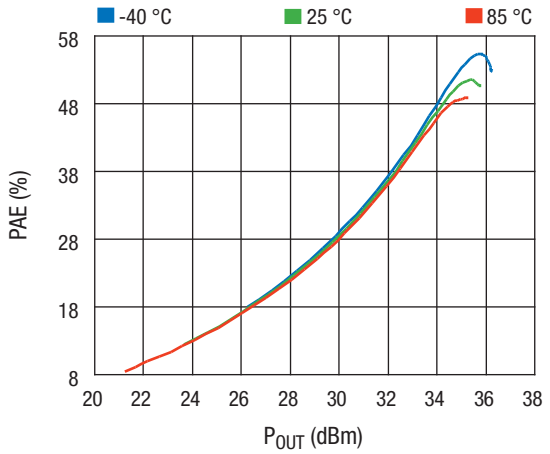
NF vs. Temperature Across V_{CC}

Typical Performance Data

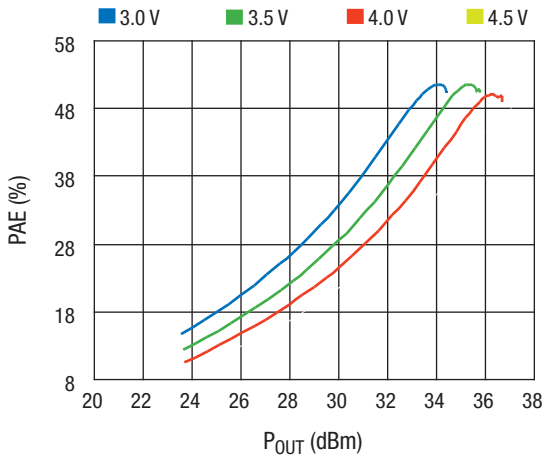
V_{CC} (V_D) = 3.5 V, V_{REG} = 2.75 V, Frequency = 815 MHz, T_C = 25 °C, unless otherwise specified.



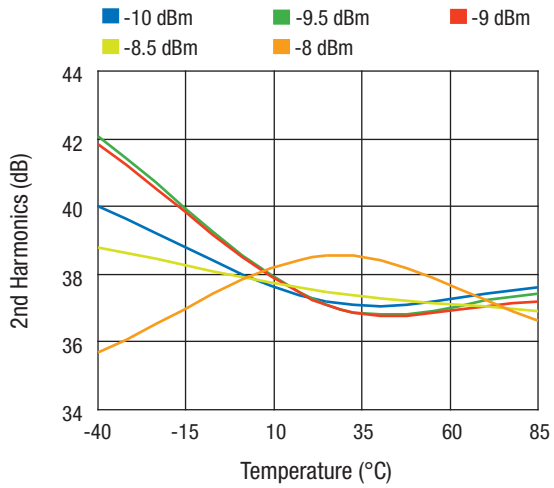
PAE vs. P_{OUT} Across Frequency



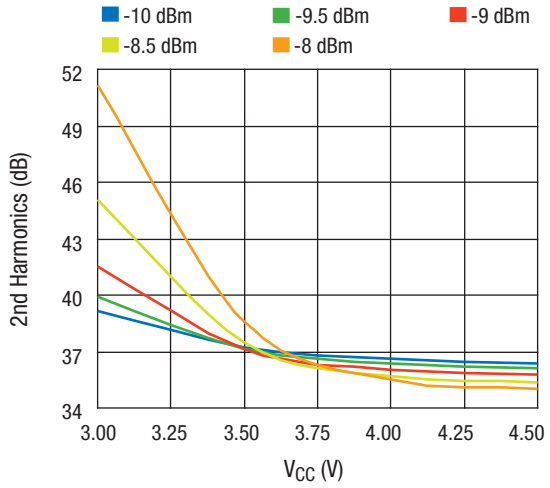
PAE vs. P_{OUT} Across Temperature



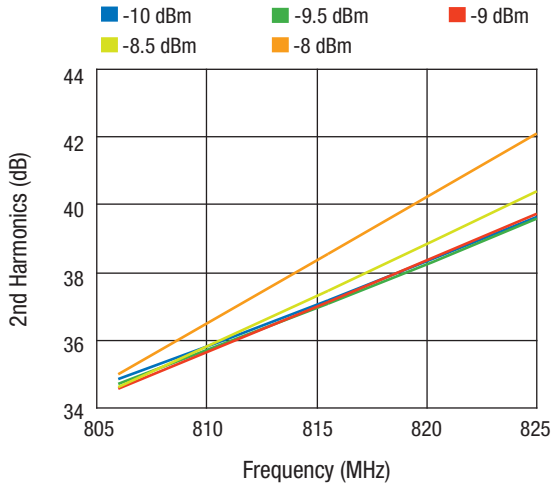
PAE vs. P_{OUT} Across V_{CC}



2nd Harmonics vs. Temperature Across P_{IN}



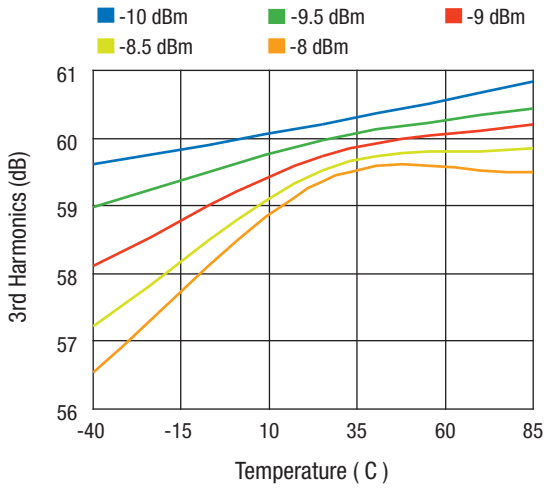
2nd Harmonics vs. V_{CC} Across P_{IN}



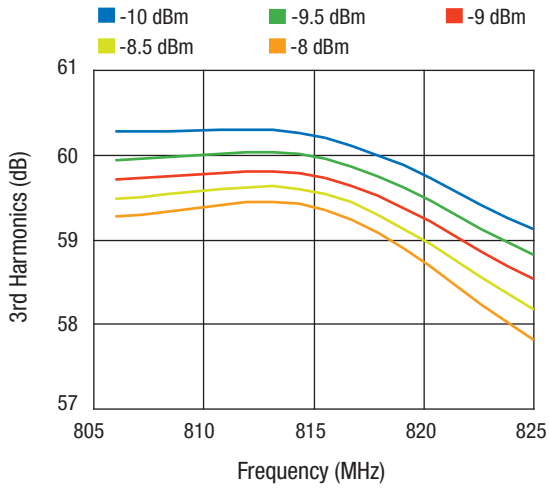
2nd Harmonics vs. Frequency Across P_{IN}

Typical Performance Data

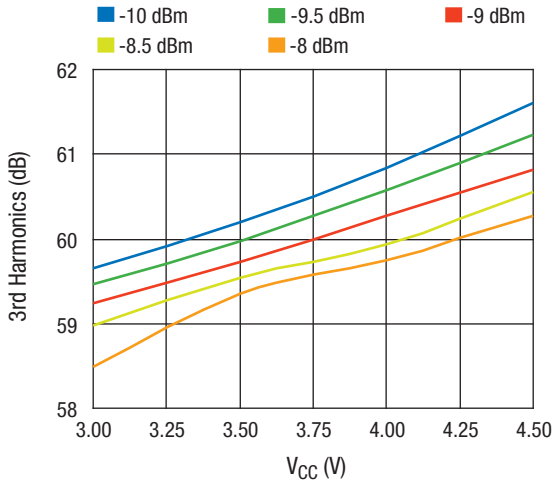
V_{CC} (V_D) = 3.5 V, V_{REG} = 2.75 V, Frequency = 815 MHz, T_C = 25 °C, unless otherwise specified.



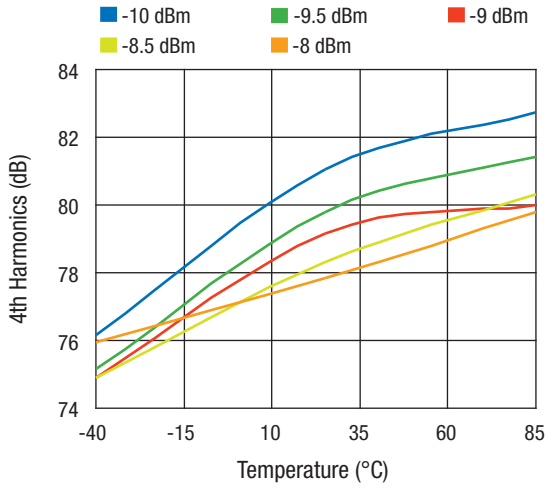
3rd Harmonics vs. Temperature Across P_{IN}



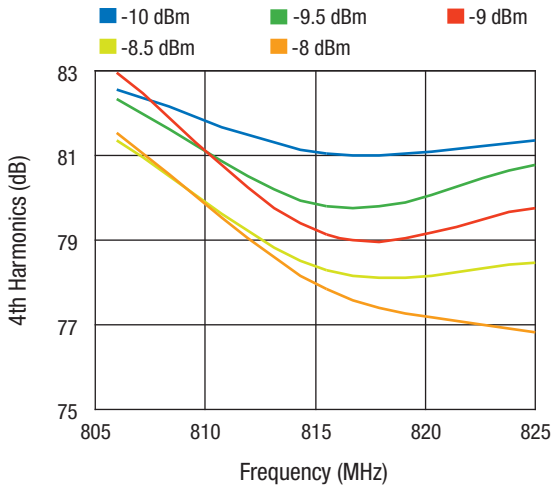
3rd Harmonics vs. Frequency Across P_{IN}



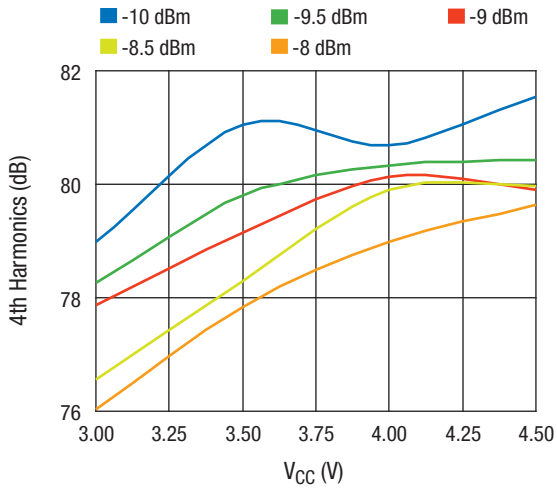
3rd Harmonics vs. V_{CC} Across P_{IN}



4th Harmonics vs. Temperature Across P_{IN}



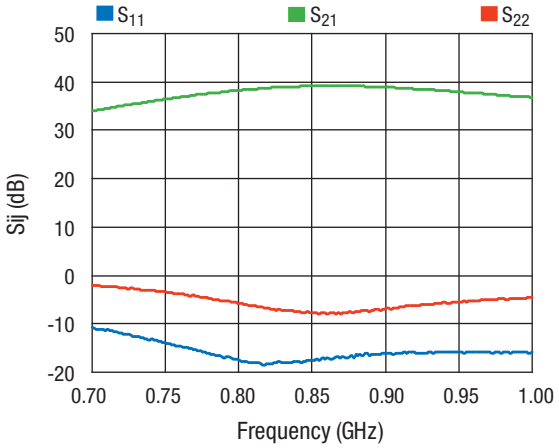
4th Harmonics vs. Frequency Across P_{IN}



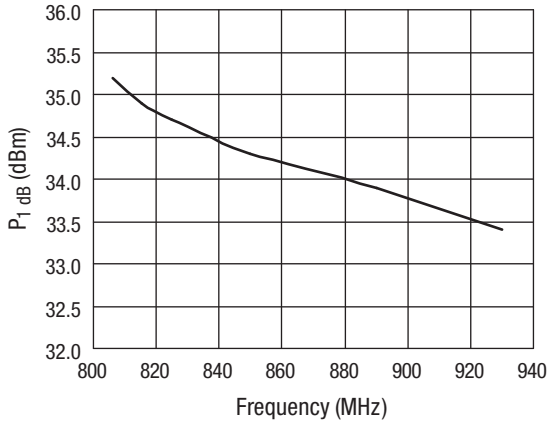
4th Harmonics vs. V_{CC} Across P_{IN}

Typical Performance Data

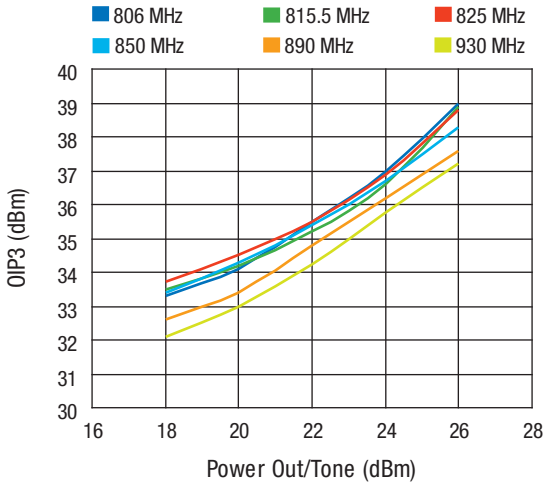
V_{CC} (V_D) = 3.5 V, V_{REG} = 2.75 V, Frequency = 815 MHz, T_C = 25 °C, unless otherwise specified.



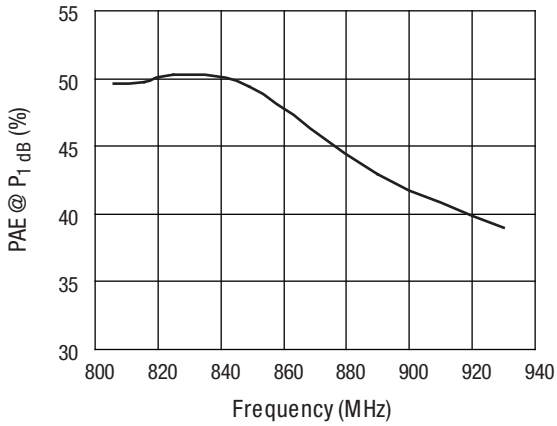
S-Parameters vs. Frequency



$P_{1\ dB}$ vs. Frequency



OIP3 vs. P_{OUT}/Tone Across Frequency
Tone Spacing =1 MHz



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

Application Circuit Notes

Center Ground. 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.

V_D2 (Pin 1). Supply voltage for output (final) stage collector bias (typically 3.5 V). Bypassing of V_D3 is accomplished with C2 and C3 and should be placed in the approximate location shown on the Evaluation Board, but placement is not critical.

Ground (Pins 2, 3, 6, 11, 13, 16, 19, 20, 23–28). Attach all ground pins 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.

No Connect (Pins 4, 5, 9, 10, 14, 17, 18, 21). The pins are open and may or may not be connected to ground.

V_D4 (Pin 7). Supply voltage for base bias circuitry to all stages (typically 3.5 V). Bypassing of V_D3 is accomplished with C1 which should be placed in the approximate location shown on the Evaluation Board, but placement is not critical.

V_{REG} (Pin 8). V_{REG} is the regulated bias enable control voltage to the silicon CMOS controller, 0.0 V = Off, 2.75 V = On. Nominal "On" operating range is between 2.65 V_{DC} and 2.85 V_{DC}. V_{REG} set to 0 V_{DC} will force the amplifier into standby mode.

RF_IN (Pin 12). Amplifier RF Input Pin. Z_O = 50 Ω. The module includes an onboard internal DC blocking capacitor. All impedance matching is provided internal to the module.

V_D3 (Pin 15). Supply voltage for driver collector bias (typically 3.5V). Bypassing of V_D3 is accomplished with C4 and C5 which should be placed in the approximate location shown on the Evaluation Board, but placement is not critical.

RF_OUT (Pin 22). Amplifier RF Output Pin. Z_O = 50 Ω. The module includes an onboard internal DC blocking capacitor. All impedance matching is provided internally to the module.

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 SKY65146 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

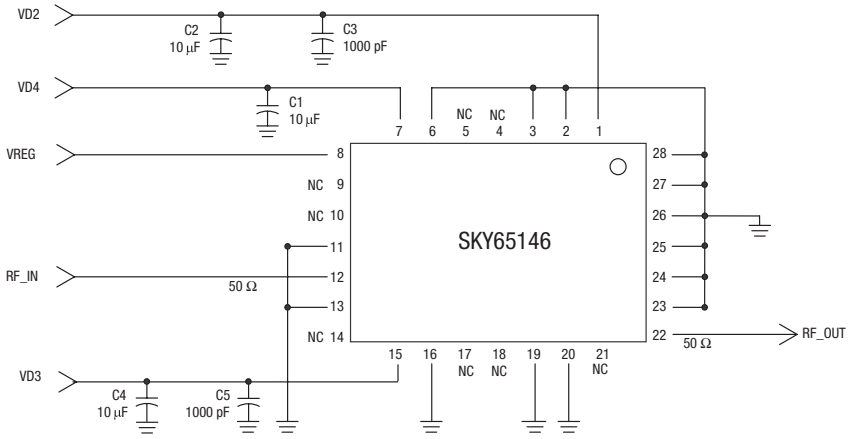
The SKY65146 is a static-sensitive electronic device. Do not operate or store near strong electrostatic fields. Take proper ESD precautions.

Theory of Operation

The SKY65146 is a fully matched 3-stage GaAs HBT power amplifier module consisting of on-chip interstage matching circuits and bias circuitry. The input and output match is realized off-chip, but within the module package. The amplifier employs series feedback on the first and second stages to provide for high gain and stability and power of up to 4 W.

The module includes a silicon CMOS controller circuit to provide a regulated bias enable control, V_{REG} (0–2.75 V) for amplifier On/Off operation. In off operation, supply current is a few microamperes with V_{REG} = 0 V. The module operates with all positive DC voltages while maintaining high efficiency and good linearity. The nominal operating voltage is 3.5 V for maximum power, but can be operated at slightly lower voltages for other mobile applications.

Application Circuit

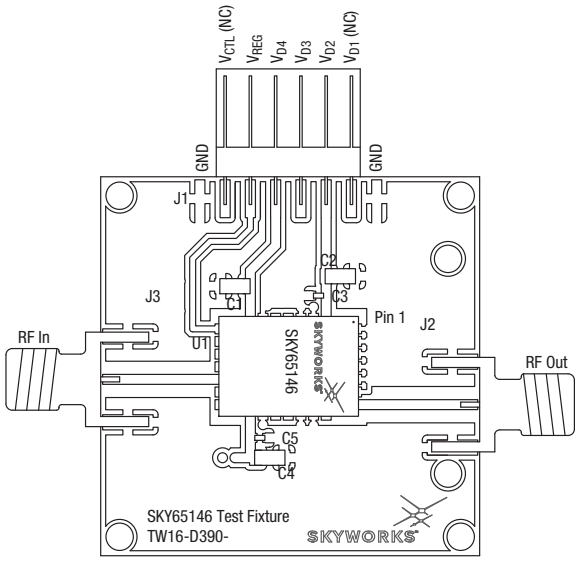


Pin Assignments

Pin	Pin Name	Description
1	V_D2	Supply voltage for output (final) stage collector bias (typically 3.5 V)
2	GND	Low inductance ground connection
3	GND	Low inductance ground connection
4	N/C	No connect
5	N/C	No connect
6	GND	Low inductance ground connection
7	V_D4	Supply voltage for base bias circuitry to all stages (typically 3.5 V)
8	V_{REG}	Regulated bias enable control voltage, 0.0 = Off, 2.75 V = On
9	N/C	No connect
10	N/C	No connect
11	GND	Low inductance ground connection
12	RFIN	806–849 MHz RF input signal 50 Ω
13	GND	Low inductance ground connection
14	N/C	No connect
15	V_D3	Supply voltage for driver collector bias (typically 3.5 V)
16	GND	Low inductance ground connection
17	N/C	No connect
18	N/C	No connect
19	GND	Low inductance ground connection
20	GND	Low inductance ground connection
21	N/C	No connect
22	RFOUT	806–849 MHz RF output signal 50 Ω
23	GND	Low inductance ground connection
24	GND	Low inductance ground connection
25	GND	Low inductance ground connection
26	GND	Low inductance ground connection
27	GND	Low inductance ground connection
28	GND	Low inductance ground connection

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

Evaluation Board



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.

Evaluation Board Description

The Skyworks SKY65146 Evaluation Board is used to test the performance of the SKY65146 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 SKY65146 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.

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

Step 1. Connect RF test equipment to Amplifier input/output SMA connectors.

Step 2. Connect DC ground.

Step 3. Connect all V_{CC} (V_D) lines to 3.5 V supply and V_{REG} to 2.75 V. Verify the I_{CQ} current is approximately 329 mA.

Step 4. Apply RF signal data -30 dBm level and observe that the output level is approximately 8 dBm or the gain of the device is approximately 38 dB.

NOTE: *It is important that the VD2, VD3, and VD4 voltage source be adjusted such that 3.5 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.*

Capacitors C6 and C7 are shown on EVB, but are not used.

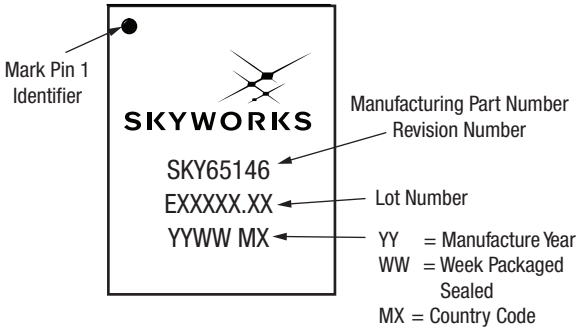
Bill of Material for Evaluation Board

Part	ID	QTY	Size	Value	Units	Manufacturer	Product Number
1	C1	1	1206	10	µF	AVX	TAJA106M006R
2	C2	1	1206	10	µF	AVX	TAJA106M006R
3	C3	1	0402	1000	pF	Murata	GRM155R71H102KA01
4	C4	1	1206	10	µF	AVX	TAJA106M006R
5	C5	1	0402	1000	pF	Murata	GRM155R71H102KA01

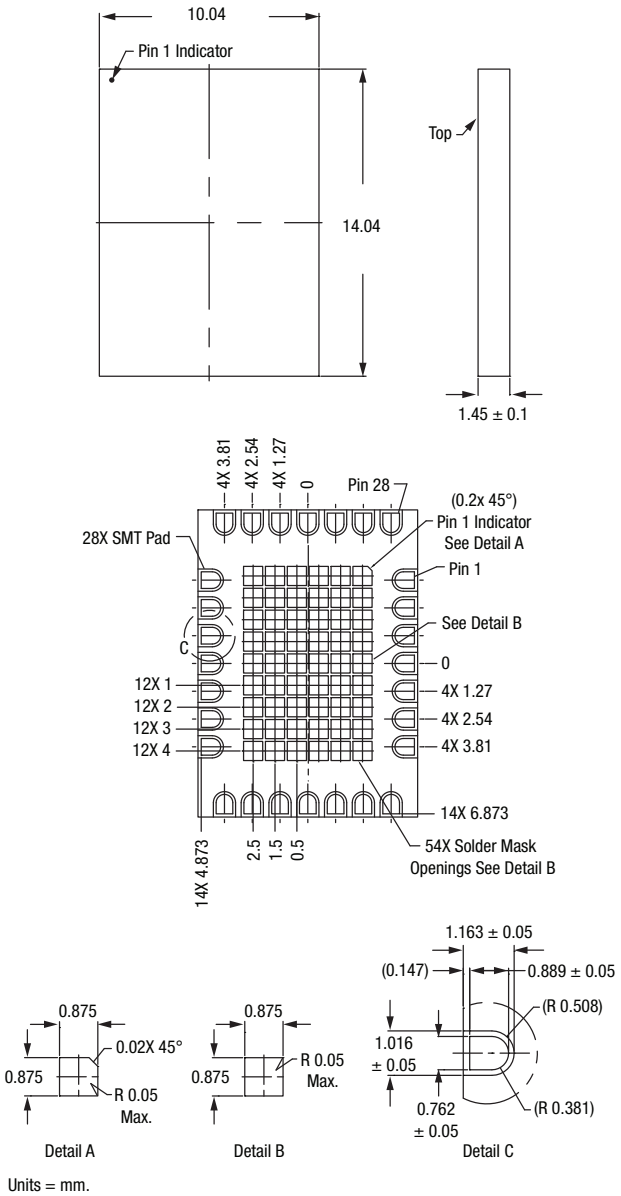
Evaluation Board Stack-Up

Cross Section	Name	Thickness (mm)	Material	ε_r
	L1	0.025	Cu	–
	Lam1	0.400	Rogers 4003	3.38
	L2	0.025	Cu	–
	Lam2	0.600	FR4	4.00
	L3	0.025	Cu	–
	Lam3	0.400	FR4	4.00
	L4	0.025	Cu	–

Branding Specifications

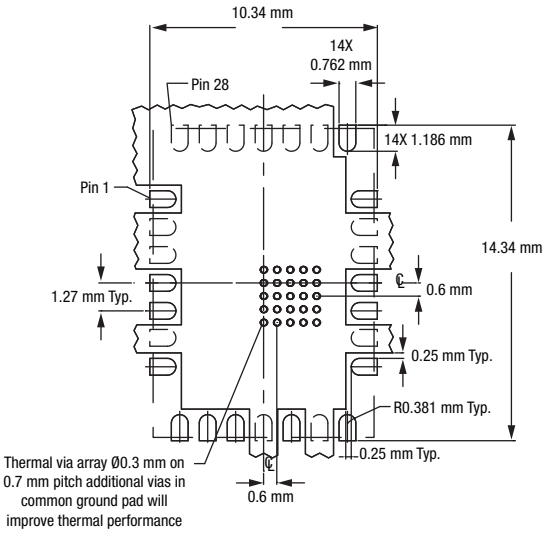


Package Outline



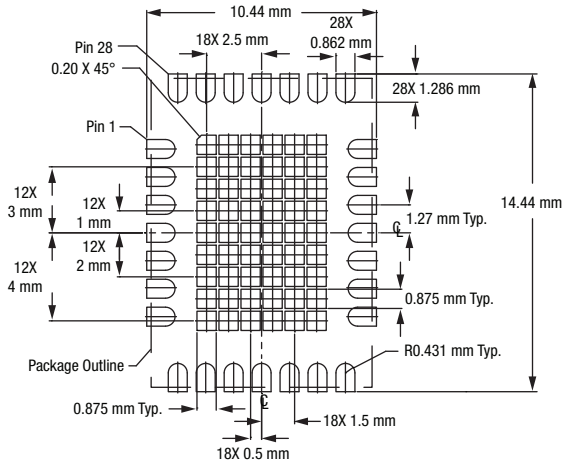
Units = mm.

Recommended Footprint

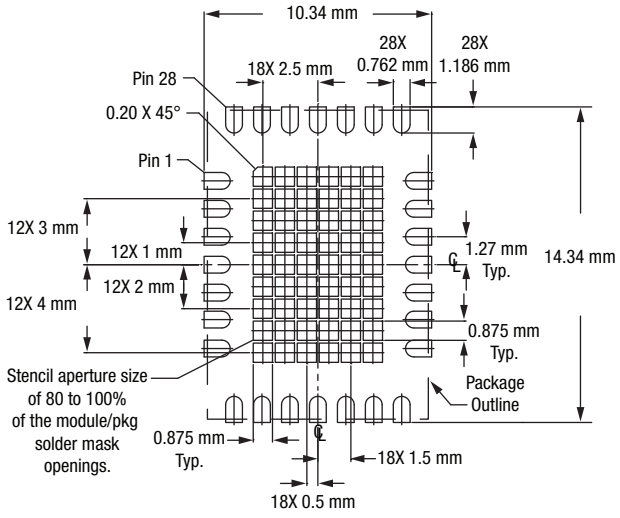


Thermal vias should be tented and filled with solder mask 30-35 µm copper plating recommended.

Solder Mask



Stencil Pattern



Ordering Information

Model Name	Manufacturing Part Number	Evaluation Kit Part Number
SKY65146: 3.5 V Broadband MCM Power Amplifier 806–849 MHz	SKY65146-21 (Pb-free package)	TW16-D390