Phase Shifter, X-Band, 6 Bits
8 - 12 GHz

MAPS-FR1024
Rev. V2

Features

- Insertion Loss: -8 dB @ 10 GHz
- Phase Shift Range: 360°
- RMS Phase Error: 2.5°
- Input P1dB: 20 dBm @ 10 GHz
- Input Return Loss:
  < -20 dB @ 10 GHz (All States)
- Output Return Loss:
  < -16 dB @ 10 GHz (All States)
- 0 / 5 V Control Lines
- Lead-Free 6 mm 48-lead PQFN Package
- RoHS* Compliant

Applications

- Radar
- Telecommunications
- Instrumentation

Description

The MAPS-FR1024 is a high performance GaAs MMIC 6-bit phase shifter operating in X-band. This device has a nominal phase shifting range of 0 - 360° in 5.625° steps and uses a combination of switched line and high pass/low pass filters to obtain very low phase error and insertion loss variations. It covers the frequency range of 8 to 12 GHz.

The die is manufactured using 0.18 µm gate length pHEMT technology. The MMIC uses gold bond pads and backside metallization and is fully protected with Silicon Nitride passivation to obtain the highest level of reliability. This technology has been evaluated for Space applications and is on the European Preferred Parts List of the European Space Agency.

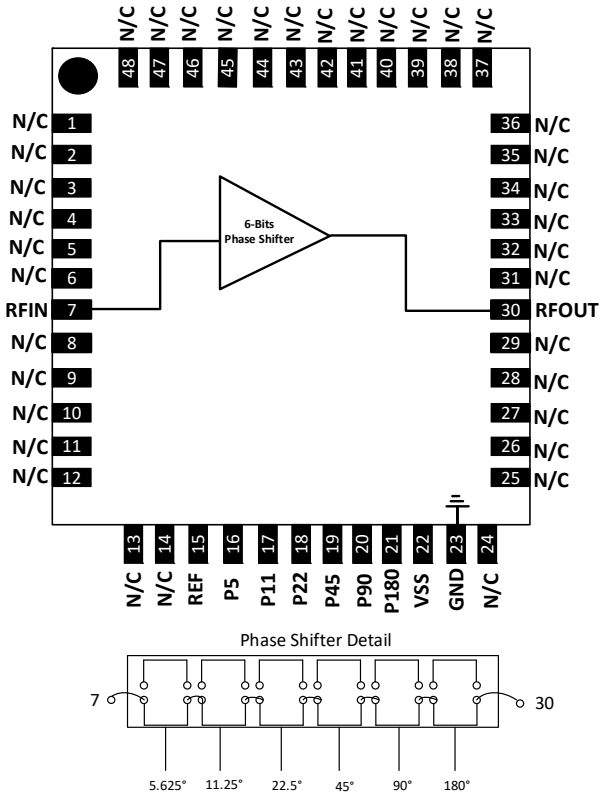
Ordering Information[1,2]

Part Number	Package
MAPS-FR1024	Bulk
MAPS-FR1024-TR0500	500 part reel
MAPS-FR1024-001SMB	Sample Board

1. Reference Application Note M513 for reel size information.
2. MAPS-FR1024 also exists in die form: CGY2172XBUH/C1.

* Restrictions on Hazardous Substances, compliant to current RoHS EU directive.

Functional Schematic



Pin Configuration[3]

Pin #	Function
1-6, 8-14, 24-29, 31-48	N/C
7	RFIN
15	REF
16	P5
17	P11
18	P22
19	P45
20	P90
21	P180
22	VSS
23	GND
30	RFOUT
Paddle[4]	GND Paddle

3. MACOM recommends connecting unused package pins to ground.
4. The exposed pad centered on the package bottom must be connected to RF, DC and thermal ground.

RF Electrical Specifications: Freq. = 8-12 GHz, V_{SS} = -5 V, I_{SS} = 4 mA, T_A = +25°C

Parameter	Test Conditions	Units	Min.	Typ.	Max.
Insertion Loss	8 GHz 10 GHz 12 GHz	dB	—	8	12 10 10
Noise Figure	@ Reference State	dB	—	8	—
Phase Accuracy Relative to Reference State	5.625 11.25 22.5 45 90 180	°	—	± 0.9 ± 0.4 ± 0.6 ± 1.2 ± 4.9 ± 2.8	—
Input Return Loss	RFIN @ 10 GHz	dB	—	20	—
Output Return Loss	RFOUT @ 10 GHz	dB	—	16	—
RMS Phase Error[5] vs. Phase Setting	@ 10 GHz	°	—	2.5	—
Maximum Phase Error vs. Phase Setting	@ 10 GHz	°	—	2	—
Maximum Attenuation Variation with Phase Setting	@ 10 GHz	dB	—	0.2	—
Input P1dB	@ 10 GHz	dBm	—	20	—

5. The RMS value is the root mean square of the error defined as below:
Where x_i is the difference between the measured value and the expected value (xi is the error), N is the number of cardinal states.

$$x_{RMS} = \sqrt{\frac{1}{N}\sum_{i=0}^{N} x_i^2}$$

Logic Truth Table (V)

	P0	P1	P2	P3	P4	P5
Nominal Phase Shift	-5.625°	-11.25°	-22.5°	-45°	-90°	-180°
Pad	P5	P11	P22	P45	P90	P180
Phase Shift Activated	+5 V	+5 V	+5 V	+5 V	+5 V	+5 V
Reference State	0 V	0 V	0 V	0 V	0 V	0 V

Recommended Operating Conditions

Parameter	Typical
Input Power	-15 dBm
Source Supply Voltage	-5 V

Control Voltage

State	Min.	Typ.	Max.	Unit
Low (0)	0	0	1.5	V
High (1)	3.5	5	—	V

Absolute Maximum Ratings[5,6]

Parameter	Absolute Maximum
Phase Control Inputs	0 to +7 V
Source Supply Voltage	-7 to 0 V
Input Power	25 dBm
Junction Temperature[7,8]	+150°C
Operating Temperature	-40°C to +85°C
Storage Temperature	-55°C to +150°C

6. Exceeding any one or combination of these limits may cause permanent damage to this device.
7. MACOM does not recommend sustained operation near these survivability limits.
8. Operating at nominal conditions with $T_J \leq +150°C$ will ensure MTTF > 1 x 10^6 hours.
9. Junction Temperature (T_J) = T_C + Θjc * (V * I)
   Typical thermal resistance (Θjc) = 91.6°C/W @ T_A = +25°C.
   a) For T_C = +25°C,
      T_J = 26.8°C @ 5 V, 4 mA
   b) For T_C = +85°C,
      T_J = 87.2°C @ 5 V, 4 mA

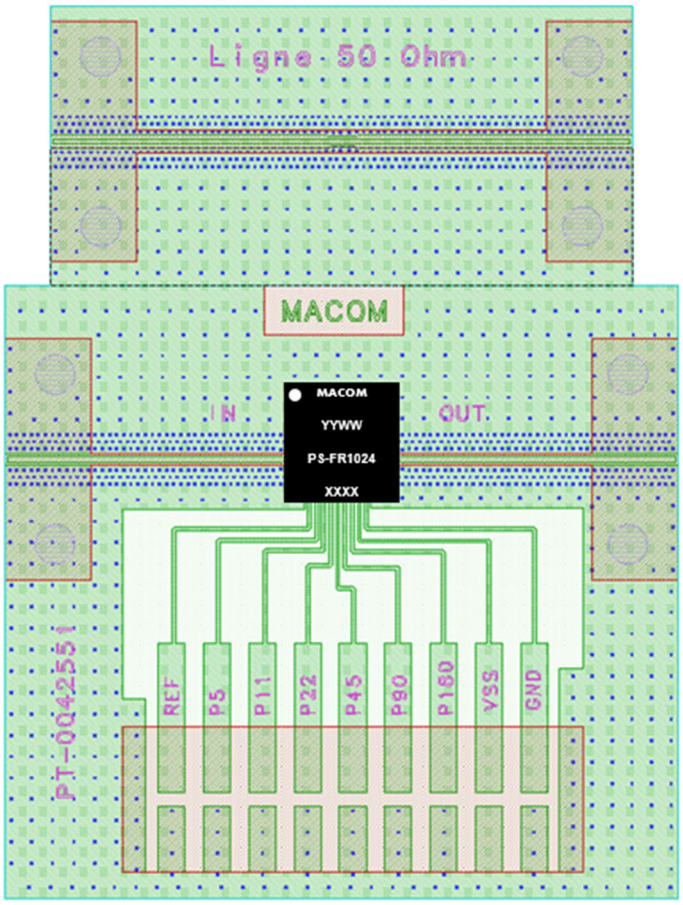
Handling Procedures

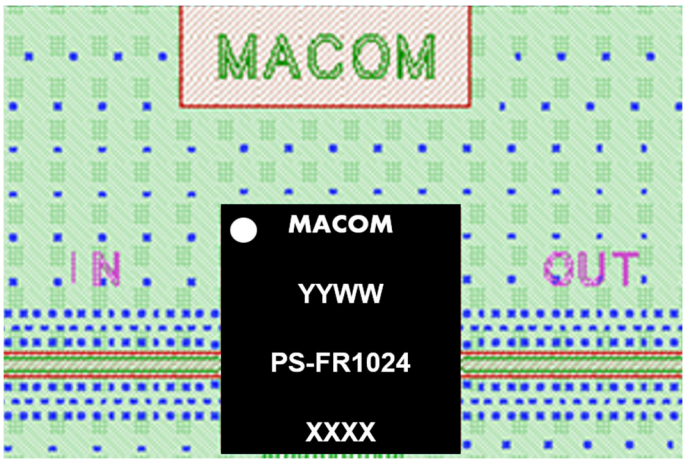
Please observe the following precautions to avoid damage:

Static Sensitivity

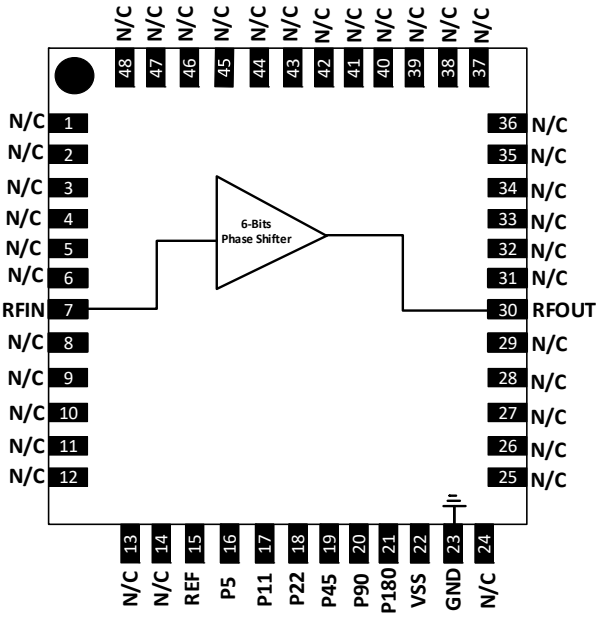
These electronic devices are sensitive to electrostatic discharge (ESD) and can be damaged by static electricity. Proper ESD control techniques should be used when handling these devices.

PCB Layout

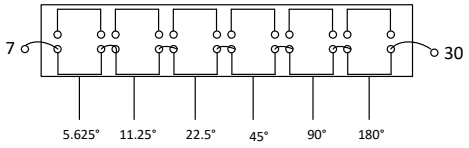




Application Schematic

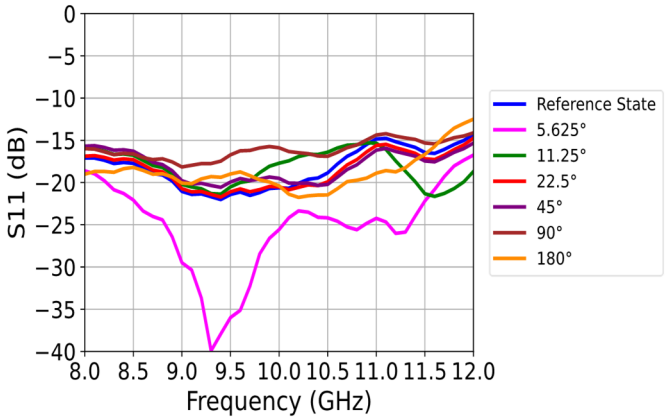


Phase Shifter Detail

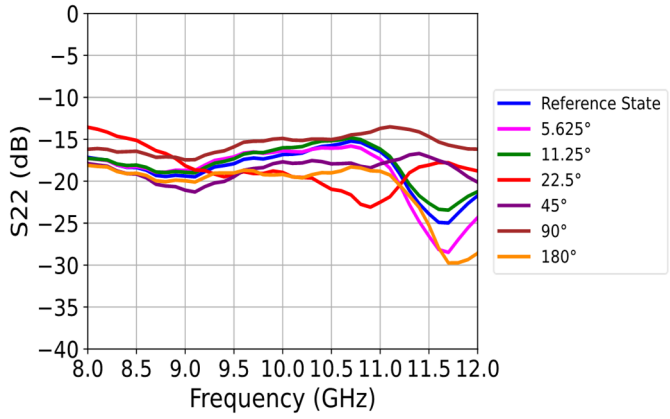


Typical Performance Curves: @ PCB level with De-Embedding at T_C = 25°C

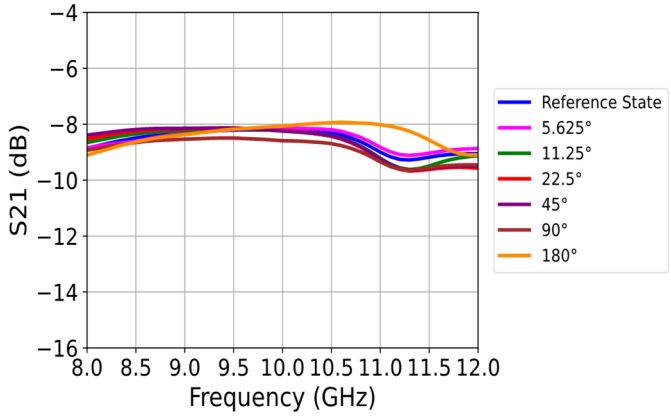
S11 Vs. Frequency (all states)



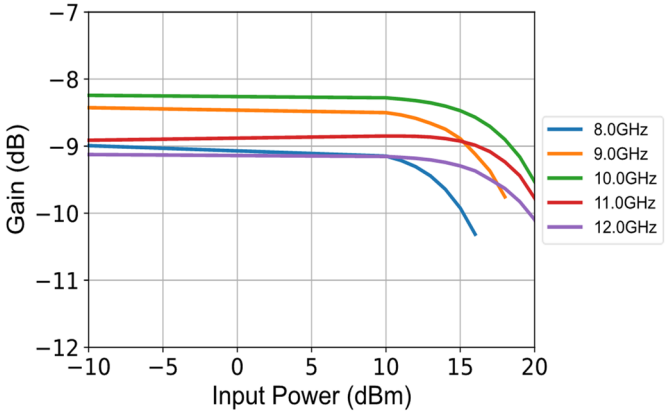
S22 Vs. Frequency (all states)



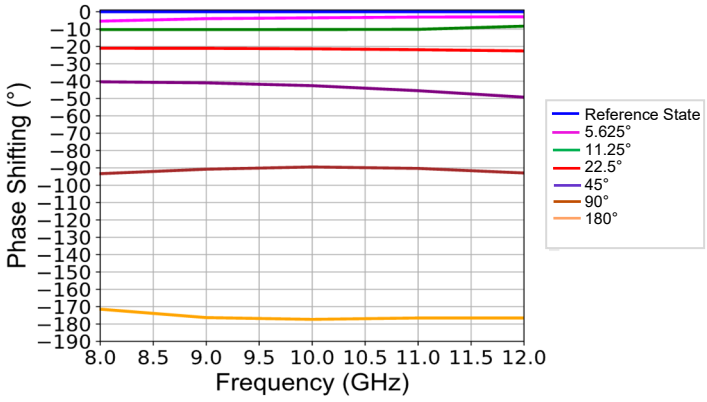
S21 Vs. Frequency (all states)



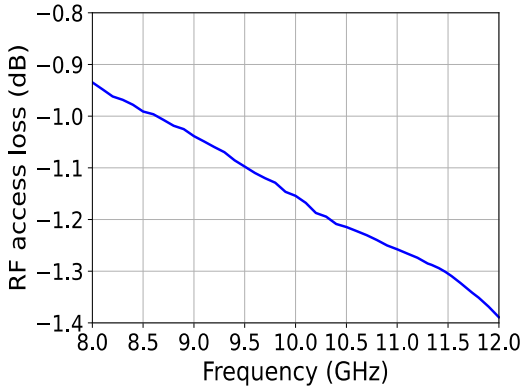
Gain Vs. Input Power Over Frequency



Phase Shifting Vs. Frequency (Main States)

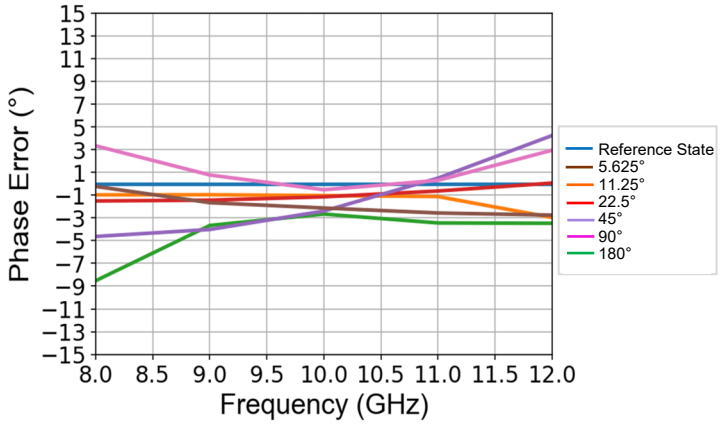


PCB RF Access Loss (Line + Connector) vs. Frequency

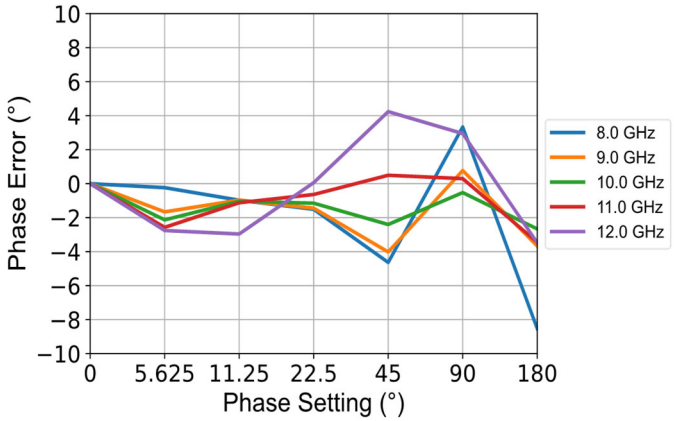


Typical Performance Curves: @ PCB level with De-Embedding at T_C = 25°C

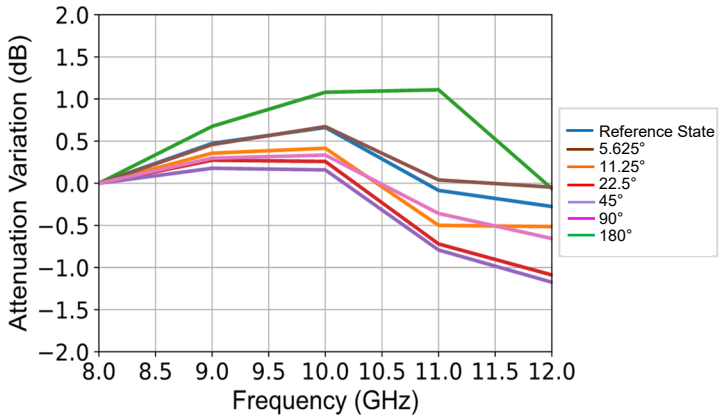
Phase Error Vs. Frequency



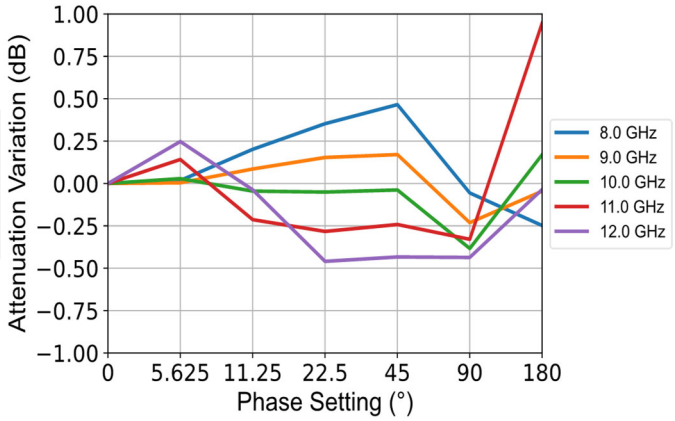
Phase Error Vs. Phase Setting @ Reference State



Attenuation Variations Vs. Frequency

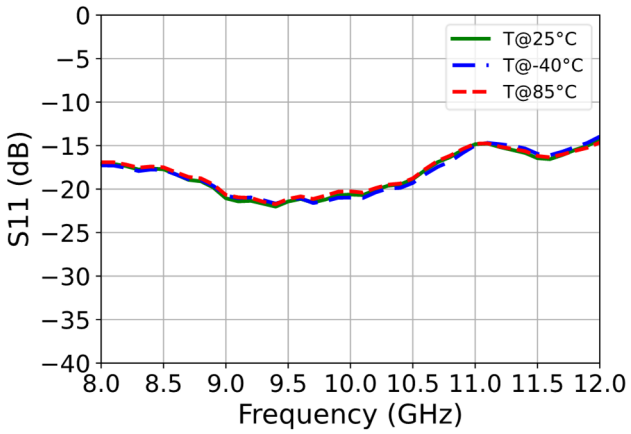


Attenuation Variations Vs. Phase Setting @ Reference State

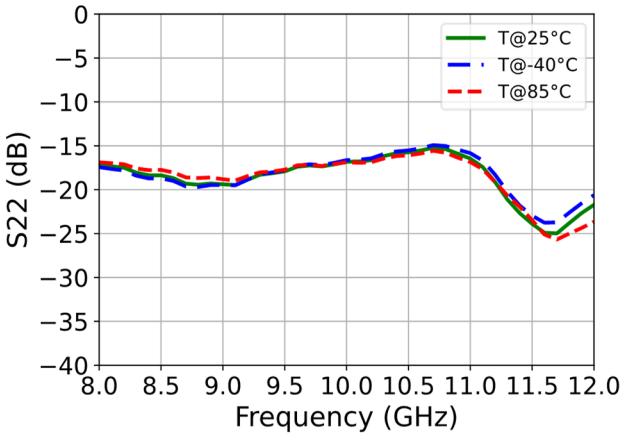


Typical Performance Curves: @ PCB level with De-Embedding at Different Temperatures

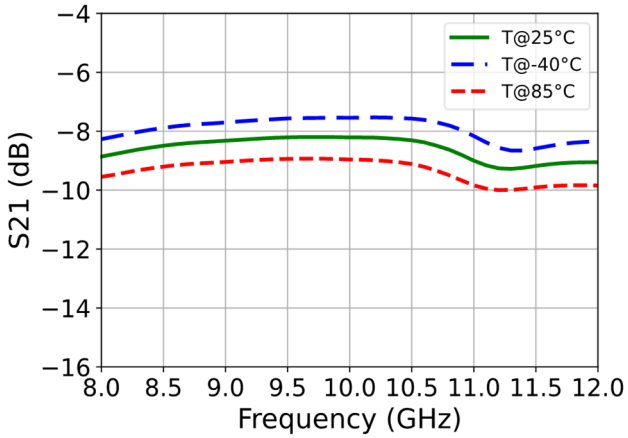
S11 Vs. Frequency Over Temperature



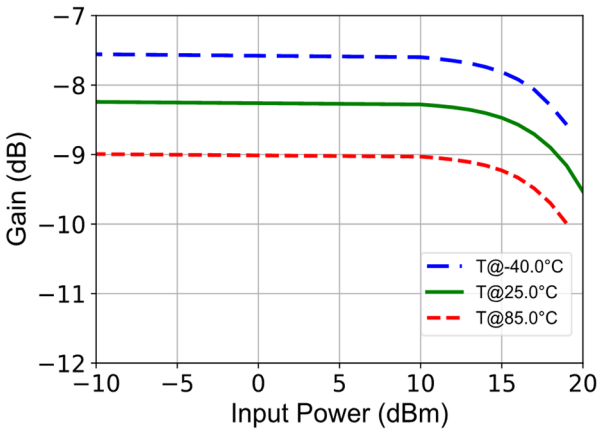
S22 Vs. Frequency Over Temperature



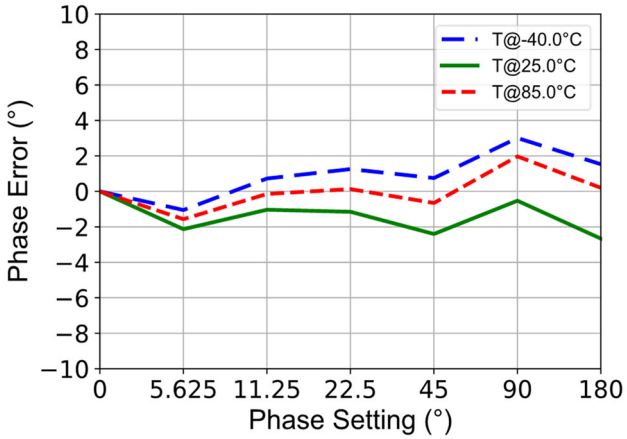
S21 Vs. Frequency Over Temperature



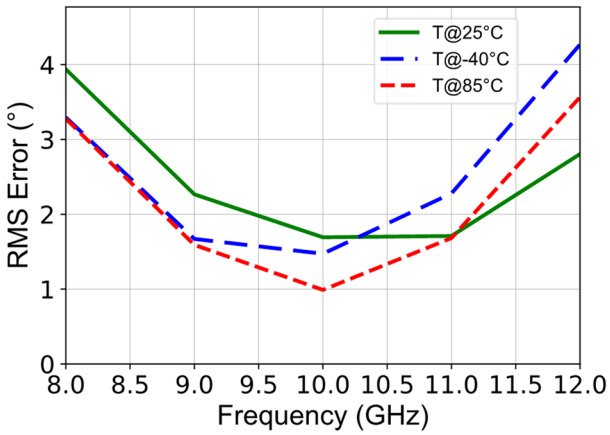
Gain Vs. Input Power Over Temperature @ 10 GHz



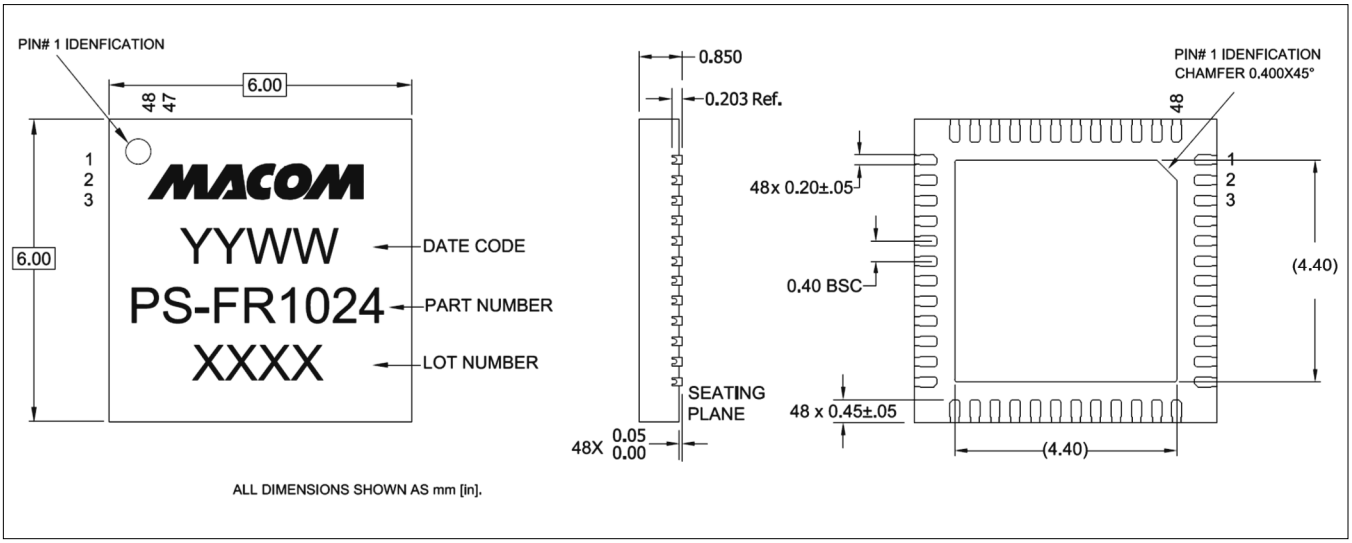
Phase Error Variations Vs. Phase Setting Over Temperature @ 10 GHz



RMS Phase Error Vs. Frequency Over Temperature



Lead-Free 6 mm 48-Lead PQFN†



† Reference Application Note S2083 for lead-free solder reflow recommendations.
Meets JEDEC moisture sensitivity level 1 requirements.
Plating is 100% matte tin over copper.

Revision History

Rev	Date	Change Description
V1	09/25/25	Initial Release
V2	11/12/25	Final Release : There was an issue with the measurements, so we decided to retrace a few curves