



MMIC DIE

X3 Frequency Multiplier

CY3-723-D+

50Ω Output 40 to 72 GHz

THE BIG DEAL

- Wideband Output from: 40 to 72 GHz
- Outstanding Fundamental and Close-in Harmonic Suppression:
 - F1: 41 dBc Typ.
 - F2: 33 dBc Typ.
 - F4: 33 dBc Typ.
- Input Drive Level: +12 to +19 dBm
- Conversion Loss: 21.1 dB Typ.

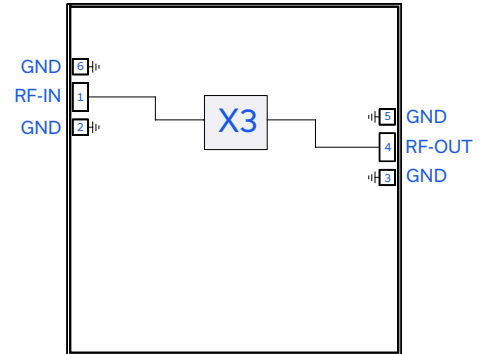
APPLICATIONS

- Test and Measurement Equipment
- 5G MIMO and Back Haul Radio Systems
- Satellite Communications
- Radar, EW, and ECM Defense Systems

PRODUCT OVERVIEW

Mini-Circuits' CY3-723-D+ is a wideband MMIC Frequency Tripler, converting input frequencies from 13.3 to 24 GHz into output frequencies from 40 to 72 GHz. Its wide output range makes this model suitable for broadband systems as well as a wide variety of narrow-band applications. The CY3-723-D+ die utilizes GaAs HBT technology and is suitable for chip and wire assemblies.

FUNCTIONAL DIAGRAM



SEE ORDERING INFORMATION ON THE LAST PAGE

KEY FEATURES

| Features | Advantages |
|---|---|
| Broadband, 40 to 72 GHz output | With an output frequency range spanning 40 to 72 GHz, this multiplier supports broadband applications such as defense and instrumentation as well as a wide range of narrowband system requirements including 5G. |
| Excellent Fundamental and Harmonic Suppression: <ul style="list-style-type: none"> • F1, 41 dBc Typ. • F2, 33 dBc Typ. • F4, 33 dBc Typ. | Harmonic and fundamental filtering requirements are dramatically simplified due to the high suppression resulting from internal cancellation within the diode configuration. |
| Wide input power range, +12 to +19 dBm | Wide input power signal range accommodates different input signal levels while still maintain a low conversion loss. |
| Unpackaged Die | Enables integration into hybrid chip and wire assemblies. |

REV. OR
ECO-018381
CY3-723-D+
MCL NY
230628





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ELECTRICAL SPECIFICATIONS^{1,3} AT +25°C AND Z₀ = 50Ω, UNLESS NOTED OTHERWISE

| Parameter | Input Frequency (GHz) | Min | Typ. | Max. | Unit |
|------------------------------|-----------------------|-------------|------|-------|------|
| Multiplication Factor | | | 3 | | |
| Frequency Range, Input (F1) | | 13.33 | - | 22.33 | GHz |
| Frequency Range, Output (F3) | | 40 | - | 72 | GHz |
| Input Power | | +12 | +18 | +19 | dBm |
| Conversion Loss (F3) | 13.3 - 15 | | 20.5 | | dB |
| | 15 - 16.6 | | 19.5 | | |
| | 16.6 - 18.3 | | 20.1 | | |
| | 18.3 - 20 | | 21.7 | | |
| | 20 - 22.3 | | 23.6 | | |
| | 22.3-24 | | 25.0 | | |
| Harmonic Output ² | F1 | 13.3 - 15 | | 50 | dBc |
| | | 15 - 16.6 | | 50 | |
| | | 16.6 - 18.3 | | 42 | |
| | | 18.3 - 20 | | 36 | |
| | | 20 - 22.3 | | 30 | |
| | | 22.3-24 | | 28 | |
| | F2 | 13.3 - 15 | | 49 | dBc |
| | | 15 - 16.6 | | 41 | |
| | | 16.6 - 18.3 | | 31 | |
| | | 18.3-20 | | 25 | |
| | | 20 - 22.3 | | 22 | |
| | | 22.3-24 | | 19 | |
| | F4 | 13.3 - 15 | | 31 | dBc |
| | | 15 - 16.6 | | 42 | |
| | | 16.6 - 18.3 | | 31 | |
| | | 18.3 - 20 | | 36 | |
| | | 20 - 22.3 | | 28 | |
| | | 22.3-24 | | 28 | |

1. Measured on Mini-Circuits Die Evaluation board. See Figure 3 for test conditions.

2. Harmonics of input frequency below the power of desired output F3.

3. All specifications are measured with RF input power = +18 dBm.





MMIC DIE

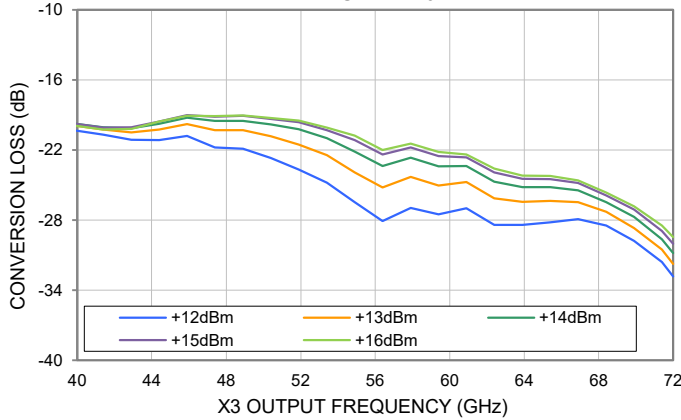
X3 Frequency Multiplier

CY3-723-D+

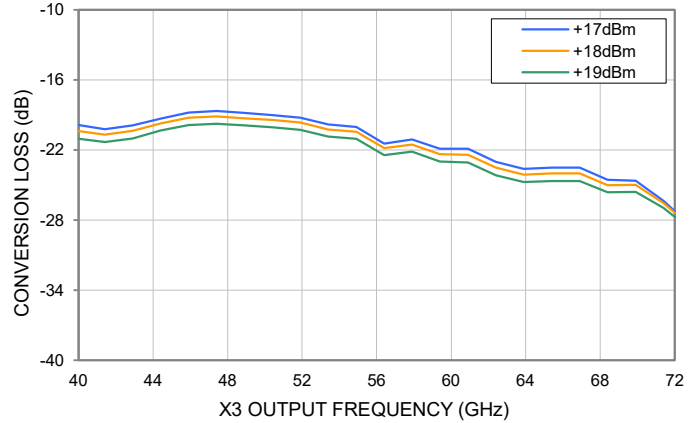
50Ω Output 40 to 72 GHz

TYPICAL PERFORMANCE GRAPHS

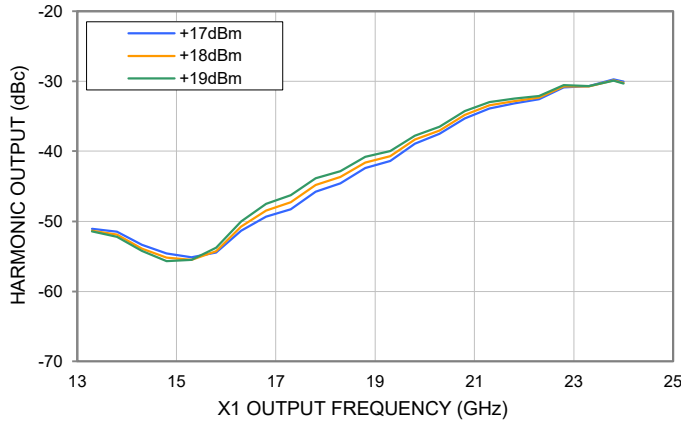
CONVERSION LOSS X3 OUTPUT vs. P_{IN}
TEMPERATURE = +25°C



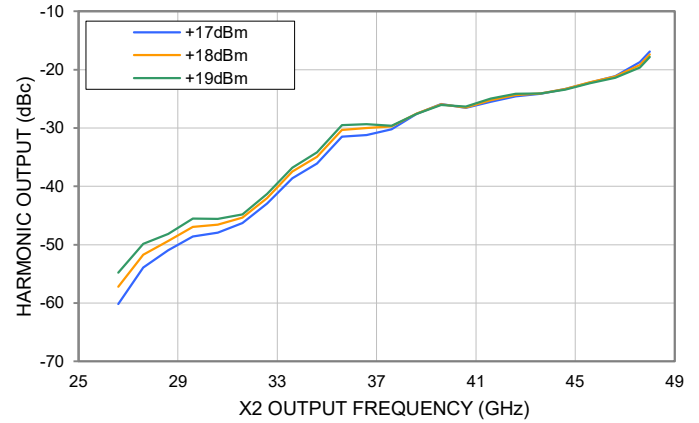
CONVERSION LOSS X3 OUTPUT vs. P_{IN}
TEMPERATURE = +25°C



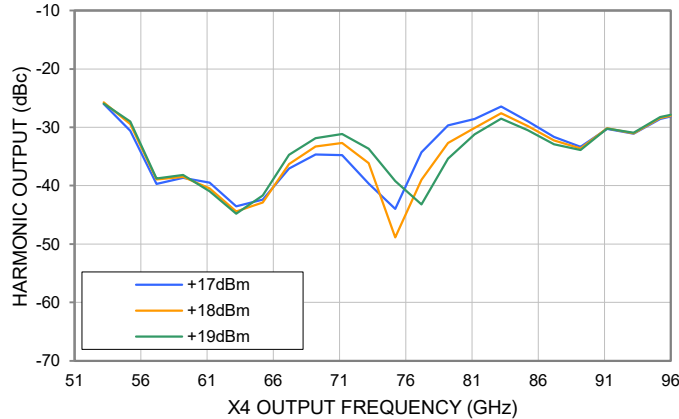
HARMONIC X1 OUTPUT vs. P_{IN}
TEMPERATURE = +25°C



HARMONIC X2 OUTPUT vs. P_{IN}
TEMPERATURE = +25°C



HARMONIC X4 OUTPUT vs. P_{IN}
TEMPERATURE = +25°C





MMIC DIE

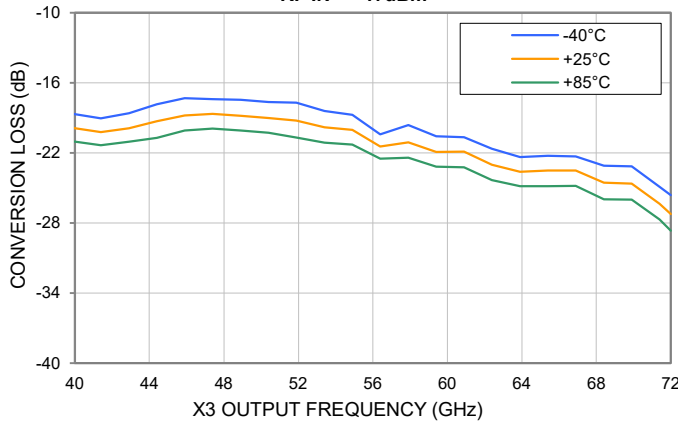
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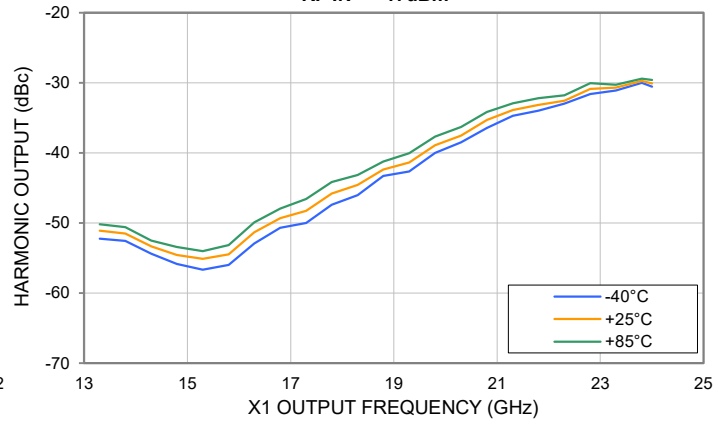
50Ω Output 40 to 72 GHz

TYPICAL PERFORMANCE GRAPHS

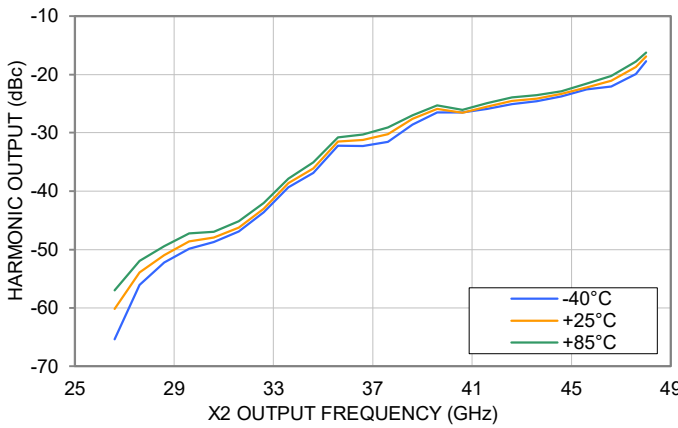
CONVERSION LOSS X3 OUTPUT vs. TEMPERATURE
RF IN = +17dBm



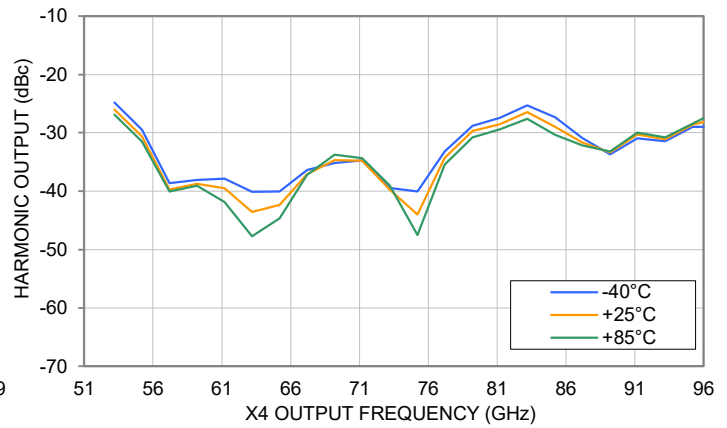
HARMONIC X1 OUTPUT vs. TEMPERATURE
RF IN = +17dBm



HARMONIC X2 OUTPUT vs. TEMPERATURE
RF IN = +17dBm



HARMONIC X4 OUTPUT vs. TEMPERATURE
RF IN = +17dBm





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X3 Frequency Multiplier

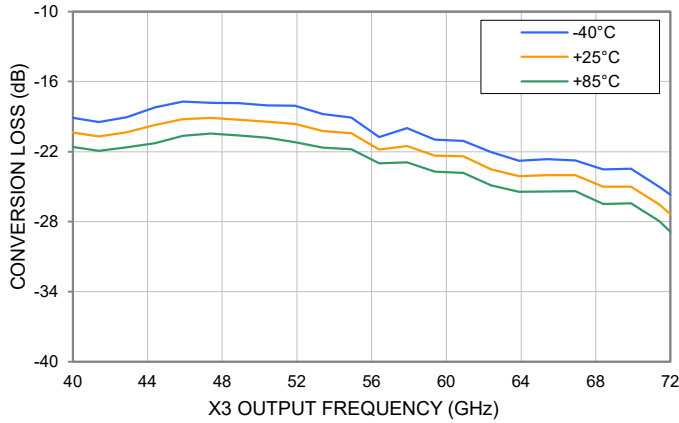
CY3-723-D+

Mini-Circuits

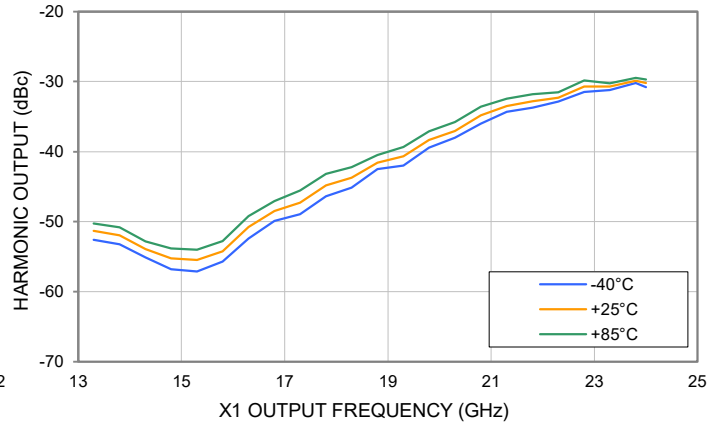
50Ω Output 40 to 72 GHz

TYPICAL PERFORMANCE GRAPHS

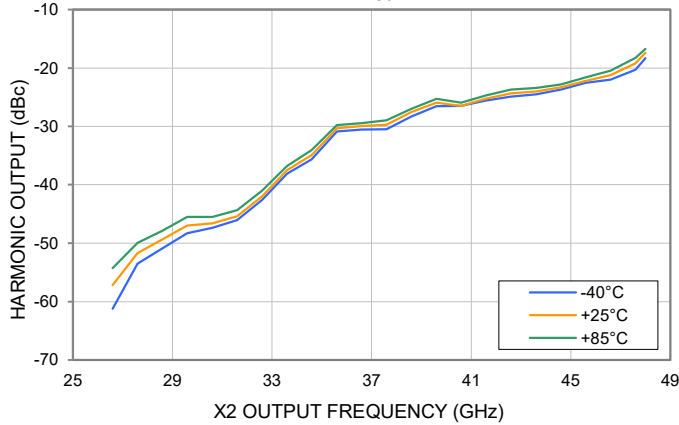
CONVERSION LOSS X3 OUTPUT vs. TEMPERATURE
RF IN = +18dBm



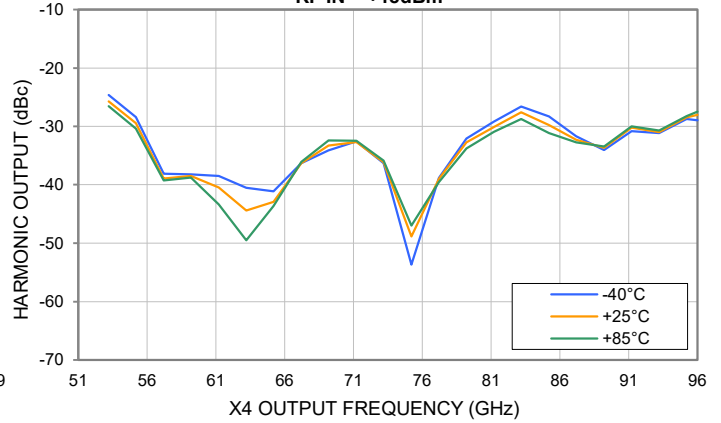
HARMONIC X1 OUTPUT vs. TEMPERATURE
RF IN = +18dBm



HARMONIC X2 OUTPUT vs. TEMPERATURE
RF IN = +18dBm



HARMONIC X4 OUTPUT vs. TEMPERATURE
RF IN = +18dBm





MMIC DIE

X3 Frequency Multiplier

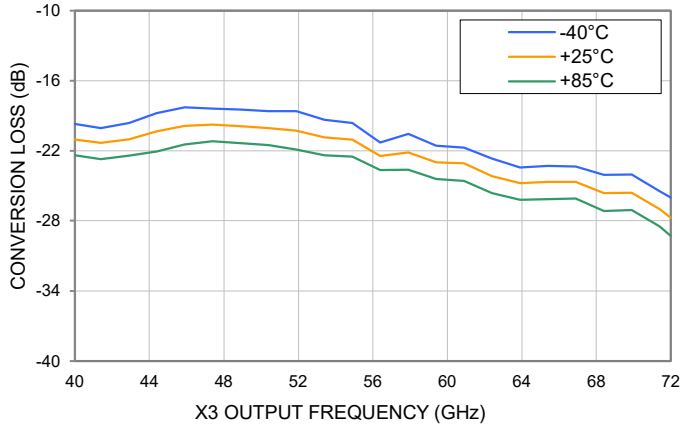
CY3-723-D+

Mini-Circuits

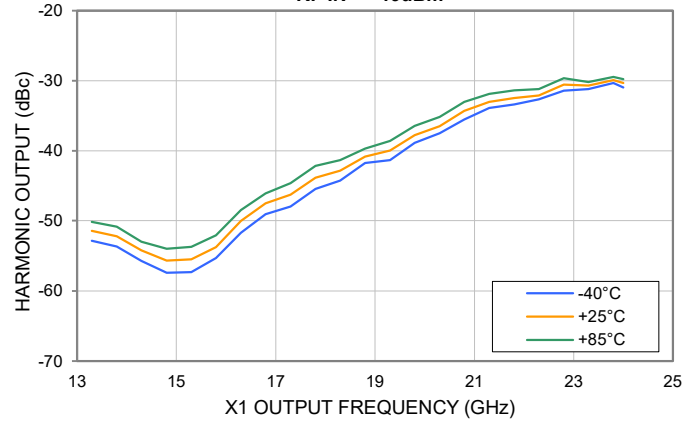
50Ω Output 40 to 72 GHz

TYPICAL PERFORMANCE GRAPHS

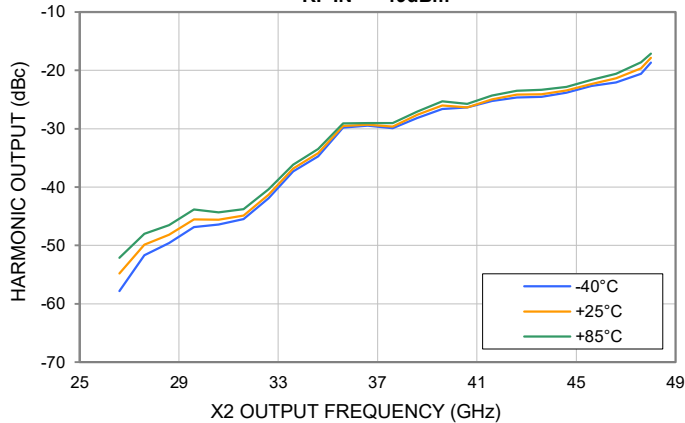
CONVERSION LOSS X3 OUTPUT vs. TEMPERATURE
RF IN = +19dBm



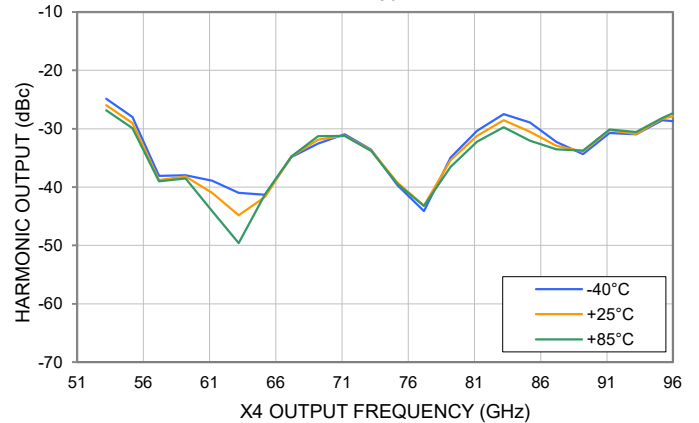
HARMONIC X1 OUTPUT vs. TEMPERATURE
RF IN = +19dBm



HARMONIC X2 OUTPUT vs. TEMPERATURE
RF IN = +19dBm



HARMONIC X4 OUTPUT vs. TEMPERATURE
RF IN = +19dBm





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ABSOLUTE MAXIMUM RATINGS⁴

| Parameter | Ratings |
|--|----------------|
| Operating Temperature ⁵ | -40°C to +85°C |
| Storage Temperature (for Die) ⁶ | +20°C to +35°C |
| RF Input Power | +22 dBm |
| Junction Temperature ⁷ | +150°C |

4. Permanent damage may occur if any of these limits are exceeded. Electrical maximum ratings are not intended for continuous normal operation.

5. Bottom of Die

6. For die shipped in Gel-Pak see ENV-80 (limited by packaging).

7. Hot spot temperature on die.



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FUNCTIONAL DIAGRAM

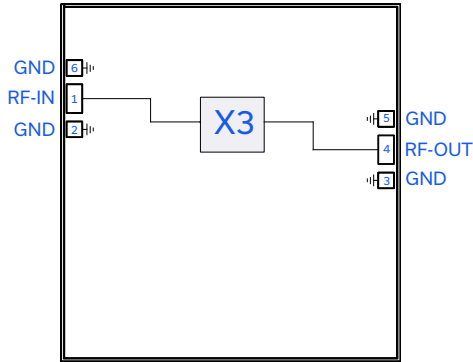


Figure 1. CY3-723-D+ Functional Diagram

PAD DESCRIPTION

| Function | Pad # | Description (Refer to Figure 1) |
|----------|-------------|--|
| RF-IN | 1 | Connect to RF Input |
| RF-OUT | 4 | Connect to RF Output |
| GND | 2, 3, 5 & 6 | Connected to die backside through vias. Bond wires to ground are optional. |

DIE OUTLINE: inches [mm], Typical

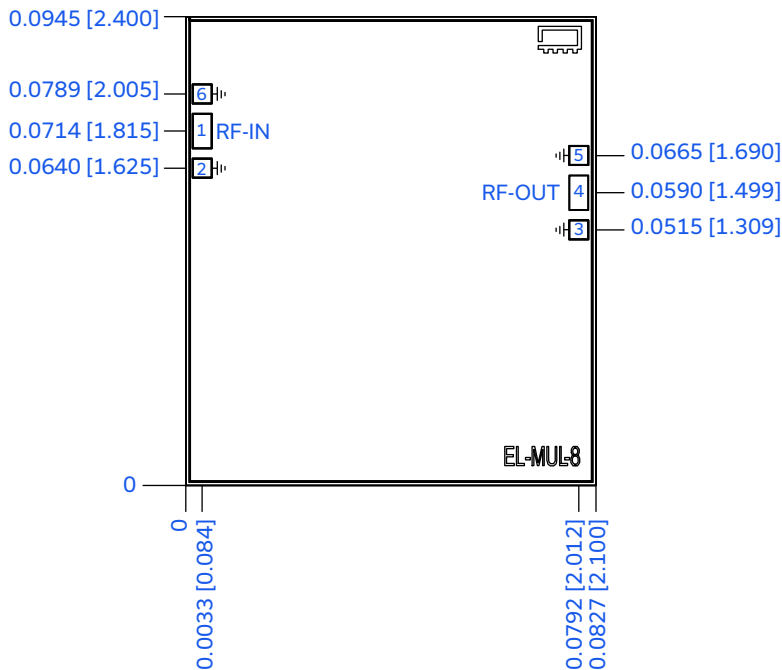


Figure 2. CY3-723-D+ Die Outline

DIMENSIONS: inches [mm], Typical

| | |
|--------------------------------|------------------------------------|
| Die Size | 0.0827 x 0.0945 [2.100 x 2.400] |
| Die Thickness | 0.0040 [0.100] |
| Bond Pad Sizes: | |
| Pads 1 & 4 | 0.0036 x 0.0068 [0.092 x 0.172] |
| Pad 2, 3, 5 & 6 | 0.0036 x 0.0036 [0.092 x 0.092] |
| Plating (Pads & Bottom of Die) | Gold |



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APPLICATION AND CHARACTERIZATION SETUP

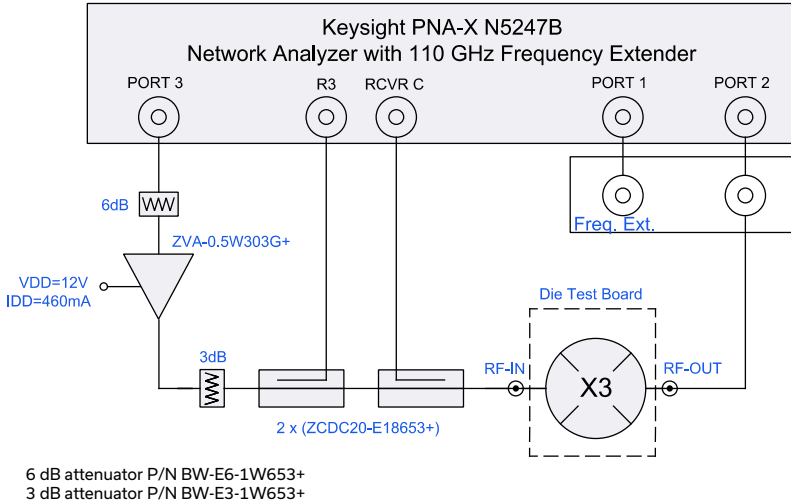


Figure 3. Application and Characterization Setup for CY3-723-D+

TEST PARAMETERS AND CONDITIONS

DUT attached on a Mini-Circuits Die Characterization Test Board. Conversion Loss and Harmonic Output are measured using PNA-X Network Analyzer.

Test Conditions:

For Conversion Loss and Harmonic Rejection: RF input power: +12 to +19 dBm.





ASSEMBLY DIAGRAM

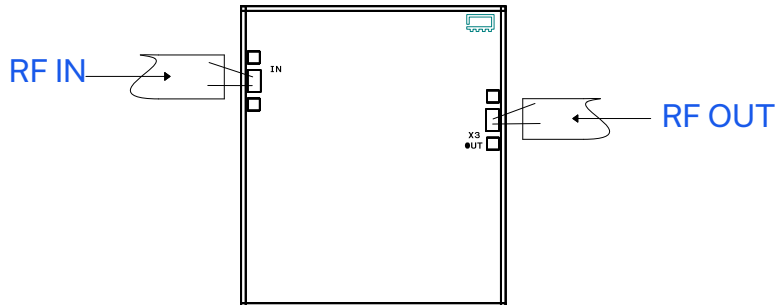



Figure 4. CY3-723-D+ Assembly Diagram

- Bond wire diameter: 1 mil
- Bond wire lengths from Die Pad to PCB at RF-IN & RF-OUT ports: 11 ± 1 mils
- Typical Gap from Die edge to PCB edge: 3mils
- PCB thickness and material: 3.5 mil (Thickness: 0.5 oz copper on each side).

ASSEMBLY AND HANDLING PROCEDURE

1. Storage
Die should be stored in a dry nitrogen purged desiccator or equivalent.
2.  ESD Precautions
MMIC Multiplier Die are susceptible to electrostatic and mechanical damage. Die are supplied in anti-static protected material, which should be opened only in clean room conditions at an appropriately grounded anti-static workstation.
3. Die Handling and Attachment
Devices require careful handling using tools appropriate for manipulating semiconductor chips. It is recommended to handle the chips along the edges with a custom designed collet. The surface of the chips have exposed air bridges and should not be touched with a vacuum collet, tweezers or fingers. The die mounting surface must be clean and flat. Using conductive silver-filled epoxy, apply sufficient adhesive to meet the required bond line thickness, fillet height and coverage around the total periphery of the device. The recommended epoxy is Ablestik 84-1 LMISR4 or equivalent. Parts should be cured in a nitrogen-filled atmosphere per manufacturer's recommended cure profile.
4. Wire Bonding
Openings in the surface passivation above the gold bond pads are provided to allow wire bonding to the die. Thermosonic bonding is recommended with minimized ultrasonic content. Bond force, time, ultrasonic power and temperature are all critical parameters. The suggested interconnect is pure gold, 1 mil diameter wire. Bonds are recommended to be made from the bond pads on the die to the package or substrate. All bond wire length and bond wire height should be kept as short as possible, unless specified by design, to minimize performance degradation due to undesirable series inductance.



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ADDITIONAL DETAILED INFORMATION IS AVAILABLE ON OUR DASH BOARD [CLICK HERE](#)

| | | | | | | | | | |
|---|---|-------------------|-----------|----------------------|-------------|------------------------------|-------------|-------------|-------------|
| Performance Data | Table Graphs | | | | | | | | |
| Case Style | Die | | | | | | | | |
| RoHs Status | Compliant | | | | | | | | |
| Die Ordering and Packaging Information | <table> <tr> <td>Quantity, Package</td> <td>Model No.</td> </tr> <tr> <td>Gel - Pak: 5, 10, 50</td> <td>CY3-723-DG+</td> </tr> <tr> <td>Medium†, Partial wafer: <460</td> <td>CY3-723-DP+</td> </tr> <tr> <td>Full wafer†</td> <td>CY3-723-DF+</td> </tr> </table> <p>†Available upon request contact sales representative. Refer to AN-60-067</p> | Quantity, Package | Model No. | Gel - Pak: 5, 10, 50 | CY3-723-DG+ | Medium†, Partial wafer: <460 | CY3-723-DP+ | Full wafer† | CY3-723-DF+ |
| Quantity, Package | Model No. | | | | | | | | |
| Gel - Pak: 5, 10, 50 | CY3-723-DG+ | | | | | | | | |
| Medium†, Partial wafer: <460 | CY3-723-DP+ | | | | | | | | |
| Full wafer† | CY3-723-DF+ | | | | | | | | |
| Die Marking | EL-MUL-8 | | | | | | | | |
| Environmental Ratings | ENV-80 | | | | | | | | |

Notes

- A. Performance and quality attributes and conditions not expressly stated in this specification document are intended to be excluded and do not form a part of this specification document.
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Typical Performance Data

TEST CONDITION: RF IN = +17dBm

| Frequency (GHz) | | | | Temperature = -40°C | | | |
|-----------------|-----------|-----------|-----------|------------------------------|-----------|-------------------------------|-----------|
| X1 Output | X2 Output | X3 Output | X4 Output | Conversion Loss X3 Output | X1 Output | Harmonic Output* X2 Output | X4 Output |
| 13.3 | 26.6 | 39.9 | 53.2 | 18.65 | 52.24 | 65.39 | 24.83 |
| 13.8 | 27.6 | 41.4 | 55.2 | 19.03 | 52.58 | 56.01 | 29.50 |
| 14.3 | 28.6 | 42.9 | 57.2 | 18.62 | 54.37 | 52.23 | 38.63 |
| 14.8 | 29.6 | 44.4 | 59.2 | 17.85 | 55.83 | 49.87 | 38.08 |
| 15.3 | 30.6 | 45.9 | 61.2 | 17.32 | 56.68 | 48.67 | 37.81 |
| 15.8 | 31.6 | 47.4 | 63.2 | 17.39 | 55.96 | 46.91 | 40.09 |
| 16.3 | 32.6 | 48.9 | 65.2 | 17.46 | 52.92 | 43.60 | 40.06 |
| 16.8 | 33.6 | 50.4 | 67.2 | 17.65 | 50.70 | 39.33 | 36.35 |
| 17.3 | 34.6 | 51.9 | 69.2 | 17.69 | 50.01 | 36.82 | 35.18 |
| 17.8 | 35.6 | 53.4 | 71.2 | 18.40 | 47.42 | 32.20 | 34.71 |
| 18.3 | 36.6 | 54.9 | 73.2 | 18.74 | 46.01 | 32.25 | 39.45 |
| 18.8 | 37.6 | 56.4 | 75.2 | 20.41 | 43.28 | 31.57 | 40.05 |
| 19.3 | 38.6 | 57.9 | 77.2 | 19.62 | 42.65 | 28.58 | 33.18 |
| 19.8 | 39.6 | 59.4 | 79.2 | 20.58 | 40.01 | 26.54 | 28.80 |
| 20.3 | 40.6 | 60.9 | 81.2 | 20.65 | 38.49 | 26.53 | 27.40 |
| 20.8 | 41.6 | 62.4 | 83.2 | 21.65 | 36.47 | 25.90 | 25.28 |
| 21.3 | 42.6 | 63.9 | 85.2 | 22.37 | 34.72 | 25.11 | 27.33 |
| 21.8 | 43.6 | 65.4 | 87.2 | 22.23 | 33.97 | 24.61 | 30.86 |
| 22.3 | 44.6 | 66.9 | 89.2 | 22.32 | 32.97 | 23.75 | 33.70 |
| 22.8 | 45.6 | 68.4 | 91.2 | 23.11 | 31.59 | 22.56 | 30.93 |
| 23.3 | 46.6 | 69.9 | 93.2 | 23.16 | 31.10 | 22.10 | 31.40 |
| 23.8 | 47.6 | 71.4 | 95.2 | 24.90 | 30.01 | 19.94 | 28.96 |
| 24.0 | 48.0 | 72.0 | 96.0 | 25.62 | 30.53 | 17.75 | 29.02 |

* Harmonic Output below power level of X3 Output

| Frequency (GHz) | | | | Temperature = +25°C | | | |
|-----------------|-----------|-----------|-----------|------------------------------|-----------|-------------------------------|-----------|
| X1 Output | X2 Output | X3 Output | X4 Output | Conversion Loss X3 Output | X1 Output | Harmonic Output* X2 Output | X4 Output |
| 13.3 | 26.6 | 39.9 | 53.2 | 19.86 | 51.07 | 60.17 | 26.01 |
| 13.8 | 27.6 | 41.4 | 55.2 | 20.21 | 51.48 | 53.89 | 30.64 |
| 14.3 | 28.6 | 42.9 | 57.2 | 19.89 | 53.34 | 50.95 | 39.70 |
| 14.8 | 29.6 | 44.4 | 59.2 | 19.30 | 54.57 | 48.57 | 38.69 |
| 15.3 | 30.6 | 45.9 | 61.2 | 18.78 | 55.13 | 47.96 | 39.49 |
| 15.8 | 31.6 | 47.4 | 63.2 | 18.66 | 54.48 | 46.25 | 43.57 |
| 16.3 | 32.6 | 48.9 | 65.2 | 18.82 | 51.35 | 42.99 | 42.38 |
| 16.8 | 33.6 | 50.4 | 67.2 | 19.01 | 49.31 | 38.63 | 37.10 |
| 17.3 | 34.6 | 51.9 | 69.2 | 19.24 | 48.31 | 36.11 | 34.65 |
| 17.8 | 35.6 | 53.4 | 71.2 | 19.81 | 45.80 | 31.53 | 34.76 |
| 18.3 | 36.6 | 54.9 | 73.2 | 20.03 | 44.58 | 31.23 | 39.68 |
| 18.8 | 37.6 | 56.4 | 75.2 | 21.45 | 42.38 | 30.22 | 43.99 |
| 19.3 | 38.6 | 57.9 | 77.2 | 21.10 | 41.37 | 27.62 | 34.27 |
| 19.8 | 39.6 | 59.4 | 79.2 | 21.90 | 38.91 | 25.87 | 29.71 |
| 20.3 | 40.6 | 60.9 | 81.2 | 21.90 | 37.52 | 26.57 | 28.57 |
| 20.8 | 41.6 | 62.4 | 83.2 | 23.03 | 35.30 | 25.49 | 26.44 |
| 21.3 | 42.6 | 63.9 | 85.2 | 23.61 | 33.90 | 24.55 | 28.93 |
| 21.8 | 43.6 | 65.4 | 87.2 | 23.53 | 33.14 | 24.17 | 31.68 |
| 22.3 | 44.6 | 66.9 | 89.2 | 23.53 | 32.53 | 23.33 | 33.36 |
| 22.8 | 45.6 | 68.4 | 91.2 | 24.56 | 30.84 | 22.24 | 30.27 |
| 23.3 | 46.6 | 69.9 | 93.2 | 24.64 | 30.71 | 21.10 | 31.12 |
| 23.8 | 47.6 | 71.4 | 95.2 | 26.35 | 29.73 | 18.75 | 28.62 |
| 24.0 | 48.0 | 72.0 | 96.0 | 27.23 | 30.05 | 16.89 | 28.15 |

* Harmonic Output below power level of X3 Output

| Frequency (GHz) | | | | Temperature = +85°C | | | |
|-----------------|-----------|-----------|-----------|------------------------------|-----------|-------------------------------|-----------|
| X1 Output | X2 Output | X3 Output | X4 Output | Conversion Loss X3 Output | X1 Output | Harmonic Output* X2 Output | X4 Output |
| 13.3 | 26.6 | 39.9 | 53.2 | 21.01 | 50.18 | 56.97 | 26.89 |
| 13.8 | 27.6 | 41.4 | 55.2 | 21.34 | 50.61 | 51.95 | 31.52 |
| 14.3 | 28.6 | 42.9 | 57.2 | 21.06 | 52.51 | 49.40 | 40.06 |
| 14.8 | 29.6 | 44.4 | 59.2 | 20.71 | 53.44 | 47.26 | 39.05 |
| 15.3 | 30.6 | 45.9 | 61.2 | 20.10 | 54.03 | 46.96 | 41.85 |
| 15.8 | 31.6 | 47.4 | 63.2 | 19.91 | 53.17 | 45.11 | 47.74 |
| 16.3 | 32.6 | 48.9 | 65.2 | 20.09 | 49.92 | 42.01 | 44.64 |
| 16.8 | 33.6 | 50.4 | 67.2 | 20.28 | 47.95 | 37.83 | 37.19 |
| 17.3 | 34.6 | 51.9 | 69.2 | 20.69 | 46.57 | 35.09 | 33.71 |
| 17.8 | 35.6 | 53.4 | 71.2 | 21.14 | 44.18 | 30.77 | 34.30 |
| 18.3 | 36.6 | 54.9 | 73.2 | 21.29 | 43.13 | 30.28 | 39.03 |
| 18.8 | 37.6 | 56.4 | 75.2 | 22.51 | 41.28 | 29.08 | 47.49 |
| 19.3 | 38.6 | 57.9 | 77.2 | 22.41 | 40.06 | 27.00 | 35.46 |
| 19.8 | 39.6 | 59.4 | 79.2 | 23.17 | 37.68 | 25.28 | 30.75 |
| 20.3 | 40.6 | 60.9 | 81.2 | 23.25 | 36.29 | 26.07 | 29.40 |
| 20.8 | 41.6 | 62.4 | 83.2 | 24.34 | 34.12 | 24.92 | 27.60 |
| 21.3 | 42.6 | 63.9 | 85.2 | 24.86 | 32.93 | 23.89 | 30.33 |
| 21.8 | 43.6 | 65.4 | 87.2 | 24.86 | 32.15 | 23.53 | 32.17 |
| 22.3 | 44.6 | 66.9 | 89.2 | 24.83 | 31.79 | 22.85 | 33.18 |
| 22.8 | 45.6 | 68.4 | 91.2 | 25.99 | 30.04 | 21.61 | 29.97 |
| 23.3 | 46.6 | 69.9 | 93.2 | 26.01 | 30.28 | 20.26 | 30.78 |
| 23.8 | 47.6 | 71.4 | 95.2 | 27.72 | 29.39 | 17.80 | 28.39 |
| 24.0 | 48.0 | 72.0 | 96.0 | 28.67 | 29.60 | 16.27 | 27.47 |

* Harmonic Output below power level of X3 Output

Typical Performance Data

TEST CONDITION: RF IN = +18dBm

| Frequency (GHz) | | | | Temperature = -40°C | | | |
|-----------------|-----------|-----------|-----------|------------------------------|-----------|-------------------------------|-----------|
| X1 Output | X2 Output | X3 Output | X4 Output | Conversion Loss X3 Output | X1 Output | Harmonic Output* X2 Output | X4 Output |
| 13.3 | 26.6 | 39.9 | 53.2 | 19.11 | 52.60 | 61.27 | 24.60 |
| 13.8 | 27.6 | 41.4 | 55.2 | 19.47 | 53.22 | 53.49 | 28.38 |
| 14.3 | 28.6 | 42.9 | 57.2 | 19.05 | 55.09 | 50.89 | 38.14 |
| 14.8 | 29.6 | 44.4 | 59.2 | 18.22 | 56.78 | 48.32 | 38.20 |
| 15.3 | 30.6 | 45.9 | 61.2 | 17.72 | 57.13 | 47.40 | 38.52 |
| 15.8 | 31.6 | 47.4 | 63.2 | 17.81 | 55.74 | 46.05 | 40.54 |
| 16.3 | 32.6 | 48.9 | 65.2 | 17.87 | 52.41 | 42.61 | 41.15 |
| 16.8 | 33.6 | 50.4 | 67.2 | 18.03 | 49.89 | 38.10 | 36.31 |
| 17.3 | 34.6 | 51.9 | 69.2 | 18.05 | 48.95 | 35.63 | 34.13 |
| 17.8 | 35.6 | 53.4 | 71.2 | 18.77 | 46.40 | 30.84 | 32.56 |
| 18.3 | 36.6 | 54.9 | 73.2 | 19.08 | 45.14 | 30.55 | 36.28 |
| 18.8 | 37.6 | 56.4 | 75.2 | 20.74 | 42.49 | 30.53 | 53.69 |
| 19.3 | 38.6 | 57.9 | 77.2 | 19.98 | 41.98 | 28.30 | 38.81 |
| 19.8 | 39.6 | 59.4 | 79.2 | 20.97 | 39.45 | 26.58 | 32.09 |
| 20.3 | 40.6 | 60.9 | 81.2 | 21.10 | 38.03 | 26.48 | 29.16 |
| 20.8 | 41.6 | 62.4 | 83.2 | 22.06 | 36.02 | 25.58 | 26.61 |
| 21.3 | 42.6 | 63.9 | 85.2 | 22.81 | 34.34 | 24.87 | 28.30 |
| 21.8 | 43.6 | 65.4 | 87.2 | 22.65 | 33.71 | 24.54 | 31.72 |
| 22.3 | 44.6 | 66.9 | 89.2 | 22.74 | 32.85 | 23.70 | 34.08 |
| 22.8 | 45.6 | 68.4 | 91.2 | 23.52 | 31.52 | 22.51 | 30.82 |
| 23.3 | 46.6 | 69.9 | 93.2 | 23.48 | 31.20 | 22.00 | 31.13 |
| 23.8 | 47.6 | 71.4 | 95.2 | 25.05 | 30.20 | 20.29 | 28.76 |
| 24.0 | 48.0 | 72.0 | 96.0 | 25.70 | 30.79 | 18.32 | 28.93 |

* Harmonic Output below power level of X3 Output

| Frequency (GHz) | | | | Temperature = +25°C | | | |
|-----------------|-----------|-----------|-----------|------------------------------|-----------|-------------------------------|-----------|
| X1 Output | X2 Output | X3 Output | X4 Output | Conversion Loss X3 Output | X1 Output | Harmonic Output* X2 Output | X4 Output |
| 13.3 | 26.6 | 39.9 | 53.2 | 20.35 | 51.34 | 57.18 | 25.73 |
| 13.8 | 27.6 | 41.4 | 55.2 | 20.69 | 51.93 | 51.74 | 29.46 |
| 14.3 | 28.6 | 42.9 | 57.2 | 20.37 | 53.89 | 49.38 | 38.94 |
| 14.8 | 29.6 | 44.4 | 59.2 | 19.72 | 55.21 | 46.98 | 38.51 |
| 15.3 | 30.6 | 45.9 | 61.2 | 19.23 | 55.48 | 46.59 | 40.49 |
| 15.8 | 31.6 | 47.4 | 63.2 | 19.12 | 54.25 | 45.40 | 44.43 |
| 16.3 | 32.6 | 48.9 | 65.2 | 19.27 | 50.78 | 42.03 | 42.92 |
| 16.8 | 33.6 | 50.4 | 67.2 | 19.44 | 48.47 | 37.50 | 36.29 |
| 17.3 | 34.6 | 51.9 | 69.2 | 19.65 | 47.28 | 34.97 | 33.30 |
| 17.8 | 35.6 | 53.4 | 71.2 | 20.23 | 44.81 | 30.33 | 32.71 |
| 18.3 | 36.6 | 54.9 | 73.2 | 20.43 | 43.71 | 29.99 | 36.15 |
| 18.8 | 37.6 | 56.4 | 75.2 | 21.85 | 41.60 | 29.74 | 48.84 |
| 19.3 | 38.6 | 57.9 | 77.2 | 21.53 | 40.67 | 27.57 | 39.01 |
| 19.8 | 39.6 | 59.4 | 79.2 | 22.36 | 38.33 | 25.92 | 32.72 |
| 20.3 | 40.6 | 60.9 | 81.2 | 22.41 | 37.04 | 26.46 | 30.13 |
| 20.8 | 41.6 | 62.4 | 83.2 | 23.51 | 34.82 | 25.24 | 27.59 |
| 21.3 | 42.6 | 63.9 | 85.2 | 24.10 | 33.47 | 24.35 | 29.77 |
| 21.8 | 43.6 | 65.4 | 87.2 | 24.01 | 32.82 | 24.07 | 32.28 |
| 22.3 | 44.6 | 66.9 | 89.2 | 24.01 | 32.35 | 23.32 | 33.65 |
| 22.8 | 45.6 | 68.4 | 91.2 | 25.03 | 30.73 | 22.20 | 30.20 |
| 23.3 | 46.6 | 69.9 | 93.2 | 25.00 | 30.74 | 21.22 | 31.02 |
| 23.8 | 47.6 | 71.4 | 95.2 | 26.55 | 29.87 | 19.22 | 28.43 |
| 24.0 | 48.0 | 72.0 | 96.0 | 27.37 | 30.23 | 17.41 | 28.03 |

* Harmonic Output below power level of X3 Output

| Frequency (GHz) | | | | Temperature = +85°C | | | |
|-----------------|-----------|-----------|-----------|------------------------------|-----------|-------------------------------|-----------|
| X1 Output | X2 Output | X3 Output | X4 Output | Conversion Loss X3 Output | X1 Output | Harmonic Output* X2 Output | X4 Output |
| 13.3 | 26.6 | 39.9 | 53.2 | 21.60 | 50.27 | 54.27 | 26.57 |
| 13.8 | 27.6 | 41.4 | 55.2 | 21.93 | 50.84 | 49.93 | 30.35 |
| 14.3 | 28.6 | 42.9 | 57.2 | 21.64 | 52.83 | 47.90 | 39.26 |
| 14.8 | 29.6 | 44.4 | 59.2 | 21.26 | 53.85 | 45.50 | 38.78 |
| 15.3 | 30.6 | 45.9 | 61.2 | 20.66 | 54.03 | 45.53 | 43.37 |
| 15.8 | 31.6 | 47.4 | 63.2 | 20.45 | 52.74 | 44.39 | 49.49 |
| 16.3 | 32.6 | 48.9 | 65.2 | 20.63 | 49.20 | 41.04 | 43.61 |
| 16.8 | 33.6 | 50.4 | 67.2 | 20.79 | 47.03 | 36.78 | 36.08 |
| 17.3 | 34.6 | 51.9 | 69.2 | 21.19 | 45.58 | 34.08 | 32.45 |
| 17.8 | 35.6 | 53.4 | 71.2 | 21.66 | 43.18 | 29.78 | 32.51 |
| 18.3 | 36.6 | 54.9 | 73.2 | 21.78 | 42.25 | 29.49 | 35.89 |
| 18.8 | 37.6 | 56.4 | 75.2 | 22.98 | 40.49 | 29.00 | 47.01 |
| 19.3 | 38.6 | 57.9 | 77.2 | 22.92 | 39.35 | 27.02 | 39.55 |
| 19.8 | 39.6 | 59.4 | 79.2 | 23.70 | 37.08 | 25.30 | 33.75 |
| 20.3 | 40.6 | 60.9 | 81.2 | 23.84 | 35.76 | 25.93 | 30.89 |
| 20.8 | 41.6 | 62.4 | 83.2 | 24.89 | 33.62 | 24.68 | 28.73 |
| 21.3 | 42.6 | 63.9 | 85.2 | 25.43 | 32.45 | 23.71 | 31.17 |
| 21.8 | 43.6 | 65.4 | 87.2 | 25.41 | 31.78 | 23.42 | 32.75 |
| 22.3 | 44.6 | 66.9 | 89.2 | 25.39 | 31.53 | 22.83 | 33.46 |
| 22.8 | 45.6 | 68.4 | 91.2 | 26.50 | 29.87 | 21.62 | 30.03 |
| 23.3 | 46.6 | 69.9 | 93.2 | 26.43 | 30.25 | 20.45 | 30.70 |
| 23.8 | 47.6 | 71.4 | 95.2 | 27.98 | 29.47 | 18.26 | 28.23 |
| 24.0 | 48.0 | 72.0 | 96.0 | 28.87 | 29.72 | 16.75 | 27.47 |

* Harmonic Output below power level of X3 Output

Typical Performance Data

TEST CONDITION: RF IN = +19dBm

| Frequency (GHz) | | | | Temperature = -40°C | | | |
|-----------------|-----------|-----------|-----------|------------------------------|-----------|-------------------------------|-----------|
| X1 Output | X2 Output | X3 Output | X4 Output | Conversion Loss X3 Output | X1 Output | Harmonic Output* X2 Output | X4 Output |
| 13.3 | 26.6 | 39.9 | 53.2 | 19.69 | 52.83 | 57.81 | 24.88 |
| 13.8 | 27.6 | 41.4 | 55.2 | 20.04 | 53.68 | 51.65 | 27.99 |
| 14.3 | 28.6 | 42.9 | 57.2 | 19.62 | 55.72 | 49.57 | 38.09 |
| 14.8 | 29.6 | 44.4 | 59.2 | 18.75 | 57.43 | 46.88 | 37.99 |
| 15.3 | 30.6 | 45.9 | 61.2 | 18.29 | 57.29 | 46.44 | 38.89 |
| 15.8 | 31.6 | 47.4 | 63.2 | 18.40 | 55.31 | 45.50 | 40.98 |
| 16.3 | 32.6 | 48.9 | 65.2 | 18.46 | 51.71 | 41.88 | 41.31 |
| 16.8 | 33.6 | 50.4 | 67.2 | 18.59 | 49.03 | 37.29 | 34.84 |
| 17.3 | 34.6 | 51.9 | 69.2 | 18.62 | 47.96 | 34.75 | 32.55 |
| 17.8 | 35.6 | 53.4 | 71.2 | 19.34 | 45.47 | 29.80 | 30.93 |
| 18.3 | 36.6 | 54.9 | 73.2 | 19.62 | 44.28 | 29.47 | 33.58 |
| 18.8 | 37.6 | 56.4 | 75.2 | 21.27 | 41.75 | 29.90 | 39.66 |
| 19.3 | 38.6 | 57.9 | 77.2 | 20.54 | 41.30 | 28.19 | 44.13 |
| 19.8 | 39.6 | 59.4 | 79.2 | 21.56 | 38.88 | 26.64 | 34.91 |
| 20.3 | 40.6 | 60.9 | 81.2 | 21.73 | 37.50 | 26.35 | 30.34 |
| 20.8 | 41.6 | 62.4 | 83.2 | 22.66 | 35.51 | 25.26 | 27.49 |
| 21.3 | 42.6 | 63.9 | 85.2 | 23.43 | 33.86 | 24.66 | 28.90 |
| 21.8 | 43.6 | 65.4 | 87.2 | 23.27 | 33.36 | 24.53 | 32.28 |
| 22.3 | 44.6 | 66.9 | 89.2 | 23.34 | 32.62 | 23.81 | 34.32 |
| 22.8 | 45.6 | 68.4 | 91.2 | 24.08 | 31.39 | 22.67 | 30.76 |
| 23.3 | 46.6 | 69.9 | 93.2 | 24.03 | 31.20 | 22.04 | 30.95 |
| 23.8 | 47.6 | 71.4 | 95.2 | 25.44 | 30.31 | 20.56 | 28.50 |
| 24.0 | 48.0 | 72.0 | 96.0 | 26.01 | 30.94 | 18.67 | 28.72 |

* Harmonic Output below power level of X3 Output

| Frequency (GHz) | | | | Temperature = +25°C | | | |
|-----------------|-----------|-----------|-----------|------------------------------|-----------|-------------------------------|-----------|
| X1 Output | X2 Output | X3 Output | X4 Output | Conversion Loss X3 Output | X1 Output | Harmonic Output* X2 Output | X4 Output |
| 13.3 | 26.6 | 39.9 | 53.2 | 21.00 | 51.42 | 54.78 | 25.97 |
| 13.8 | 27.6 | 41.4 | 55.2 | 21.33 | 52.19 | 49.88 | 29.00 |
| 14.3 | 28.6 | 42.9 | 57.2 | 21.01 | 54.22 | 48.16 | 38.76 |
| 14.8 | 29.6 | 44.4 | 59.2 | 20.34 | 55.66 | 45.51 | 38.19 |
| 15.3 | 30.6 | 45.9 | 61.2 | 19.87 | 55.50 | 45.57 | 40.99 |
| 15.8 | 31.6 | 47.4 | 63.2 | 19.75 | 53.76 | 44.82 | 44.83 |
| 16.3 | 32.6 | 48.9 | 65.2 | 19.89 | 50.03 | 41.28 | 41.69 |
| 16.8 | 33.6 | 50.4 | 67.2 | 20.05 | 47.52 | 36.80 | 34.74 |
| 17.3 | 34.6 | 51.9 | 69.2 | 20.27 | 46.28 | 34.20 | 31.86 |
| 17.8 | 35.6 | 53.4 | 71.2 | 20.86 | 43.85 | 29.49 | 31.19 |
| 18.3 | 36.6 | 54.9 | 73.2 | 21.03 | 42.83 | 29.33 | 33.70 |
| 18.8 | 37.6 | 56.4 | 75.2 | 22.43 | 40.82 | 29.63 | 39.23 |
| 19.3 | 38.6 | 57.9 | 77.2 | 22.14 | 39.96 | 27.63 | 43.19 |
| 19.8 | 39.6 | 59.4 | 79.2 | 22.98 | 37.76 | 26.02 | 35.39 |
| 20.3 | 40.6 | 60.9 | 81.2 | 23.08 | 36.50 | 26.35 | 31.22 |
| 20.8 | 41.6 | 62.4 | 83.2 | 24.15 | 34.28 | 24.96 | 28.50 |
| 21.3 | 42.6 | 63.9 | 85.2 | 24.77 | 32.98 | 24.19 | 30.46 |
| 21.8 | 43.6 | 65.4 | 87.2 | 24.67 | 32.45 | 24.08 | 32.89 |
| 22.3 | 44.6 | 66.9 | 89.2 | 24.65 | 32.09 | 23.43 | 33.89 |
| 22.8 | 45.6 | 68.4 | 91.2 | 25.61 | 30.55 | 22.35 | 30.23 |
| 23.3 | 46.6 | 69.9 | 93.2 | 25.59 | 30.71 | 21.38 | 30.91 |
| 23.8 | 47.6 | 71.4 | 95.2 | 26.97 | 29.91 | 19.63 | 28.28 |
| 24.0 | 48.0 | 72.0 | 96.0 | 27.73 | 30.32 | 17.86 | 27.87 |

* Harmonic Output below power level of X3 Output

| Frequency (GHz) | | | | Temperature = +85°C | | | |
|-----------------|-----------|-----------|-----------|------------------------------|-----------|-------------------------------|-----------|
| X1 Output | X2 Output | X3 Output | X4 Output | Conversion Loss X3 Output | X1 Output | Harmonic Output* X2 Output | X4 Output |
| 13.3 | 26.6 | 39.9 | 53.2 | 22.37 | 50.14 | 52.08 | 26.82 |
| 13.8 | 27.6 | 41.4 | 55.2 | 22.70 | 50.84 | 48.02 | 29.89 |
| 14.3 | 28.6 | 42.9 | 57.2 | 22.41 | 52.98 | 46.51 | 39.04 |
| 14.8 | 29.6 | 44.4 | 59.2 | 22.03 | 53.96 | 43.81 | 38.52 |
| 15.3 | 30.6 | 45.9 | 61.2 | 21.45 | 53.74 | 44.30 | 44.09 |
| 15.8 | 31.6 | 47.4 | 63.2 | 21.19 | 52.10 | 43.75 | 49.61 |
| 16.3 | 32.6 | 48.9 | 65.2 | 21.35 | 48.45 | 40.34 | 41.22 |
| 16.8 | 33.6 | 50.4 | 67.2 | 21.50 | 46.08 | 36.16 | 34.74 |
| 17.3 | 34.6 | 51.9 | 69.2 | 21.90 | 44.58 | 33.44 | 31.27 |
| 17.8 | 35.6 | 53.4 | 71.2 | 22.38 | 42.19 | 29.04 | 31.21 |
| 18.3 | 36.6 | 54.9 | 73.2 | 22.48 | 41.32 | 28.99 | 33.80 |
| 18.8 | 37.6 | 56.4 | 75.2 | 23.65 | 39.69 | 28.99 | 39.44 |
| 19.3 | 38.6 | 57.9 | 77.2 | 23.61 | 38.57 | 27.02 | 43.23 |
| 19.8 | 39.6 | 59.4 | 79.2 | 24.41 | 36.45 | 25.30 | 36.56 |
| 20.3 | 40.6 | 60.9 | 81.2 | 24.58 | 35.17 | 25.75 | 32.21 |
| 20.8 | 41.6 | 62.4 | 83.2 | 25.63 | 33.01 | 24.34 | 29.75 |
| 21.3 | 42.6 | 63.9 | 85.2 | 26.18 | 31.91 | 23.48 | 32.07 |
| 21.8 | 43.6 | 65.4 | 87.2 | 26.14 | 31.35 | 23.33 | 33.51 |
| 22.3 | 44.6 | 66.9 | 89.2 | 26.09 | 31.21 | 22.82 | 33.75 |
| 22.8 | 45.6 | 68.4 | 91.2 | 27.15 | 29.62 | 21.63 | 30.15 |
| 23.3 | 46.6 | 69.9 | 93.2 | 27.07 | 30.15 | 20.56 | 30.60 |
| 23.8 | 47.6 | 71.4 | 95.2 | 28.45 | 29.45 | 18.62 | 28.15 |
| 24.0 | 48.0 | 72.0 | 96.0 | 29.29 | 29.74 | 17.11 | 27.34 |

* Harmonic Output below power level of X3 Output

Typical Performance Data

TEST CONDITION: RF IN = +12 to 16dBm

| Frequency (GHz) | | | | Temperature = +25°C | | |
|-----------------|-----------|-----------|-----------|---------------------|-------|-------|
| X1 Output | X2 Output | X3 Output | X4 Output | Conversion Loss | | |
| | | | | 12dBm | 13dBm | 14dBm |
| 13.3 | 26.6 | 39.9 | 53.2 | 20.34 | 19.92 | 19.74 |
| 13.8 | 27.6 | 41.4 | 55.2 | 20.69 | 20.24 | 20.06 |
| 14.3 | 28.6 | 42.9 | 57.2 | 21.13 | 20.48 | 20.15 |
| 14.8 | 29.6 | 44.4 | 59.2 | 21.16 | 20.24 | 19.75 |
| 15.3 | 30.6 | 45.9 | 61.2 | 20.81 | 19.78 | 19.23 |
| 15.8 | 31.6 | 47.4 | 63.2 | 21.80 | 20.31 | 19.51 |
| 16.3 | 32.6 | 48.9 | 65.2 | 21.89 | 20.32 | 19.50 |
| 16.8 | 33.6 | 50.4 | 67.2 | 22.68 | 20.84 | 19.82 |
| 17.3 | 34.6 | 51.9 | 69.2 | 23.67 | 21.52 | 20.23 |
| 17.8 | 35.6 | 53.4 | 71.2 | 24.80 | 22.43 | 20.98 |
| 18.3 | 36.6 | 54.9 | 73.2 | 26.49 | 23.91 | 22.13 |
| 18.8 | 37.6 | 56.4 | 75.2 | 28.08 | 25.20 | 23.37 |
| 19.3 | 38.6 | 57.9 | 77.2 | 26.99 | 24.30 | 22.65 |
| 19.8 | 39.6 | 59.4 | 79.2 | 27.53 | 25.05 | 23.40 |
| 20.3 | 40.6 | 60.9 | 81.2 | 26.99 | 24.75 | 23.38 |
| 20.8 | 41.6 | 62.4 | 83.2 | 28.41 | 26.14 | 24.72 |
| 21.3 | 42.6 | 63.9 | 85.2 | 28.40 | 26.43 | 25.18 |
| 21.8 | 43.6 | 65.4 | 87.2 | 28.18 | 26.37 | 25.18 |
| 22.3 | 44.6 | 66.9 | 89.2 | 27.90 | 26.45 | 25.45 |
| 22.8 | 45.6 | 68.4 | 91.2 | 28.48 | 27.31 | 26.45 |
| 23.3 | 46.6 | 69.9 | 93.2 | 29.79 | 28.67 | 27.75 |
| 23.8 | 47.6 | 71.4 | 95.2 | 31.58 | 30.54 | 29.63 |
| 24.0 | 48.0 | 72.0 | 96.0 | 32.83 | 31.77 | 30.83 |

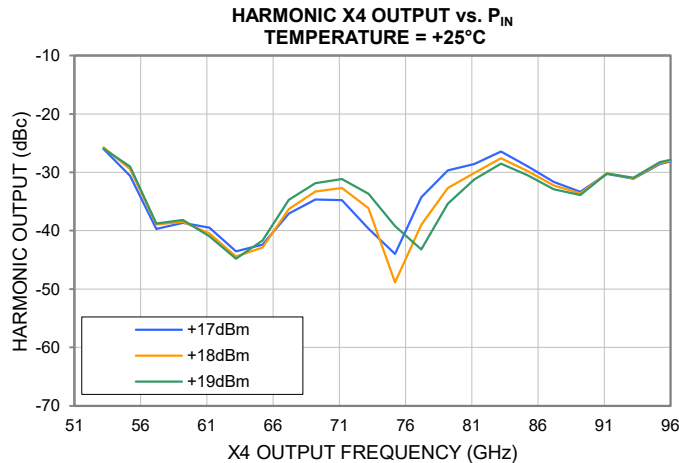
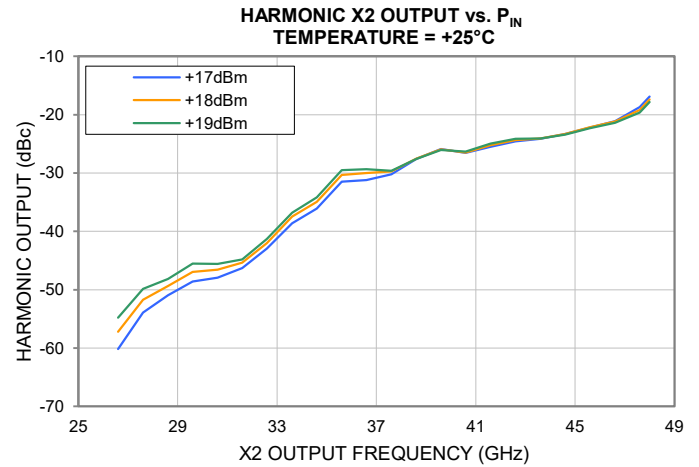
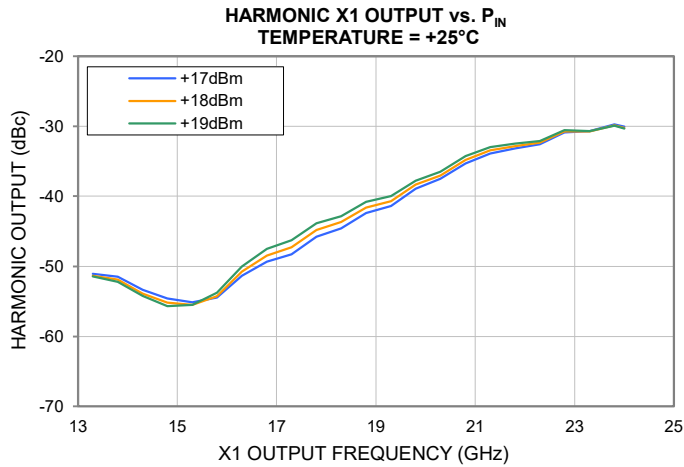
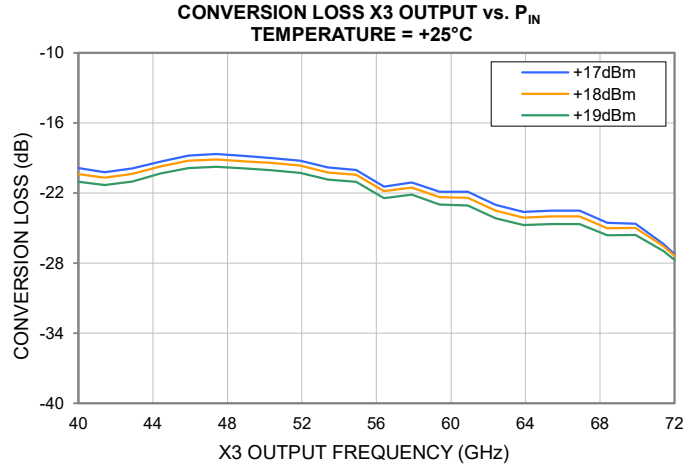
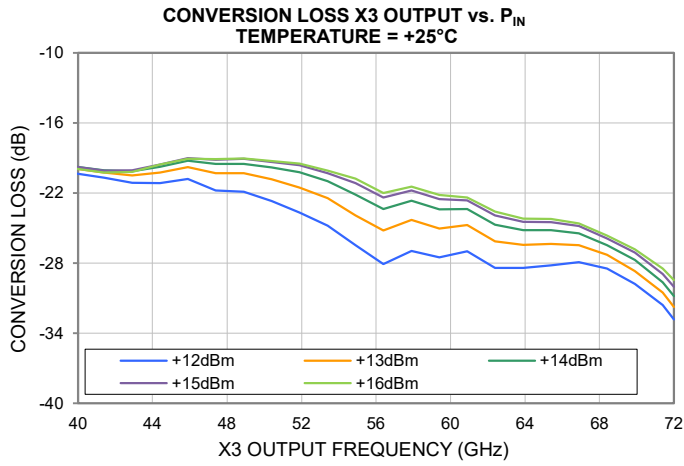
* Harmonic Output below power level of X3 Output

| Frequency (GHz) | | | | Temperature = +25°C | |
|-----------------|-----------|-----------|-----------|---------------------|-------|
| X1 Output | X2 Output | X3 Output | X4 Output | Conversion Loss | |
| | | | | 15dBm | 16dBm |
| 13.3 | 26.6 | 39.9 | 53.2 | 19.76 | 19.92 |
| 13.8 | 27.6 | 41.4 | 55.2 | 20.08 | 20.24 |
| 14.3 | 28.6 | 42.9 | 57.2 | 20.08 | 20.20 |
| 14.8 | 29.6 | 44.4 | 59.2 | 19.55 | 19.58 |
| 15.3 | 30.6 | 45.9 | 61.2 | 19.02 | 19.05 |
| 15.8 | 31.6 | 47.4 | 63.2 | 19.16 | 19.10 |
| 16.3 | 32.6 | 48.9 | 65.2 | 19.09 | 19.03 |
| 16.8 | 33.6 | 50.4 | 67.2 | 19.34 | 19.25 |
| 17.3 | 34.6 | 51.9 | 69.2 | 19.63 | 19.48 |
| 17.8 | 35.6 | 53.4 | 71.2 | 20.30 | 20.10 |
| 18.3 | 36.6 | 54.9 | 73.2 | 21.16 | 20.76 |
| 18.8 | 37.6 | 56.4 | 75.2 | 22.40 | 21.99 |
| 19.3 | 38.6 | 57.9 | 77.2 | 21.79 | 21.45 |
| 19.8 | 39.6 | 59.4 | 79.2 | 22.51 | 22.17 |
| 20.3 | 40.6 | 60.9 | 81.2 | 22.64 | 22.39 |
| 20.8 | 41.6 | 62.4 | 83.2 | 23.91 | 23.59 |
| 21.3 | 42.6 | 63.9 | 85.2 | 24.46 | 24.18 |
| 21.8 | 43.6 | 65.4 | 87.2 | 24.47 | 24.21 |
| 22.3 | 44.6 | 66.9 | 89.2 | 24.84 | 24.61 |
| 22.8 | 45.6 | 68.4 | 91.2 | 25.88 | 25.64 |
| 23.3 | 46.6 | 69.9 | 93.2 | 27.11 | 26.82 |
| 23.8 | 47.6 | 71.4 | 95.2 | 28.94 | 28.49 |
| 24.0 | 48.0 | 72.0 | 96.0 | 30.03 | 29.46 |

* Harmonic Output below power level of X3 Output

Typical Performance Curves

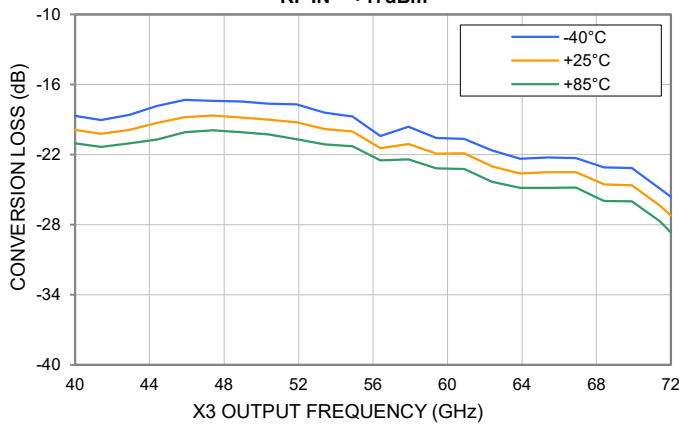
Note: Harmonics data is presented as the harmonic of input frequency below the power of F3



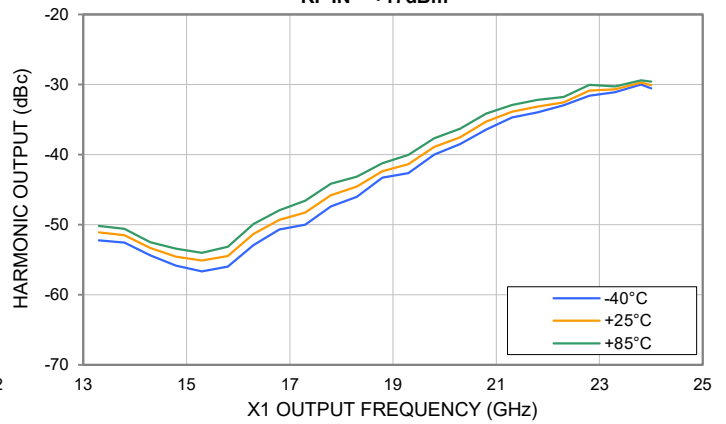
Typical Performance Curves

Note: Harmonics data is presented as the harmonic of input frequency below the power of F3

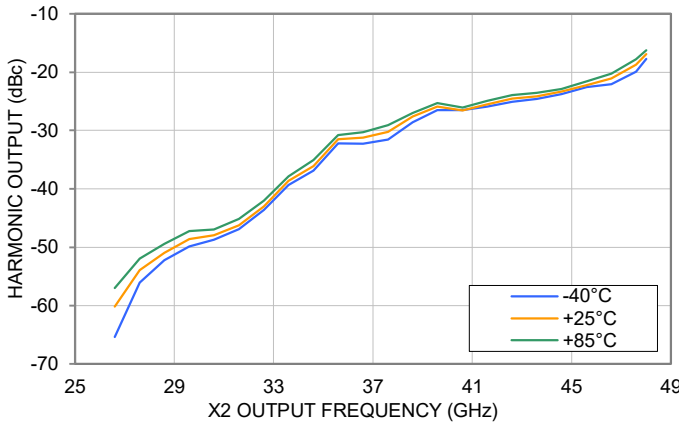
CONVERSION LOSS X3 OUTPUT vs. TEMPERATURE
RF IN = +17dBm



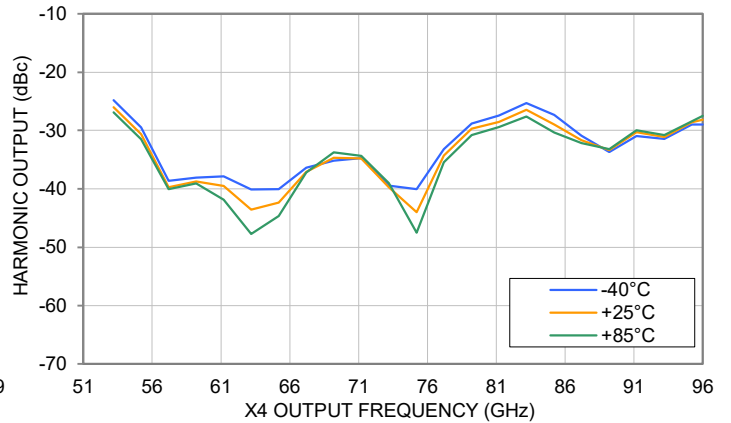
HARMONIC X1 OUTPUT vs. TEMPERATURE
RF IN = +17dBm



HARMONIC X2 OUTPUT vs. TEMPERATURE
RF IN = +17dBm

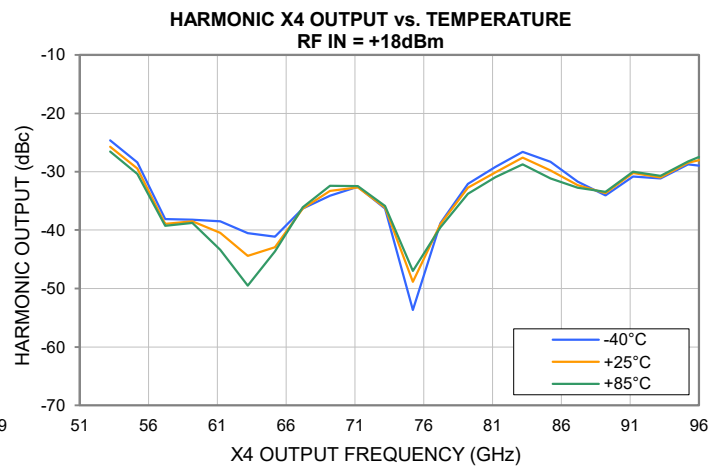
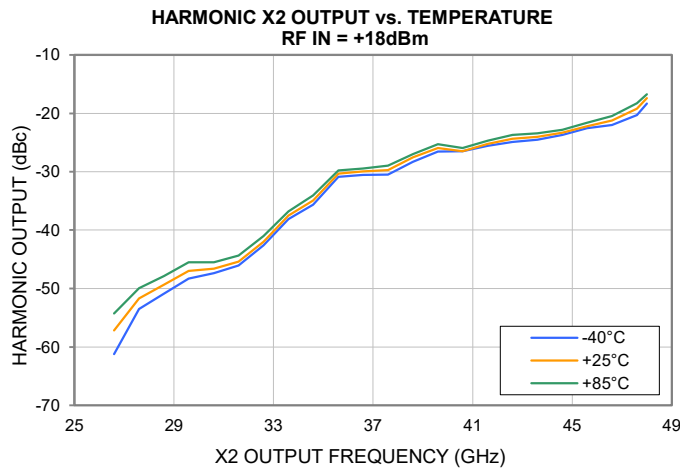
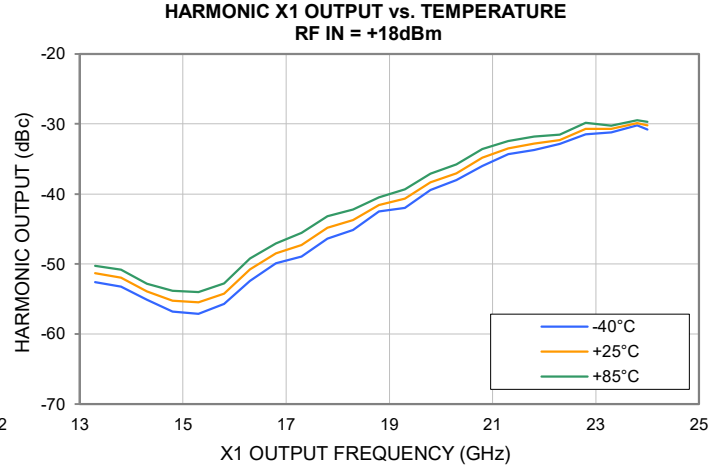
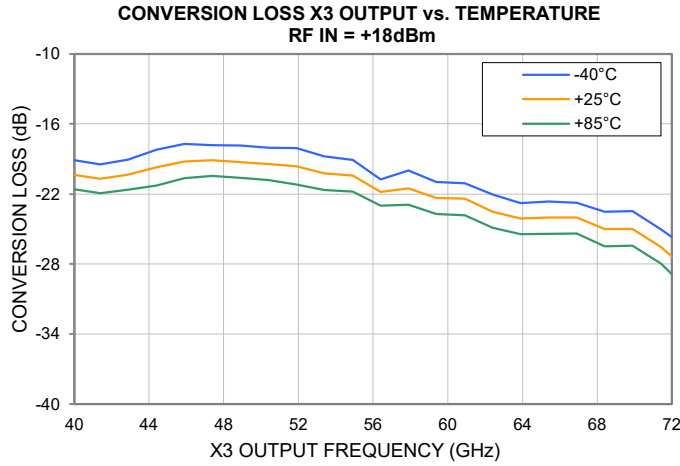


HARMONIC X4 OUTPUT vs. TEMPERATURE
RF IN = +17dBm



Typical Performance Curves

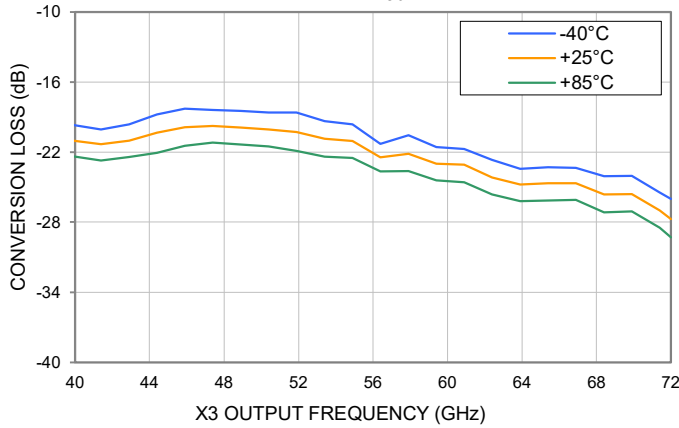
Note: Harmonics data is presented as the harmonic of input frequency below the power of F3



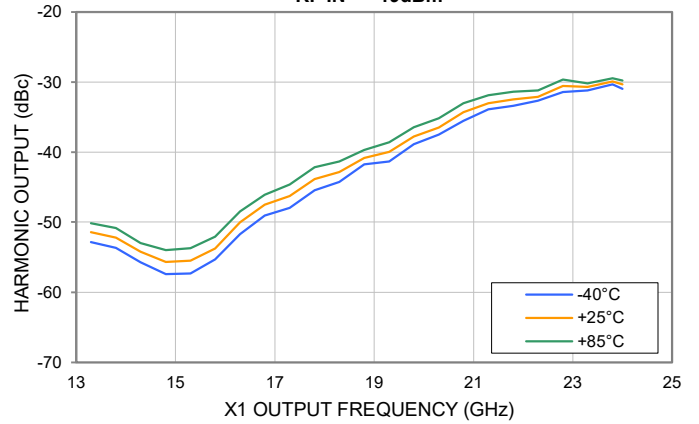
Typical Performance Curves

Note: Harmonics data is presented as the harmonic of input frequency below the power of F3

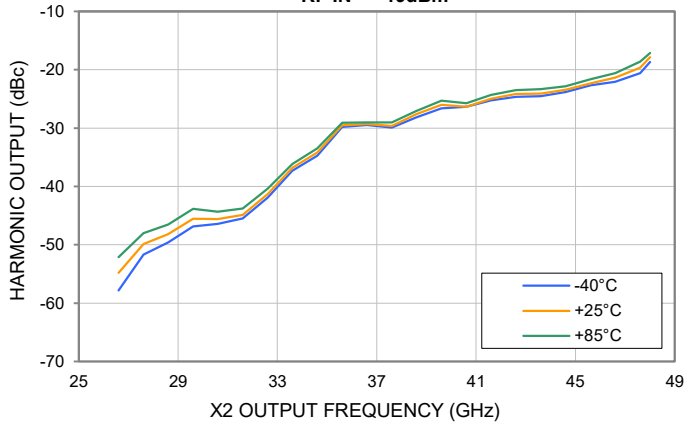
CONVERSION LOSS X3 OUTPUT vs. TEMPERATURE
RF IN = +19dBm



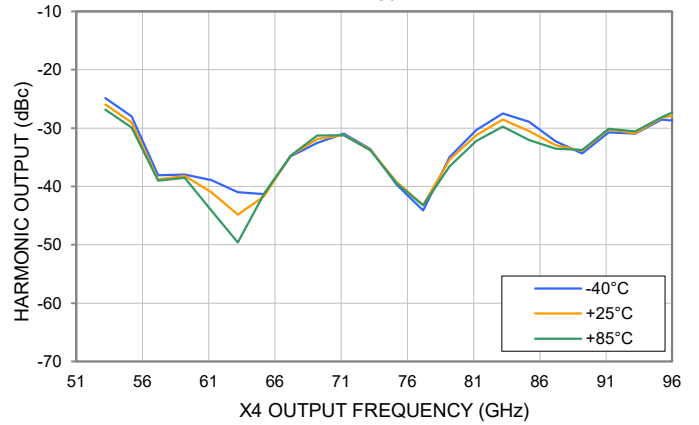
HARMONIC X1 OUTPUT vs. TEMPERATURE
RF IN = +19dBm



HARMONIC X2 OUTPUT vs. TEMPERATURE
RF IN = +19dBm



HARMONIC X4 OUTPUT vs. TEMPERATURE
RF IN = +19dBm



All Mini-Circuits products are manufactured under exacting quality assurance and control standards, and are capable of meeting published specifications after being subjected to any or all of the following physical and environmental test.

| Specification | Test/Inspection Condition | Reference/Spec |
|--------------------------------|--|--------------------------------------|
| Operating Temperature | -40° to 85° C or -40° to 105° C or -55° to 105° C or -45° to 105° C Ambient Environment | Refer to Individual Model Data Sheet |
| Storage Environment (Die) | -65° to 150°C | Individual Model Data Sheet |
| Storage Environment(Packaging) | -40° to 70°C and 40 to 60% humidity (In Factory Shipped Package) | |