

Ultra Low Noise, Medium Current

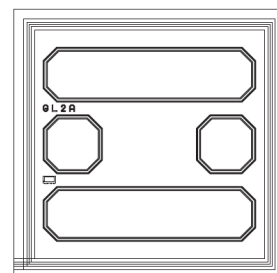
# E-PHEMT Transistor Die

TAV2-14LN-D+

50Ω 0.05 to 10 GHz

## The Big Deal

- Low Noise Figure, 0.6 dB typ. at 6 GHz, 2V
- High Gain, 16.4 dB typ. at 6 GHz, 4V
- High OIP3, +30.9 dBm typ. at 6 GHz, 4V
- High P1dB, 18.8 dBm typ. at 6 GHz, 4V



## Product Overview

Mini-Circuits' TAV2-14LN-D+ is a MMIC E-PHEMT\* transistor die with an operating frequency range from 0.05 to 10 GHz. This model combines high gain with extremely low noise figure, resulting in lower overall system noise. Low NF and IP3 performance make it an ideal choice for sensitive receivers in communications systems. This model requires external biasing and matching.

## Key Features

| Feature  | Advantages   |
|--|--|
| Wideband, 0.05 to 10 GHz<br>Usable to 12 GHz   | A single device covers many wireless communications bands including cellular, ISM, GSM, WCDMA, WiMax, WLAN, 5G and more.   |
| High IP3 vs. DC power consumption <ul style="list-style-type: none"><li>• +30.9 dBm at 6 GHz, 4V</li><li>• +33.2 dBm at 12 GHz, 4V</li></ul> | The TAV2-14LN-D+ matches industry leading IP3 performance relative to device size and power consumption. Enhanced linearity over a broad frequency range makes the device ideal for use in: <ul style="list-style-type: none"><li>• Driver amplifiers for complex waveform up converter paths</li><li>• Drivers in linearized transmit systems</li></ul> |
| Combines high gain (16.4 dB) with very low Noise Figure (0.7 dB)   | The unique combination of high gain and low Noise Figure results in lower overall system noise.  |
| Unpackaged Die   | Enables the user to integrate the amplifier directly into hybrids  |

\* Enhancement mode Pseudomorphic High Electron Mobility Transistor.



# Ultra Low Noise, Medium Current E-PHEMT Transistor Die

## TAV2-14LN-D+

### Product Features

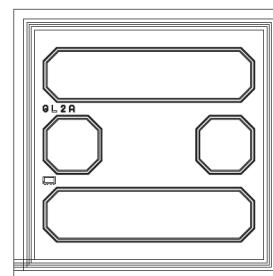
- Low Noise Figure, 0.6 dB typ. at 6 GHz, 2V,
- Gain, 16.4 dB typ. at 6 GHz, 4V
- High Output IP3, +30.9 dBm at 6 GHz, 4V
- Output Power at 1dB comp., +18.8 dBm at 6 GHz, 4V
- External biasing and matching required
- Usable to 12 GHz

### Typical Applications

- 5G
- Cellular
- ISM
- GSM
- WCDMA
- WiMax
- WLAN
- UNII and HIPERLAN

### General Description

Mini-Circuits' TAV2-14LN-D+ is a MMIC E-PHEMT\* transistor die with an operating frequency range from 0.05 to 10 GHz. This model combines high gain with extremely low noise figure, resulting in lower overall system noise. Low NF and IP3 performance make it an ideal choice for sensitive receivers in communications systems. This model requires external biasing and matching.

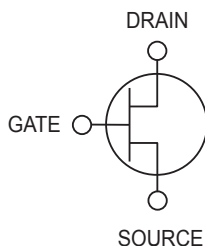


#### +RoHS Compliant

The +Suffix identifies RoHS Compliance. See our web site for RoHS Compliance methodologies and qualifications

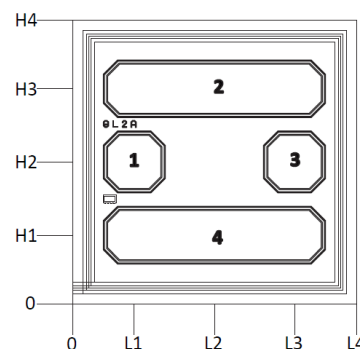
Ordering Information: Refer to Last Page

### Simplified Schematic and Pad description



| Pad#                | Description                          |
|---------------------|--------------------------------------|
| 1                   | GATE used for RF-IN                  |
| 2,4 & bottom of die | SOURCE Terminal, connected to ground |
| 3                   | DRAIN used for RF-OUT                |

### Bonding Pad Position



Dimensions in  $\mu\text{m}$ , Typical

| L1 | L2  | L3  | L4  | H1 | H2  | H3  | H4  |
|----|-----|-----|-----|----|-----|-----|-----|
| 87 | 200 | 313 | 400 | 97 | 200 | 303 | 400 |

| Thickness | Die size  | Pad Size 1 & 3 | Pad size 2 & 4 |
|-----------|-----------|----------------|----------------|
| 100       | 400 x 400 | 75 x 75        | 301 x 69       |

Electrical Specifications at  $T_{AMB}=25^{\circ}\text{C}$ 

| Symbol                   | Parameter               | Condition   | Min. | Typ. | Max. | Units         |
|--------------------------|-------------------------|---|------|------|------|---------------|
| <b>DC Specifications</b> |                         |   |      |      |      |               |
| $V_{TH}$                 | Threshold Voltage       | $V_{DS}=4\text{V}, I_{DS}=4\text{ mA}$  |      | 0.37 |      | V             |
| $I_{DSS}$                | Saturated Drain Current | $V_{DS}=4\text{V}, V_{GS}=0\text{ V}$   | —    | 2.0  | —    | $\mu\text{A}$ |
| $G_M$                    | Transconductance        | $V_{DS}=4\text{V}, G_M=\Delta I_{DS}/\Delta V_{GS}$<br>$\Delta V_{GS}=V_{GS2}-V_{GS1}$<br>$V_{GS2}=0.7\text{V}, V_{GS1}=0.6\text{V}$<br>$\Delta I_{DS}=(I_{DS}\text{ at } V_{GS2})-(I_{DS}\text{ at } V_{GS1})$ | —    | 192  | —    | mS            |
| $I_{GSS}$                | Gate leakage Current    | $V_{GD}=V_{GS}=-3\text{V}$  | —    | 1.0  |      | $\mu\text{A}$ |

| <b>RF &amp; DC Specifications, <math>Z_0=50\text{ Ohms}</math></b> |                 |  |      |      |  |       |
|--|-----------------|--|------|------|--|-------|
| Parameter  | Condition (GHz) | $V_{DS}=4\text{V}^1$ ,<br>$I_{DS}=40\text{mA}$ |      |      | $V_{DS}=2\text{V}^1$<br>$I_{DS}=20\text{mA}$ | Units |
|  |                 | Min.   | Typ. | Max. | Typ.   |       |
| Gain   | 0.05            |  | 23.4 |      | 22   | dB    |
|  | 6               |  | 16.4 |      | 15.9   |       |
|  | 8               |  | 13.9 |      | 13.3   |       |
|  | 10              |  | 11.8 |      | 11.3   |       |
|  | 12              |  | 10.2 |      | 10   |       |
| Input Return Loss  | 0.05            |  | —    |      | —  | dB    |
|  | 6               |  | 7    |      | 6  |       |
|  | 8               |  | 7    |      | 6  |       |
|  | 10              |  | 7    |      | 7  |       |
|  | 12              |  | 8    |      | 7  |       |
| Output Return Loss   | 0.05            |  | 5    |      | 5  | dB    |
|  | 6               |  | 13   |      | 13   |       |
|  | 8               |  | 20   |      | 17   |       |
|  | 10              |  | 20   |      | 17   |       |
|  | 12              |  | 19   |      | 16   |       |
| P1dB <sup>2</sup>  | 0.05            |  | 17.7 |      | 13.3   | dBm   |
|  | 6               |  | 18.8 |      | 13.1   |       |
|  | 8               |  | 19.1 |      | 13.4   |       |
|  | 10              |  | 19.4 |      | 13.5   |       |
|  | 12              |  | 19.1 |      | 13   |       |
| OIP3<br>Pout=5dBm/Tone   | 0.05            |  | 27.1 |      | 22.8   | dBm   |
|  | 6               |  | 30.9 |      | 24.9   |       |
|  | 8               |  | 31.6 |      | 25.9   |       |
|  | 10              |  | 33.0 |      | 28.5   |       |
|  | 12              |  | 33.2 |      | 29.0   |       |
| Noise Figure   | 0.05            |  | 2.5  |      | 0.7  | dB    |
|  | 6               |  | 0.7  |      | 0.6  |       |
|  | 8               |  | 0.7  |      | 0.6  |       |
|  | 10              |  | 0.8  |      | 0.7  |       |
|  | 12              |  | 1.0  |      | 0.8  |       |
| $I_{DS}$   | DC              |  | 40   |      | 20   | mA    |
| $V_{GS}$   | DC              | 0.44   | 0.65 | 0.72 | 0.58   | V     |

1. Die is packaged in 2x2 mm, 6-lead MCLP package and soldered on TB-TAV2-14LN+. See Fig. 1

2. Drain current bias allowed to increase during compression measurement.

Absolute Maximum Ratings<sup>3</sup>

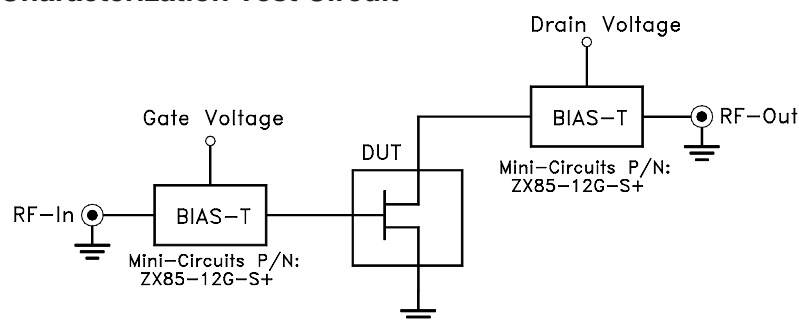
| Symbol        | Parameter                          | Max.                                  | Units         |
|---------------|------------------------------------|---------------------------------------|---------------|
| $V_{DS}^4$    | Drain-Source Voltage               | 5                                     | V             |
| $V_{GS}^4$    | Gate-Source Voltage at $V_{DS}=4V$ | -5 & 1                                | V             |
| $I_{DS}^4$    | Drain Current at $V_{DS}=4V$       | 65                                    | mA            |
| $I_{GS}$      | Gate Current                       | 15                                    | $\mu A$       |
| $P_{DISS}$    | Total Dissipated Power             | 325                                   | mW            |
| $P_{IN}^5$    | RF Input Power                     | 18 (5-minute max.)<br>15 (continuous) | dBm           |
| $T_{CH}$      | Channel Temperature                | 150                                   | $^{\circ}C$   |
| $T_{OP}$      | Operating Temperature              | -40 to 85                             | $^{\circ}C$   |
| $T_{STD}$     | Storage Temperature                | -65 to 150                            | $^{\circ}C$   |
| $\theta_{JC}$ | Thermal Resistance                 | 170                                   | $^{\circ}C/W$ |

3. Operation of this device above any one of these parameters may cause permanent damage.

4. Assumes DC quiescent conditions.

5.  $I_{GS}$  is limited to 15 $\mu A$  during test.

## Characterization Test Circuit

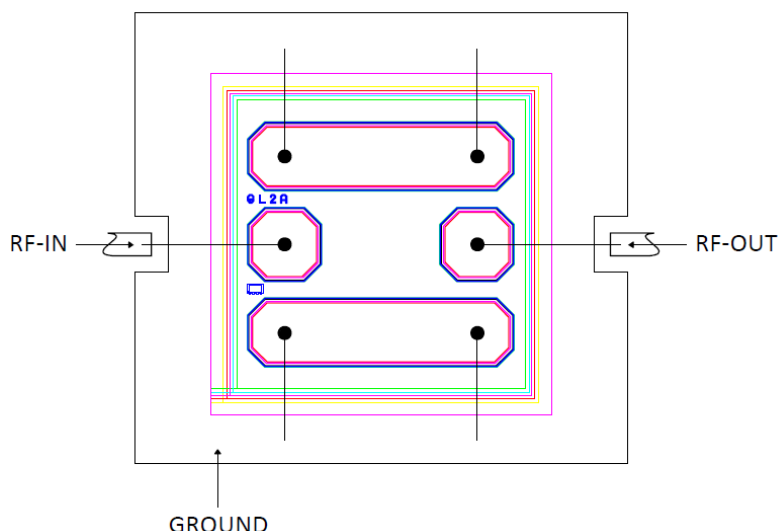


**Fig 1. Block Diagram of Test Circuit used for characterization. (DUT is soldered on Mini-Circuits Test Board TB-TAV2-14LN+)** Gain, Output power at 1dB compression (P1dB), Noise Figure and output IP3 (OIP3) are measured using Agilent's Microwave Network Analyzer N5242A PNA-X.

## Conditions:

1. Drain voltage (with reference to source,  $V_{DS}$ )= 2V&4V as shown.
2. Gate Voltage (with reference to source,  $V_{GS}$ ) is set to obtain desired Drain-Source current ( $I_{DS}$ ) as shown in graphs or specification table.
3. Gain:  $P_{in} = -25dBm$
4. Output IP3 (OIP3): Two tones, spaced 1 MHz apart, 5 dBm/tone at output.
5. No external matching components used.

## Assembly Diagram



## Assembly and Handling Procedure

1. Storage  
Dice should be stored in a dry nitrogen purged desiccators or equivalent.
2. ESD  
MMIC E-PHEMT transistor dice are susceptible to electrostatic and mechanical damage. Die are supplied in antistatic protected material, which should be opened in clean room conditions at an appropriately grounded anti-static workstation. Devices need careful handling using correctly designed collets, vacuum pickup tips or sharp antistatic tweezers to deter ESD damage to dice.
3. Die Attach  
The die mounting surface must be clean and flat. Using conductive silver filled epoxy, recommended epoxies are DieMat DM6030HK-PT/H579 or Ablestik 84-1LMISR4. Apply sufficient epoxy to meet required epoxy bond line thickness, epoxy fillet height and epoxy coverage around total die periphery. Parts shall be cured in a nitrogen filled atmosphere per manufacturer's cure condition. It is recommended to use antistatic die pick up tools only.
4. Wire Bonding  
Bond pad openings in the surface passivation above the bond pads are provided to allow wire bonding to the dice gold bond pads. Thermosonic bonding is used with minimized ultrasonic content. Bond force, time, ultrasonic power and temperature are all critical parameters. Suggested wire is pure gold, 1 mil diameter. Bonds must be made from the bond pads on the die to the package or substrate. All bond wires should be kept as short as low as reasonable to minimize performance degradation due to undesirable series inductance.

**Additional Detailed Technical Information***additional information is available on our dash board.*

|  |  |               |
|--|--|---------------|
| Performance Data                       | Data Table   |               |
|  | Swept Graphs   |               |
|  | S-Parameter (S2P Files) Data Set                     |               |
| Case Style                             | Die  |               |
| Die Ordering and packaging information | Quantity, Package                                    | Model No.     |
|  | Small, Gel - Pak: 5,10,50,100 KGD*                   | TAV2-14LN-DG+ |
|  | Medium†, Partial wafer: KGD*<3721                    | TAV2-14LN-DP+ |
|  | Large†, Full Wafer                                   | TAV2-14LN-DF+ |
|  | †Available upon request contact sales representative |               |
|  | Refer to <a href="#">AN-60-067</a>                   |               |
| Environmental Ratings                  | ENV80  |               |

\*Known Good Dice ("KGD") means that the dice in question have been subjected to Mini-Circuits DC test performance criteria and measurement instructions and that the parametric data of such dice fall within a predefined range. While DC testing is not definitive, it does help to provide a higher degree of confidence that dice are capable of meeting typical RF electrical parameters specified by Mini-Circuits.

**ESD Rating\*\***

Human Body Model (HBM): Class 0 (pass 50V) in accordance with ANSI/ESD STM 5.1 - 2001

\*\* Tested in industry standard 2x2 mm, 6-Lead MCLP package.

**Additional Notes**

- 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***Definitions:**

Input Return Loss = -S11 (dB)

Gain(Power Gain) = S21 (dB)

Reverse Isolation = -S12 (dB)

Output Return Loss = -S22 (dB)

TEST CONDITIONS: Vd = 2.00V, Id = 20mA @ Temperature = +25°C

| FREQ  | Gain  | Isolation | Input<br>Return<br>Loss | Output<br>Return<br>Loss | Stability |         | IP-3<br>Output | 1dB<br>Comp.<br>Output | Noise<br>Figure |
|-------|-------|-----------|-------------------------|--------------------------|-----------|---------|----------------|------------------------|-----------------|
| (MHz) | (dB)  | (dB)      | (dB)                    | (dB)                     | K         | Measure | (dBm)          | (dBm)                  | (dB)            |
| 100   | 22.12 | 51.36     | 0.00                    | 4.38                     | 0.01      | 1.27    | 24.22          | 13.03                  | 0.65            |
| 200   | 22.10 | 45.16     | 0.02                    | 4.41                     | 0.03      | 1.27    | 24.10          | 12.96                  | 0.58            |
| 300   | 22.06 | 41.41     | 0.04                    | 4.44                     | 0.06      | 1.27    | 24.38          | 13.24                  | 0.64            |
| 400   | 22.01 | 39.22     | 0.07                    | 4.47                     | 0.06      | 1.27    | 24.50          | 12.81                  | 0.69            |
| 500   | 21.95 | 37.29     | 0.11                    | 4.52                     | 0.09      | 1.26    | 24.04          | 12.88                  | 0.68            |
| 1000  | 21.55 | 31.62     | 0.44                    | 4.84                     | 0.18      | 1.23    | 23.41          | 13.30                  | 0.64            |
| 2000  | 20.28 | 26.75     | 1.44                    | 5.77                     | 0.34      | 1.14    | 23.19          | 12.84                  | 0.67            |
| 3000  | 18.93 | 24.38     | 2.51                    | 6.64                     | 0.47      | 1.07    | 23.52          | 12.67                  | 0.76            |
| 4000  | 17.82 | 22.73     | 3.60                    | 7.68                     | 0.57      | 1.01    | 23.67          | 12.76                  | 0.72            |
| 5000  | 16.89 | 21.36     | 4.77                    | 9.38                     | 0.67      | 0.97    | 23.76          | 13.15                  | 0.67            |
| 6000  | 15.88 | 20.35     | 5.89                    | 12.39                    | 0.78      | 0.95    | 25.45          | 13.20                  | 0.75            |
| 7000  | 14.66 | 19.78     | 6.45                    | 16.16                    | 0.88      | 0.97    | 26.32          | 13.41                  | 0.81            |
| 8000  | 13.39 | 19.40     | 6.55                    | 17.80                    | 0.97      | 1.00    | 26.56          | 13.41                  | 0.83            |
| 9000  | 12.28 | 18.91     | 6.72                    | 17.59                    | 1.03      | 1.01    | 28.24          | 13.73                  | 0.80            |
| 10000 | 11.37 | 18.29     | 7.12                    | 17.44                    | 1.07      | 1.00    | 28.98          | 13.52                  | 0.78            |
| 11000 | 10.54 | 17.64     | 7.57                    | 17.37                    | 1.12      | 0.98    | 27.83          | 13.64                  | 0.99            |
| 12000 | 9.70  | 17.04     | 7.48                    | 16.35                    | 1.15      | 0.97    | 29.89          | 13.33                  | 1.01            |
| 13000 | 8.77  | 16.53     | 6.94                    | 14.92                    | 1.17      | 0.98    | 27.54          | 13.20                  | 1.02            |
| 14000 | 7.89  | 15.98     | 6.59                    | 14.26                    | 1.19      | 0.99    | 30.01          | 13.42                  | 1.13            |
| 15000 | 7.22  | 15.23     | 6.72                    | 14.60                    | 1.20      | 0.98    | 30.88          | 13.61                  | 1.21            |
| 16000 | 6.66  | 14.35     | 7.07                    | 15.31                    | 1.19      | 0.96    | 30.61          | 13.91                  | 1.37            |
| 17000 | 6.08  | 13.47     | 7.17                    | 14.83                    | 1.18      | 0.93    | 30.15          | 13.71                  | 1.13            |
| 18000 | 5.36  | 12.71     | 6.87                    | 12.99                    | 1.17      | 0.90    | 32.36          | 13.46                  | 1.27            |
| 19000 | 4.51  | 12.04     | 6.35                    | 11.28                    | 1.15      | 0.88    | 33.58          | 12.72                  | 1.57            |
| 20000 | 3.65  | 11.35     | 5.98                    | 10.19                    | 1.14      | 0.86    | 34.36          | 12.55                  | 2.00            |

Note: Test data of Die packaged in industry standard 2x2 mm, 6-lead MCLP package

## Typical Performance Data

### Definitions:

Input Return Loss = -S11 (dB)

Gain(Power Gain) = S21 (dB)

Reverse Isolation = -S12 (dB)

Output Return Loss = -S22 (dB)

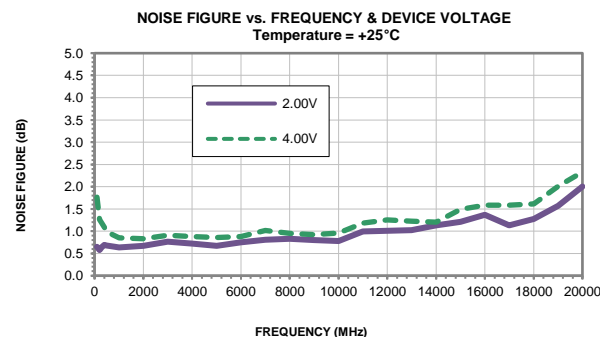
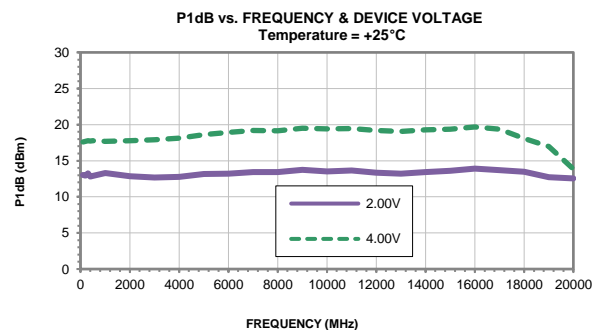
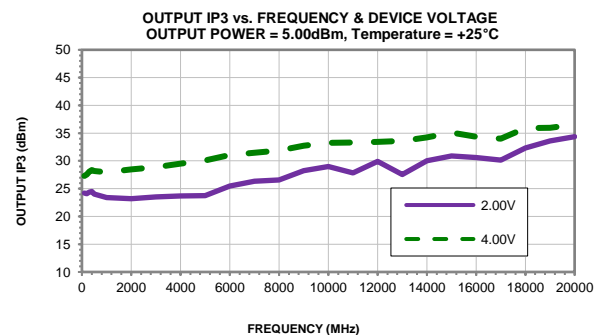
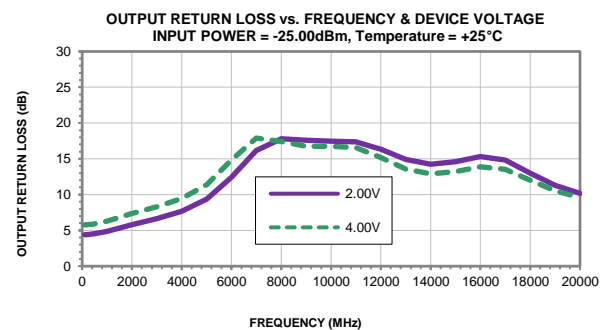
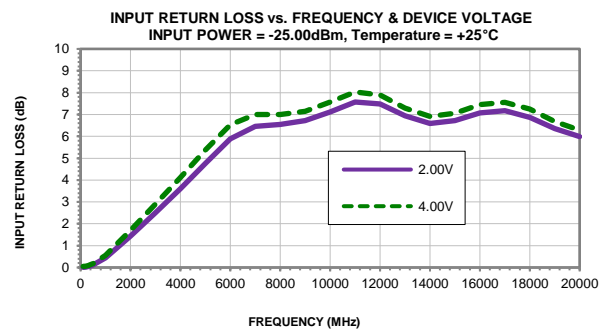
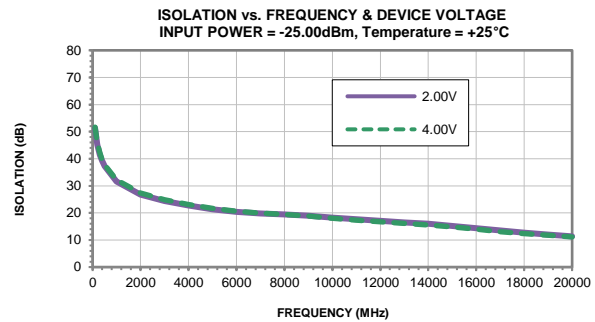
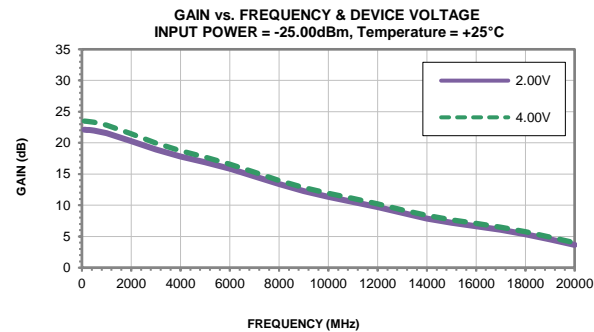
TEST CONDITIONS: Vd = 4.00V, Id = 40mA @ Temperature = +25°C

| FREQ  | Gain  | Isolation | Input<br>Return<br>Loss | Output<br>Return<br>Loss | Stability |         | IP-3<br>Output | 1dB<br>Comp.<br>Output | Noise<br>Figure |
|-------|-------|-----------|-------------------------|--------------------------|-----------|---------|----------------|------------------------|-----------------|
| (MHz) | (dB)  | (dB)      | (dB)                    | (dB)                     | K         | Measure | (dBm)          | (dBm)                  | (dB)            |
| 100   | 23.49 | 51.66     | 0.05                    | 5.77                     | 0.13      | 1.46    | 27.30          | 17.57                  | 1.76            |
| 200   | 23.46 | 45.86     | 0.06                    | 5.80                     | 0.08      | 1.46    | 27.55          | 17.67                  | 1.26            |
| 300   | 23.42 | 42.17     | 0.09                    | 5.82                     | 0.09      | 1.45    | 28.09          | 17.75                  | 1.18            |
| 400   | 23.36 | 39.63     | 0.13                    | 5.85                     | 0.11      | 1.45    | 28.38          | 17.71                  | 1.09            |
| 500   | 23.30 | 37.76     | 0.18                    | 5.90                     | 0.12      | 1.44    | 28.17          | 17.77                  | 0.99            |
| 1000  | 22.84 | 32.16     | 0.55                    | 6.28                     | 0.22      | 1.38    | 27.94          | 17.68                  | 0.85            |
| 2000  | 21.44 | 27.33     | 1.70                    | 7.34                     | 0.39      | 1.23    | 28.44          | 17.76                  | 0.83            |
| 3000  | 19.98 | 24.90     | 2.90                    | 8.30                     | 0.53      | 1.10    | 28.90          | 17.89                  | 0.90            |
| 4000  | 18.75 | 23.13     | 4.12                    | 9.46                     | 0.64      | 1.00    | 29.48          | 18.10                  | 0.88            |
| 5000  | 17.70 | 21.68     | 5.38                    | 11.40                    | 0.73      | 0.93    | 30.06          | 18.60                  | 0.86            |
| 6000  | 16.57 | 20.64     | 6.53                    | 14.82                    | 0.83      | 0.89    | 31.04          | 18.90                  | 0.88            |
| 7000  | 15.28 | 19.94     | 6.99                    | 17.90                    | 0.92      | 0.89    | 31.45          | 19.17                  | 1.01            |
| 8000  | 13.97 | 19.40     | 7.00                    | 17.42                    | 0.99      | 0.91    | 31.89          | 19.13                  | 0.95            |
| 9000  | 12.85 | 18.81     | 7.15                    | 16.75                    | 1.03      | 0.92    | 32.75          | 19.52                  | 0.92            |
| 10000 | 11.92 | 18.07     | 7.57                    | 16.77                    | 1.06      | 0.91    | 33.27          | 19.39                  | 0.96            |
| 11000 | 11.08 | 17.35     | 8.03                    | 16.55                    | 1.10      | 0.89    | 33.34          | 19.47                  | 1.18            |
| 12000 | 10.21 | 16.69     | 7.89                    | 15.19                    | 1.12      | 0.88    | 33.45          | 19.19                  | 1.25            |
| 13000 | 9.27  | 16.16     | 7.29                    | 13.57                    | 1.14      | 0.88    | 33.58          | 19.07                  | 1.22            |
| 14000 | 8.37  | 15.57     | 6.91                    | 12.90                    | 1.15      | 0.89    | 34.26          | 19.27                  | 1.20            |
| 15000 | 7.68  | 14.82     | 7.06                    | 13.23                    | 1.16      | 0.89    | 35.11          | 19.38                  | 1.49            |
| 16000 | 7.10  | 13.95     | 7.45                    | 13.89                    | 1.16      | 0.87    | 34.37          | 19.68                  | 1.58            |
| 17000 | 6.50  | 13.11     | 7.56                    | 13.53                    | 1.15      | 0.84    | 33.98          | 19.37                  | 1.58            |
| 18000 | 5.75  | 12.39     | 7.24                    | 11.99                    | 1.14      | 0.81    | 35.90          | 18.07                  | 1.61            |
| 19000 | 4.88  | 11.77     | 6.68                    | 10.53                    | 1.13      | 0.80    | 35.96          | 16.95                  | 2.01            |
| 20000 | 4.00  | 11.12     | 6.28                    | 9.61                     | 1.13      | 0.79    | 36.53          | 13.85                  | 2.33            |

Note: Test data of Die packaged in industry standard 2x2 mm, 6-lead MCLP package



## Typical Performance Curves



Note: Test data of Die packaged in industry standard 2x2 mm, 6-lead MCLP package



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<br>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)                           |                                      |