

Wideband

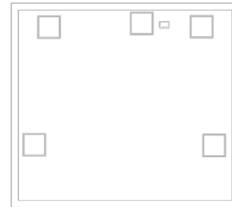
Low Noise Bypass Amplifier Die

TSS-53LNB-D+

50Ω 0.5 to 6 GHz

The Big Deal

- Very wideband, 500 MHz – 6 GHz
- Ultra-flat gain, ± 0.4 dB from 700 to 2100 MHz
- Low NF over entire frequency band, 1.4 dB
- Internal bypass switching extends useable dynamic range



Product Overview

Mini-Circuits TSS-53LNB-D+ is a low-noise amplifier die offering industry-leading performance over its full frequency range from 500 MHz to 6 GHz. It contains internal switching, allowing the user control of the amplifier to handle both high and low signal levels by bypassing the LNA in the presence of large signals. The TSS-53LNB-D+ utilizes E-PHEMT technology to achieve excellent noise figure performance in a unique cascade configuration enabling the combination of very wide band performance and flat gain.

Key Features

| Feature | Advantages |
|--|--|
| Ultra-wideband: 500 MHz – 6 GHz | Ideal for a wide range of receiver applications including military, commercial wireless, and instrumentation. |
| Very flat gain: ± 0.4 dB over 0.7-2.1 GHz | Ideal for broadband or multi-band applications. Just one, cost-efficient model required for multiple frequency usage. |
| Minimal external matching components required. 15 dB return loss typ. | Minimizes the need for external matching networks, simplifying circuit designs, and enabling the amplifier to operate over multiple bands in a single application circuit. |
| High IP3: 48 dBm typ. (bypass mode) | Provides enhanced linearity over broad frequency range under high signal conditions. |
| Internal bypass switch feature | Unique design handles low to high signal levels with minimal noise distortion. |
| Built-in DC blocking cap at RF-Out port & separate pads for RF-Out & Vdd | Simplifies biasing eliminates need for Bias-Tee at output. |
| Unpackaged Die | Enables the users to integrate amplifier directly into hybrids. |

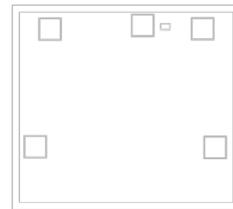
Wideband

Low Noise Bypass Amplifier Die

TSS-53LNB-D+

Product Features

- Wideband: 0.5-6 GHz
- Built-in Bypass switching
- Low Noise figure: 1.3 dB typ. at 2.0 GHz
- High Gain: 21.4 dB typ. at 2 GHz
- Ultra Flat Gain: 0.4 dB from 0.7 to 2.1 GHz
- P1dB: +21 dBm typ. at 2.0 GHz
- Minimal matching components



Typical Applications

- Wireless Base Station Systems
- Test and Measurement Systems
- Multi-Band Receivers

+RoHS Compliant

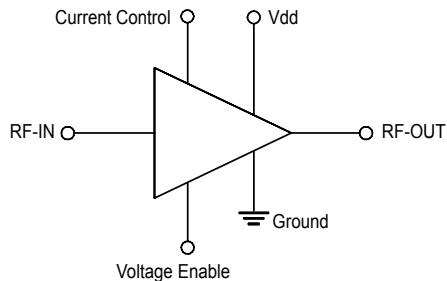
The +Suffix identifies RoHS Compliance. See our web site for RoHS Compliance methodologies and qualifications

Ordering Information: Refer to Last Page

General Description

TSS-53LNB-D+ (RoHS compliant) is an advanced ultra-flat gain Low Noise wideband amplifier die fabricated using E-PHEMT technology offering extremely high dynamic range over a broad frequency range. It has integrated switches enabling users to bypass the amplifier during high signal conditions. In addition, the TSS-53LNB-D+ has good input and output return loss over a broad frequency range without the need for external matching components.

simplified schematic and bonding pad description



| Function | Description (See Figure 2) |
|-----------------|--|
| RF-IN | RF-Input pad. Connect to Ground Via L1. Add a DC blocking cap in series of appropriate value if required. |
| RF-OUT | RF-Output pad. No external DC blocking cap required. |
| Current Control | Current Control pad, Voltage level on this pad sets the Idd. Connect to pad Voltage Enable pad via 3.92 kΩ resistor. |
| Voltage Enable | Voltage Enable Pad. Voltage level on this pad determines Amplifier is ON or bypassed. |
| Vdd | Supply Voltage Pad. Connect to Vdd via L2. |
| Ground | Bottom of Die |

Electrical Specifications⁽¹⁾ at 25°C, Zo=50Ω and V=5V, unless otherwise noted

| Parameter | Condition (GHz) | Amplifier-ON | | | Amplifier-Bypass Typ. | Units |
|---|-----------------|--------------|-------|------|-----------------------|-------|
| | | Min. | Typ. | Max. | | |
| Frequency Range | | 0.5 | 1.4 | 6.0 | 0.8 | GHz |
| Noise Figure | 0.5 | 1.0 | 1.2 | 1.3 | 1.4 | dB |
| | 2.0 | 4.0 | 5.0 | 6.0 | 1.1 | |
| | 4.0 | 5.0 | 6.0 | 2.2 | 1.4 | |
| | 5.0 | 6.0 | 6.0 | 2.2 | 1.4 | |
| | 6.0 | 6.0 | 6.0 | 2.2 | 1.7 | |
| | 6.0 | 6.0 | 6.0 | 2.2 | 1.7 | |
| Gain | 0.5 | 1.0 | 2.0 | 4.0 | -0.8 | dB |
| | 2.0 | 4.0 | 5.0 | 6.0 | -0.9 | |
| | 4.0 | 5.0 | 6.0 | 6.0 | -1.1 | |
| | 5.0 | 6.0 | 6.0 | 6.0 | -1.7 | |
| | 6.0 | 6.0 | 6.0 | 6.0 | -1.6 | |
| | 6.0 | 6.0 | 6.0 | 6.0 | -2.0 | |
| Gain Flatness | 0.7 - 2.1 | | ±0.4 | | ±0.7 | dB |
| Input Return Loss | 0.5 | 1.0 | 2.0 | 4.0 | 23.9 | dB |
| | 2.0 | 4.0 | 5.0 | 6.0 | 18.3 | |
| | 4.0 | 5.0 | 6.0 | 6.0 | 14.3 | |
| | 5.0 | 6.0 | 6.0 | 6.0 | 10.4 | |
| | 6.0 | 6.0 | 6.0 | 6.0 | 14.7 | |
| | 6.0 | 6.0 | 6.0 | 6.0 | 13.3 | |
| Output Return Loss | 0.5 | 1.0 | 2.0 | 4.0 | 22.3 | dB |
| | 2.0 | 4.0 | 5.0 | 6.0 | 17.1 | |
| | 4.0 | 5.0 | 6.0 | 6.0 | 15.0 | |
| | 5.0 | 6.0 | 6.0 | 6.0 | 10.9 | |
| | 6.0 | 6.0 | 6.0 | 6.0 | 13.5 | |
| | 6.0 | 6.0 | 6.0 | 6.0 | 11.1 | |
| Output Power @ 1dB compression AMP-ON ⁽²⁾ Input Power @ 1dB compression AMP-Bypass ^(4,5) | 0.5 | 1.0 | 2.0 | 4.0 | 32.0 | dBm |
| | 1.0 | 2.0 | 4.0 | 5.0 | — | |
| | 2.0 | 4.0 | 5.0 | 6.0 | 33.0 | |
| | 4.0 | 5.0 | 6.0 | 6.0 | — | |
| | 5.0 | 6.0 | 6.0 | 6.0 | 27.0 | |
| | 6.0 | 6.0 | 6.0 | 6.0 | 32.0 | |
| Output IP3 | 0.5 | 1.0 | 2.0 | 4.0 | 45.4 | |
| | 2.0 | 4.0 | 5.0 | 6.0 | 46.1 | |
| | 4.0 | 5.0 | 6.0 | 6.0 | 45.8 | |
| | 5.0 | 6.0 | 6.0 | 6.0 | 41.2 | |
| | 6.0 | 6.0 | 6.0 | 6.0 | 40.3 | |
| | 6.0 | 6.0 | 6.0 | 6.0 | 38.0 | |
| Device Operating Voltage (Vdd) | | | 5.0 | | 4.8-5.2 (5.0 typ.) | V |
| Device Operating Current (Id) | | 46 | 82 | 105 | 2 | mA |
| Enable Voltage (Ve) | | | 5.0 | | 0 | V |
| Enable Control Current (Ie) | | | 2.0 | | 0 | mA |
| DC Current (Id) Variation Vs. Voltage | | | 0.007 | | — | mA/mV |
| Thermal Resistance, junction-to-ground lead | | | 48 | | — | °C/W |

⁽¹⁾ Measured on Mini-Circuits Die Characterization test board. See Characterization Test Circuit (Fig. 1)⁽²⁾ Current increases at P1dBAbsolute Maximum Ratings^(3,4)

| Parameter | Ratings | | |
|---------------------------------------|------------------|--|--|
| Operating Temperature (bottom of die) | -40°C to 85°C | | |
| Total Power Dissipation | 0.7 W | | |
| Input Power | Amplifier-ON | 8 dBm (continuous), 19 dBm (5 min max.) | |
| | Amplifier Bypass | 16 dBm (continuous), 29 dBm (5 min max.) | |
| DC Voltage Vdd | | 7.0 V | |
| DC Voltage Enable | | 7.0 V | |
| Max. Voltage on RF-OUT Pad | | 15 V | |

⁽³⁾ Permanent damage may occur if any of these limits are exceeded.

Electrical maximum ratings are not intended for continuous normal operation.

⁽⁴⁾ Die performance measured in industry standard 3x3 mm 12-lead package.⁽⁵⁾ Do not exceed absolute maximum ratings.

Enable Voltage (Ve) Fig. 1

| | Min. | Typ. | Max. | Units |
|------------------|------|------|------|-------|
| Amplifier-ON | 4.5 | 5.0 | 5.5 | V |
| Amplifier-Bypass | 0 | — | 0.5 | V |



Switching Specifications (Rise/Fall Time)

| Parameter | | Min. | Typ. | Max. | Units |
|-------------------------|----------------------------------|------|------|------|-------|
| Amplifier ON to Bypass | OFF TIME (50% Control to 10% RF) | — | 50 | — | ns |
| | FALL TIME (90 to 10% RF) | — | 12 | — | |
| Amplifier Bypass to ON | ON TIME (50% Control to 90% RF) | — | 740 | — | ns |
| | RISE TIME (10% to 90% RF) | — | 240 | — | |
| Control Voltage Leakage | | — | 65 | — | mV |

Characterization Test Circuit

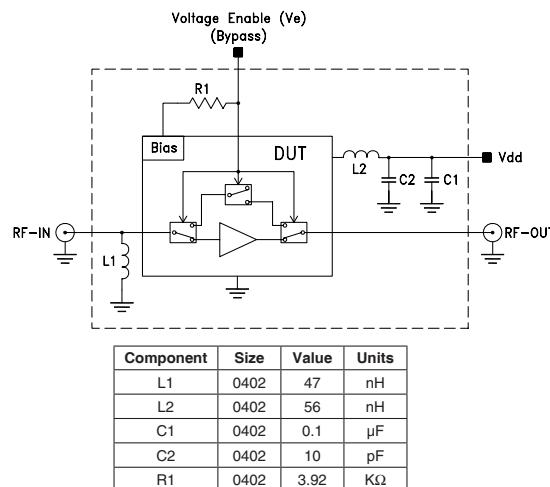


Fig 1. Block diagram of Test Circuit used for Die characterization. Gain, Return loss, Output power at 1dB compression (P1 dB), output IP3 (OIP3) and noise figure measured using Agilent's N5242A PNA-X microwave network analyzer.

Conditions:

1. Gain and Return loss: Pin= -25dBm
2. Output IP3 (OIP3): Two tones, spaced 1 MHz apart, 0 dBm/tone at output.
3. Switching Time: Pin= -25 dBm at 500 MHz. Venable=4.5, 5.0, 5.5V at 10 kHz. Vd=4.75, 5.0 and 5.5V. (Note 4)

Die Layout

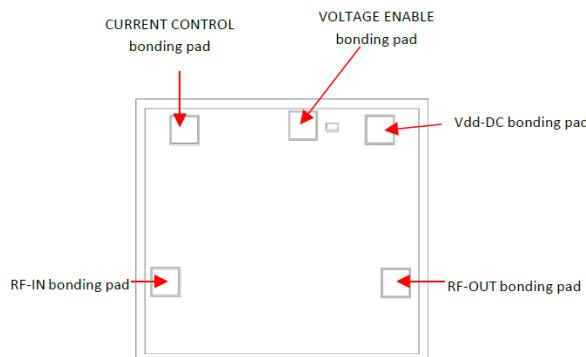
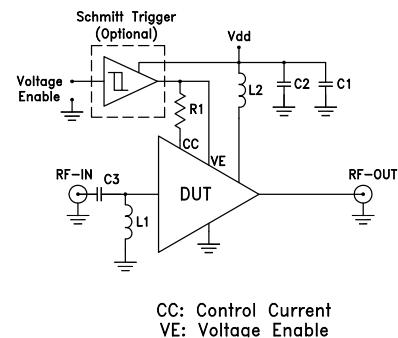


Fig 3. Die Layout

Critical Dimensions

| Parameter | Values |
|-------------------|-----------|
| Die Thickness, μm | 100 |
| Die Width, μm | 900 |
| Die Length, μm | 1000 |
| Bond Pad Size, μm | 100 x 100 |

Recommended Application Circuit



| Component | Size | Value | Units |
|-----------------|-----------------|-------|-------------------|
| L1 | 0402 | 47 | nH |
| L2 | 0402 | 56 | nH |
| R1 | 0402 | 3.92 | kΩ |
| C1 | 0402 | 0.1 | μF |
| C2 | 0402 | 10 | pF |
| C3 | 0402 | 1000 | pF |
| Schmitt Trigger | SN74LVC2G17DCKR | | Texas Instruments |

Fig 2. Recommended Application Circuit.

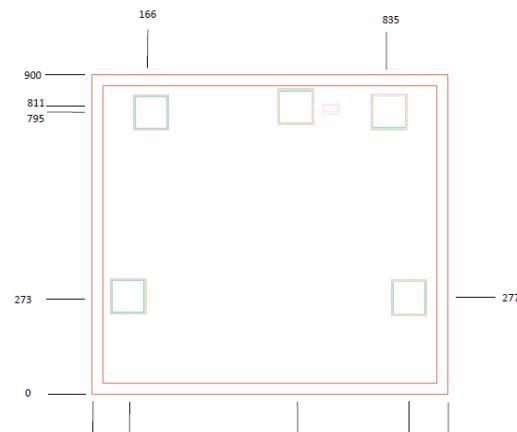
Bonding Pad Position
(Dimensions in μm, Typical)

Fig 4. Bonding Pad Positions

Monolithic E-PHEMT MMIC Amplifier

Assembly and Handling Procedure

1. Storage

Dice should be stored in a dry nitrogen purged desiccators or equivalent.

2. ESD

MMIC EPHEMPT amplifier 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.

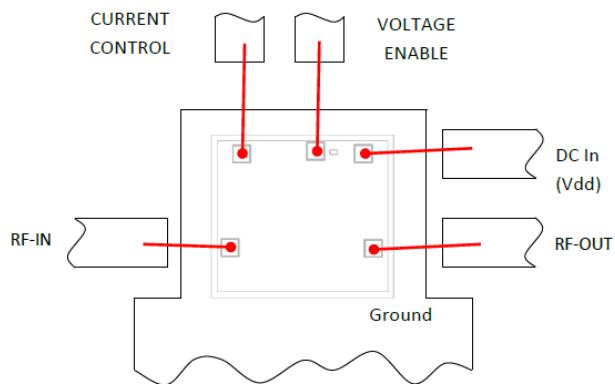
3. Die Attach

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 reasonable to minimize performance degradation due to undesirable series inductance.

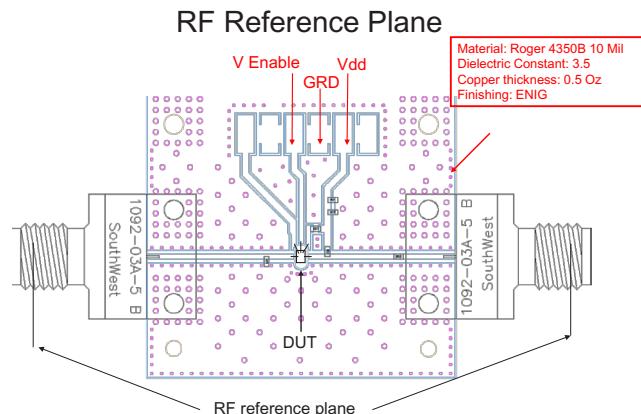
Assembly Diagram



Recommended Wire Length, Typical

| Wire | Wire Length (mm) | Wire Loop Height (mm) |
|--|------------------|-----------------------|
| RF-IN | 0.9 | 0.15 |
| DC IN (Vdd), Voltage Enable, Current Control | 0.5 | 0.15 |
| RF-OUT | 0.6 | 0.15 |

RF Reference Plane - No port extension



 **Mini-Circuits®**

| Additional Detailed Technical Information <i>additional information is available on our dash board.</i> | | |
|---|--|--|
| Performance Data | Data Table | |
| | Swept Graphs | |
| | S-Parameter (S2P Files) Data Set with and without port extension(.zip file) | |
| Case Style | Die | |
| Die Ordering and packaging information | Quantity, Package Small, Gel - Pak: 10,50,100 KGD* Medium [†] , Partial wafer: KGD*<5K Large [†] , Full Wafer | Model No. TSS-53LNB-DG+ TSS-53LNB-DP+ TSS-53LNB-DF+ |
| | [†] Available upon request contact sales representative | |
| | Refer to AN-60-067 | |
| Environmental Ratings | ENV-80 | |

*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 1A (250 to <500V) in accordance with ANSI/ESD STM 5.1 - 2001

Machine Model (MM): Class M1 (pass 50V) in accordance with ANSI/ESD STM5.2-1999

** Die performance measured in industry standard 3x3 mm 12-lead package.

Additional 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.
- B. Electrical specifications and performance data contained in this specification document are based on Mini-Circuit's applicable established test performance criteria and measurement instructions.
- C. The parts covered by this specification document are subject to Mini-Circuits standard limited warranty and terms and conditions (collectively, "Standard Terms"); Purchasers of this part are entitled to the rights and benefits contained therein. For a full statement of the Standard Terms and the exclusive rights and remedies thereunder, please visit Mini-Circuits' website at www.minicircuits.com/MCLStore/terms.jsp

