

## Evaluation Board Manual for NBSG86A



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### EVALUATION BOARD MANUAL

#### DESCRIPTION

This document describes the NBSG86A evaluation board and the appropriate lab test setups. It should be used in conjunction with the device data sheet, which includes specifications and a full description of device operation.

The board is used to evaluate the NBSG86A GigaComm™ differential Smart Gate multi-function logic gate, which can be configured as an AND/NAND, OR/NOR, XOR/XNOR, or 2:1 MUX. The OLS input of the NBSG86A is used to program the peak-to-peak output amplitude between 0 and 800 mV in five discrete steps.

The board is implemented in two layers and provides a high bandwidth 50  $\Omega$  controlled impedance environment for higher performance. The first layer or primary trace layer is 5 mils thick Rogers RO6002 material, which is engineered to have equal electrical length on all signal traces from the NBSG86A device to the sense output. The second layer is 32 mils thick copper ground plane.

For standard lab setup and test, a split (dual) power supply is required enabling the 50  $\Omega$  impedance from the scope to be used as termination of the ECL signals, where  $V_{TT}$  is the system ground ( $V_{CC} = 2.0$  V,  $V_{TT} = V_{CC} - 2.0$  V and  $V_{EE}$  is -0.5 V or -1.3 V, see Setup 1).

#### What measurements can you expect to make?

The following measurements can be performed in the single-ended (Note 1) or differential mode of operation:

- Frequency Performance
- Output Amplitude ( $V_{OH}$  /  $V_{OL}$ )
- Output Rise and Fall Time
- Output Skew
- Eye pattern generation
- Jitter
- $V_{IHCMR}$  (Input High Common Mode Range)

#### NOTE:

1. Single-ended measurements can only be made at  $V_{CC} - V_{EE} = 3.3$  V using this board setup.

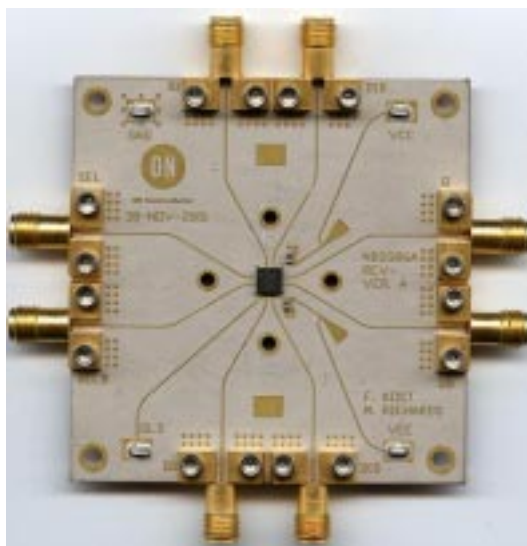


Figure 1. NBSG86A Evaluation Board

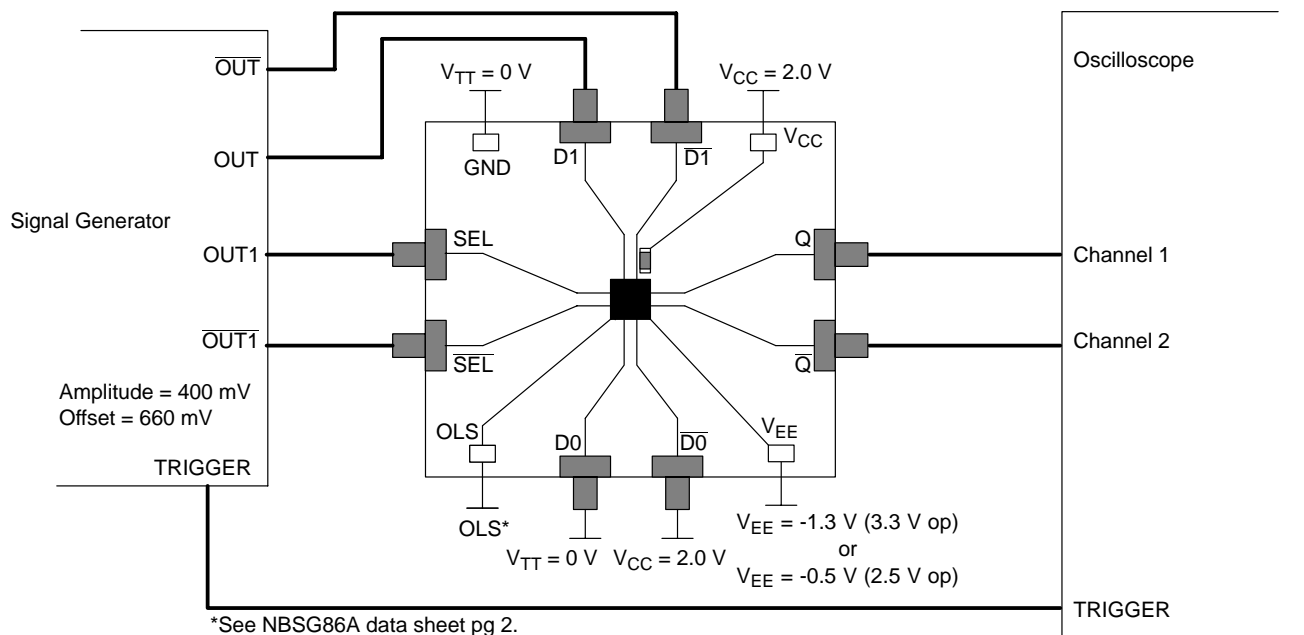
## Setup for Time Domain Measurements

**Table 1. Basic Equipment Needed**

Description	Example Equipment (Note 1)	Qty.
Power Supply with 2 Outputs	HP6624A	1
Oscilloscope	TDS8000 with 80E01 Sampling Head (Note 2)	1
Differential Signal Generator	HP 8133A, Advantest D3186	1
Matched High Speed Cables with SMA Connectors	Storm, Semflex	8
Power Supply Cables with Clips		3 / 4 (Note 3)

1. This equipment was used to obtain the measurements included in this document.
2. The 50 GHz sample module was used in order to obtain accurate and repeatable rise, fall, and jitter measurements.
3. Additional power supply cable with clip is needed when output level select (OLS) tested (see device data sheet).

### AND/NAND Function Setup



**Figure 2. NBSG86A Board Setup - Time Domain (AND/NAND Function)**

#### Connect Power

##### Step 1:

1a. Connect the following supplies to the evaluation board via surface mount clips.

**Power Supply Summary Table**

3.3 V Setup	2.5 V Setup
$V_{CC} = 2.0 \text{ V}$	$V_{CC} = 2.0 \text{ V}$
$V_{TT} = \text{GND}$	$V_{TT} = \text{GND}$
$V_{EE} = -1.3 \text{ V}$	$V_{EE} = -0.5 \text{ V}$

## AND/NAND Function Setup (continued)

### Step 2:

#### Connect the Inputs

##### For Differential Mode (3.3 V and 2.5 V operation)

- 2a: Connect the differential outputs of the generator to the differential inputs of the device ( $D1/\overline{D1}$  and  $SEL/\overline{SEL}$ ).
- 2b: Connect the  $DO$  input to  $V_{TT}$ .
- 2c: Connect the  $\overline{DO}$  input to  $V_{CC}$ .
- 2d: Connect the generator trigger to the oscilloscope trigger.

##### For Single-Ended Mode (3.3 V operation only)

- 2a: Connect an AC-coupled output of the generator to the desired differential input of the device.
- 2b: Connect the unused differential input of the device to  $V_{TT}$  (GND) through a  $50\ \Omega$  resistor.
- 2c: Connect the  $DO$  input to  $V_{TT}$ .
- 2d: Connect the  $\overline{DO}$  input to  $V_{CC}$ .
- 2e: Connect the generator trigger to the oscilloscope trigger.

#### All Function Setups

Connect OLS (Output Level Select) to the required voltage to obtain desired output amplitude. Refer to the NBSG86A device data sheet page 2 OLS voltage table.

### Step 3:

#### Setup Input Signal

- 3a: Set the signal generator amplitude to 400 mV. Note that the signal generator amplitude can vary from 75 mV to 900 mV to produce a 400 mV DUT output.
- 3b: Set the signal generator offset to 660 mV (the center of a nominal RSECL output). Note that the  $V_{IHCMR}$  (Input High Voltage Common Mode Range) allows the signal generator offset to vary as long as  $V_{IH}$  is within the  $V_{IHCMR}$  range. Refer to the device data sheet for further information.
- 3c: Set the generator output for a square wave clock signal with a 50% duty cycle, or for a PRBS data signal.

### Step 4:

#### Connect Output Signals

- 4a: Connect the outputs of the evaluation board ( $Q$ ,  $\overline{Q}$ ) to the oscilloscope. The oscilloscope sampling head must have internal  $50\ \Omega$  termination to ground.

NOTE: Where a single output is being used, the unconnected output for the pair **must be** terminated to  $V_{TT}$  through a  $50\ \Omega$  resistor for best operation. Unused pairs may be left unconnected. Since  $V_{TT} = 0\text{ V}$ , a standard  $50\ \Omega$  SMA termination is recommended.

## OR/NOR Function Setup

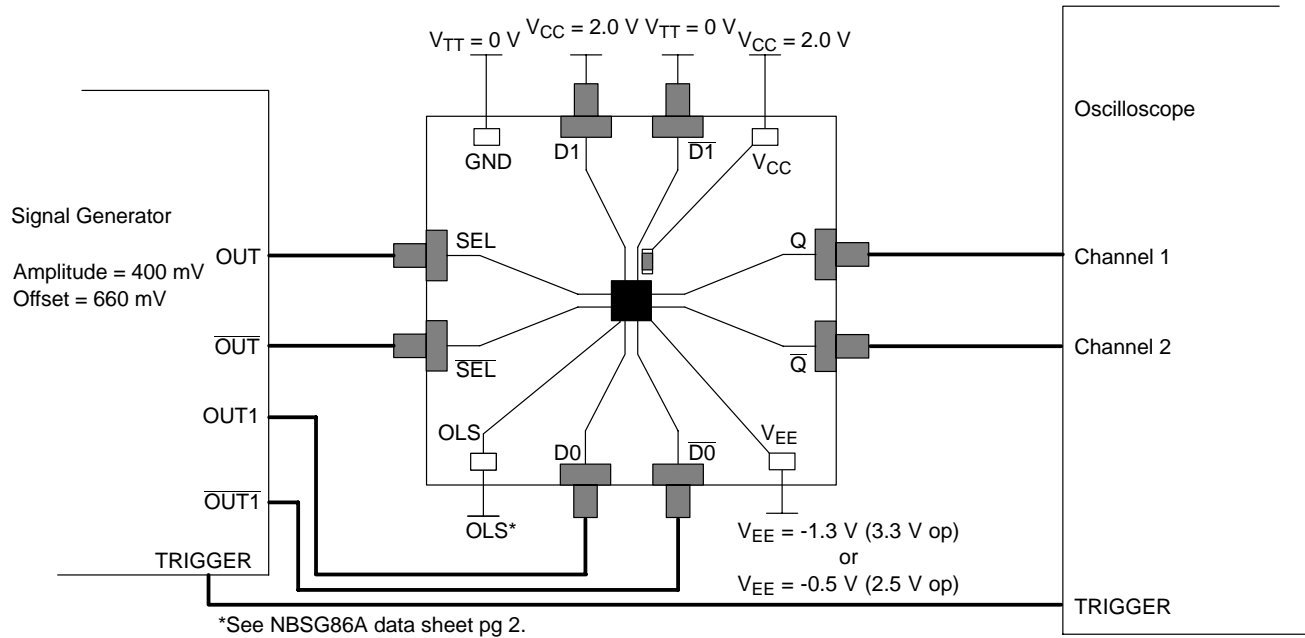


Figure 3. NBSG86A Board Setup - Time Domain (OR/NOR Function)

## Connect Power

### Step 1:

1a: Connect the following supplies to the evaluation board via surface mount clips.

Power Supply Summary Table

3.3 V Setup	2.5 V Setup
$V_{CC} = 2.0\text{ V}$	$V_{CC} = 2.0\text{ V}$
$V_{TT} = \text{GND}$	$V_{TT} = \text{GND}$
$V_{EE} = -1.3\text{ V}$	$V_{EE} = -0.5\text{ V}$

## OR/NOR Function Setup (continued)

### Step 2:

#### Connect the Inputs

##### For Differential Mode (3.3 V and 2.5 V operation)

- 2a: Connect the differential outputs of the generator to the differential inputs of the device (D0/ $\overline{D0}$  and SEL/ $\overline{SEL}$ ).
- 2a: Connect the  $\overline{DI}$  input to  $V_{TT}$ .
- 2b: Connect the D1 input to  $V_{CC}$ .
- 2e: Connect the generator trigger to the oscilloscope trigger.

##### For Single-Ended Mode (3.3 V operation only)

- 2a: Connect an AC-coupled output of the generator to the desired differential input of the device.
- 2b: Connect the unused differential input of the device to  $V_{TT}$  (GND) through a 50  $\Omega$  resistor.
- 2c: Connect the  $\overline{DI}$  input to  $V_{TT}$ .
- 2d: Connect the D1 input to  $V_{CC}$ .
- 2e: Connect the generator trigger to the oscilloscope trigger.

#### All Function Setups

Connect OLS (Output Level Select) to the required voltage to obtain desired output amplitude. Refer to the NBSG86A device data sheet page 2 OLS voltage table.

### Step 3:

#### Setup Input Signal

- 3a: Set the signal generator amplitude to 400 mV. Note that the signal generator amplitude can vary from 75 mV to 900 mV to produce a 400 mV DUT output.
- 3b: Set the signal generator offset to 660 mV (the center of a nominal RSECL output). Note that the  $V_{IHCMR}$  (Input High Voltage Common Mode Range) allows the signal generator offset to vary as long as  $V_{IH}$  is within the  $V_{IHCMR}$  range. Refer to the device data sheet for further information.
- 3c: Set the generator output for a square wave clock signal with a 50% duty cycle, or for a PRBS data signal.

### Step 4:

#### Connect Output Signals

- 4a: Connect the outputs of the evaluation board (Q,  $\overline{Q}$ ) to the oscilloscope. The oscilloscope sampling head must have internal 50  $\Omega$  termination to ground.

NOTE: Where a single output is being used, the unconnected output for the pair **must be** terminated to  $V_{TT}$  through a 50  $\Omega$  resistor for best operation. Unused pairs may be left unconnected. Since  $V_{TT} = 0$  V, a standard 50  $\Omega$  SMA termination is recommended.

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## XOR/XNOR Function Setup

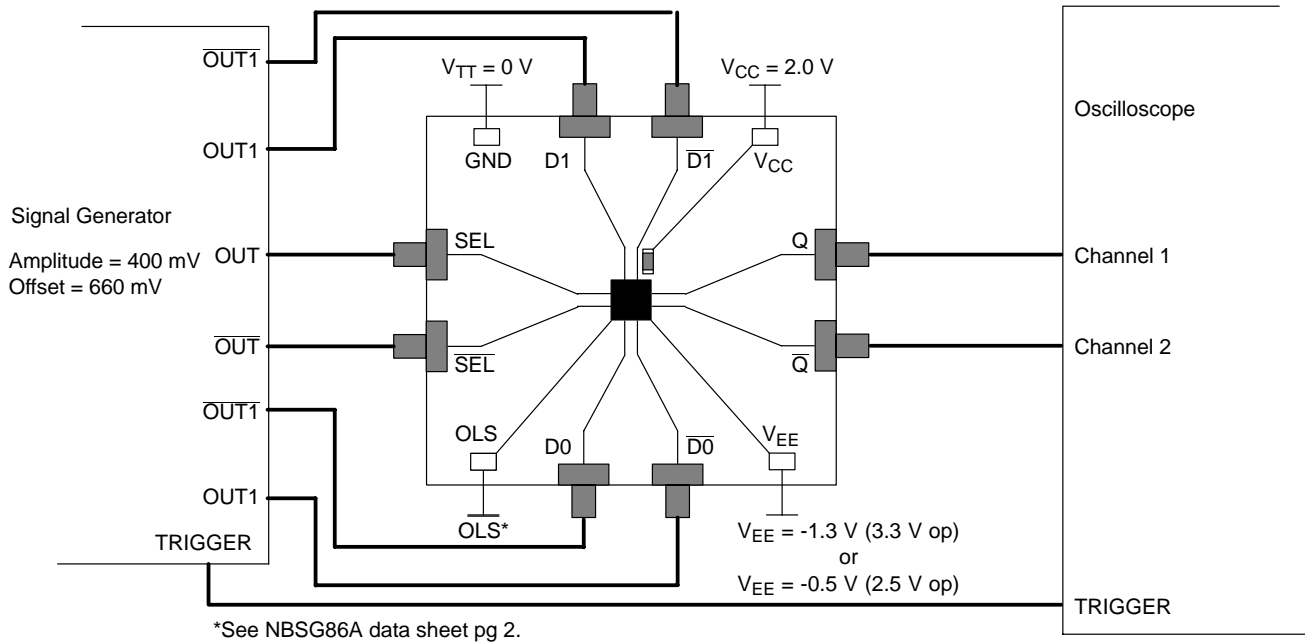


Figure 4. NBSG86A Board Setup - Time Domain (XOR/XNOR Function)

## Connect Power

### Step 1:

1a: Connect the following supplies to the evaluation board via surface mount clips.

Power Supply Summary Table

3.3 V Setup	2.5 V Setup
$V_{CC} = 2.0\text{ V}$	$V_{CC} = 2.0\text{ V}$
$V_{TT} = \text{GND}$	$V_{TT} = \text{GND}$
$V_{EE} = -1.3\text{ V}$	$V_{EE} = -0.5\text{ V}$

## XOR/XNOR Function Setup (continued)

### Step 2:

#### Connect the Inputs

##### For Differential Mode (3.3 V and 2.5 V operation)

2a: Connect the differential outputs of the generator to the differential inputs of the device (OUT  $\overline{\text{OUT}}$  to SEL/ $\overline{\text{SEL}}$ ; OUT1/ $\overline{\text{OUT1}}$  to DO& $\overline{\text{D1}}$ / $\overline{\text{D0}}$ &D1 respectively).

Step 2e: Connect the generator trigger to the oscilloscope trigger.

##### For Single-Ended Mode (3.3 V operation only)

2a: Connect an AC-coupled output of the generator to the desired differential input of the device.

2b: Connect the unused differential input of the device to  $V_{\text{TT}}$  (GND) through a 50  $\Omega$  resistor.

2e: Connect the generator trigger to the oscilloscope trigger.

#### All Function Setups

Connect OLS (Output Level Select) to the required voltage to obtain desired output amplitude. Refer to the NBSG86A device data sheet page 2 OLS voltage table.

### Step 3:

#### Setup Input Signal

3a: Set the signal generator amplitude to 400 mV. Note that the signal generator amplitude can vary from 75 mV to 900 mV to produce a 400 mV DUT output.

3b: Set the signal generator offset to 660 mV (the center of a nominal RSECL output). Note that the  $V_{\text{IHCMR}}$  (Input High Voltage Common Mode Range) allows the signal generator offset to vary as long as  $V_{\text{IH}}$  is within the  $V_{\text{IHCMR}}$  range. Refer to the device data sheet for further information.

3c: Set the generator output for a square wave clock signal with a 50% duty cycle, or for a PRBS data signal.

### Step 4:

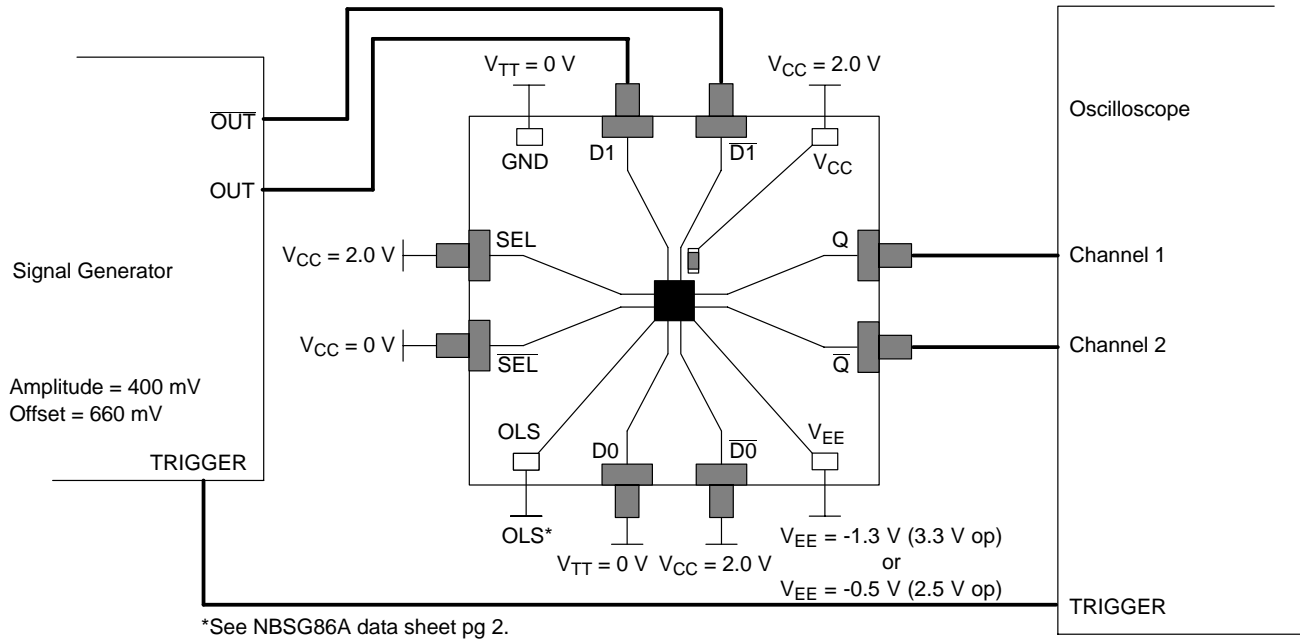
#### Connect Output Signals

4a: Connect the outputs of the evaluation board (Q,  $\overline{\text{Q}}$ ) to the oscilloscope. The oscilloscope sampling head must have internal 50  $\Omega$  termination to ground.

NOTE: Where a single output is being used, the unconnected output for the pair **must be** terminated to  $V_{\text{TT}}$  through a 50  $\Omega$  resistor for best operation. Unused pairs may be left unconnected. Since  $V_{\text{TT}} = 0 \text{ V}$ , a standard 50  $\Omega$  SMA termination is recommended.

# NBSG86ABAEVB

## 2:1 MUX Function Setup



**Figure 5. NBSG86A Board Setup - Time Domain (2:1 MUX Function)**

### Connect Power

#### Step 1:

1a: Connect the following supplies to the evaluation board via surface mount clips.

**Power Supply Summary Table**

3.3 V Setup	2.5 V Setup
$V_{CC} = 2.0\text{ V}$	$V_{CC} = 2.0\text{ V}$
$V_{TT} = \text{GND}$	$V_{TT} = \text{GND}$
$V_{EE} = -1.3\text{ V}$	$V_{EE} = -0.5$



## 2:1 MUX Function Setup (continued)

### Step 2:

#### Connect the Inputs

##### For Differential Mode (3.3 V and 2.5 V operation)

- 2a: Connect the differential outputs of the generator to the differential inputs of the device ( $D1/\overline{D1}$ ).
- 2b: Connect the  $D0$  input to  $V_{TT}$  and the  $\overline{D0}$  input to  $V_{CC}$ .
- 2c: Connect the SEL input to  $V_{CC}$  and the  $\overline{SEL}$  input to  $V_{TT}$ .
- 2d: Connect the generator trigger to the oscilloscope trigger.

##### For Single-Ended Mode (3.3 V operation only)

- 2a: Connect an AC-coupled output of the generator to the desired differential input of the device.
- 2b: Connect the unused differential input of the device to  $V_{TT}$  (GND) through a 50  $\Omega$  resistor.
- 2c: Connect the  $D0$  input to  $V_{TT}$  and the  $\overline{D0}$  input to  $V_{CC}$ .
- 2d: Connect the SEL input to  $V_{CC}$  and the  $\overline{SEL}$  input to  $V_{TT}$ .
- 2e: Connect the generator trigger to the oscilloscope trigger.

#### All Function Setups

Connect OLS (Output Level Select) to the required voltage to obtain desired output amplitude. Refer to the NBSG86A device data sheet page 2 OLS voltage table.

### Step 3:

#### Setup Input Signal

- 3a: Set the signal generator amplitude to 400 mV. Note that the signal generator amplitude can vary from 75 mV to 900 mV to produce a 400 mV DUT output.
- 3b: Set the signal generator offset to 660 mV (the center of a nominal RSECL output). Note that the  $V_{IHCMR}$  (Input High Voltage Common Mode Range) allows the signal generator offset to vary as long as  $V_{IH}$  is within the  $V_{IHCMR}$  range. Refer to the device data sheet for further information.
- 3c: Set the generator output for a square wave clock signal with a 50% duty cycle, or for a PRBS data signal.

### Step 4:

#### Connect Output Signals

- 4a: Connect the outputs of the evaluation board ( $Q, \overline{Q}$ ) to the oscilloscope. The oscilloscope sampling head must have internal 50  $\Omega$  termination to ground.

NOTE: Where a single output is being used, the unconnected output for the pair **must be** terminated to  $V_{TT}$  through a 50  $\Omega$  resistor for best operation. Unused pairs may be left unconnected. Since  $V_{TT} = 0$  V, a standard 50  $\Omega$  SMA termination is recommended.

## Setup for Frequency Domain Measurements

**Table 2. Basic Equipment**

Description	Example Equipment (Note 4)	Qty.
Power Supply with 2 outputs	HP 6624A	1
Vector Network Analyzer (VNA)	R&S ZVK (10 MHz to 40 GHz)	1
180° Hybrid Coupler	Krytar Model #4010180	1
Bias Tee with 50 $\Omega$ Resistor Termination	Picosecond Model #5542-219	1
Matched high speed cables with SMA connectors	Storm, Semflex	3
Power Supply cables with clips		3

4. Equipment used to generate example measurements within this document.

## Setup

### Step 1:

#### Connect Power

1a: Three power levels must be provided to the board for  $V_{CC}$ ,  $V_{EE}$ , and GND via the surface mount clips. Using the split power supply mode,  $GND = V_{TT} = V_{CC} - 2.0$  V.

Power Supply Connections
<b>3.3 V Setup</b>
$V_{CC} = 2.0$ V
$V_{TT} = GND$
$V_{EE} = -1.3$ V

NOTE: For frequency domain measurements, 2.5 V power supply is not recommended because additional equipment (bias tee, etc.) is needed for proper operation. The input signal has to be properly offset to meet  $V_{IHCMR}$  range of the device.

## Setup Test Configurations For Differential Operation

### Small Signal Setup

<b>Step 2:</b>	<b>Input Setup</b> 2a: Calibrate VNA from 1.0 GHz to 12 GHz. 2b: Set input level to -35 dBm at the output of the 180° Hybrid coupler (input of the DUT).
<b>Step 3:</b>	<b>Output Setup</b> 3a: Set display to measure S21 and record data.

### Large Signal Setup

<b>Step 2:</b>	<b>Input Setup</b> 2a: Calibrate VNA from 1.0 GHz to 12 GHz. 2b: Set input levels to -2.0 dBm (500 mV) at the input of DUT.
<b>Step 3:</b>	<b>Output Setup</b> 3a: Set display to measure S21 and record data.

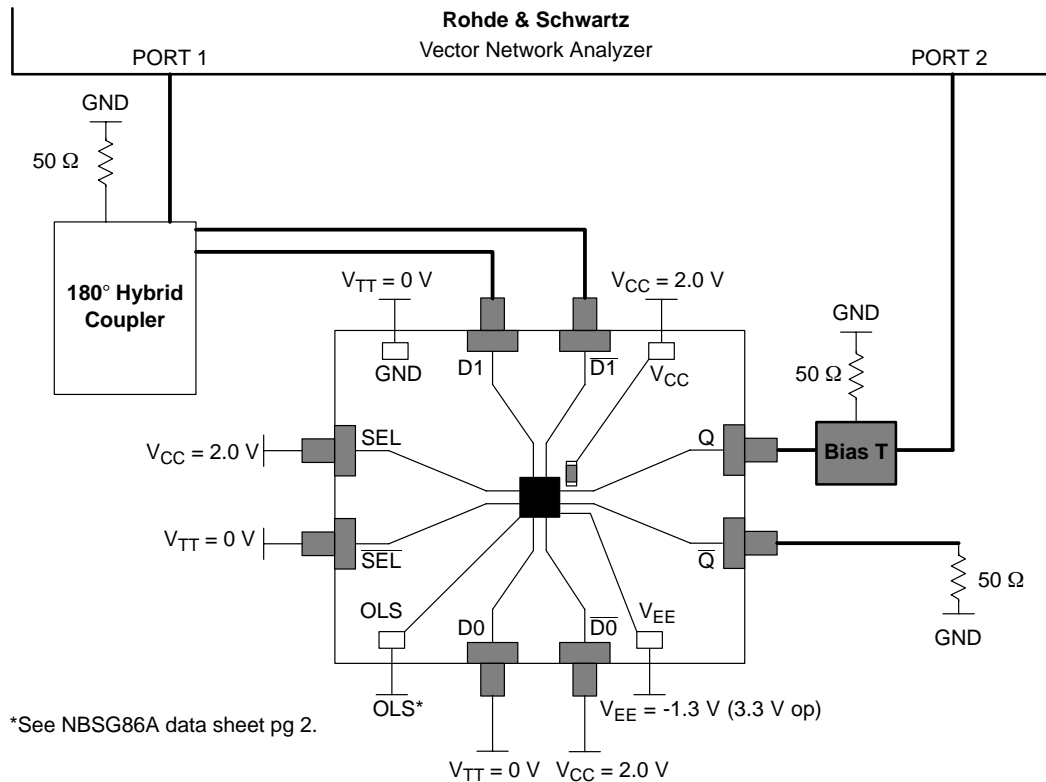


Figure 6. NBSG86A Board Setup - Frequency Domain (Differential 2:1 MUX Function - D1 Selected)

## Setup Test Configurations For Single-Ended Operation

### Single-Ended Mode – Small Signal

<b>Step 2:</b>	<b>Input Setup</b> 2a: Calibrate VNA from 1.0 GHz to 12 GHz. 2b: Set input level to $-35$ dBm at the input of DUT.
<b>Step 3:</b>	<b>Output Setup</b> 3a: Set display to measure S21 and record data.

### Single-Ended Mode – Large Signal

<b>Step 2:</b>	<b>Input Setup</b> 2a: Calibrate VNA from 1.0 GHz to 12 GHz. 2b: Set input levels to $+2$ dBm (500 mV) at the input of DUT.
<b>Step 3:</b>	<b>Output Setup</b> 3a: Set display to measure S21 and record data.

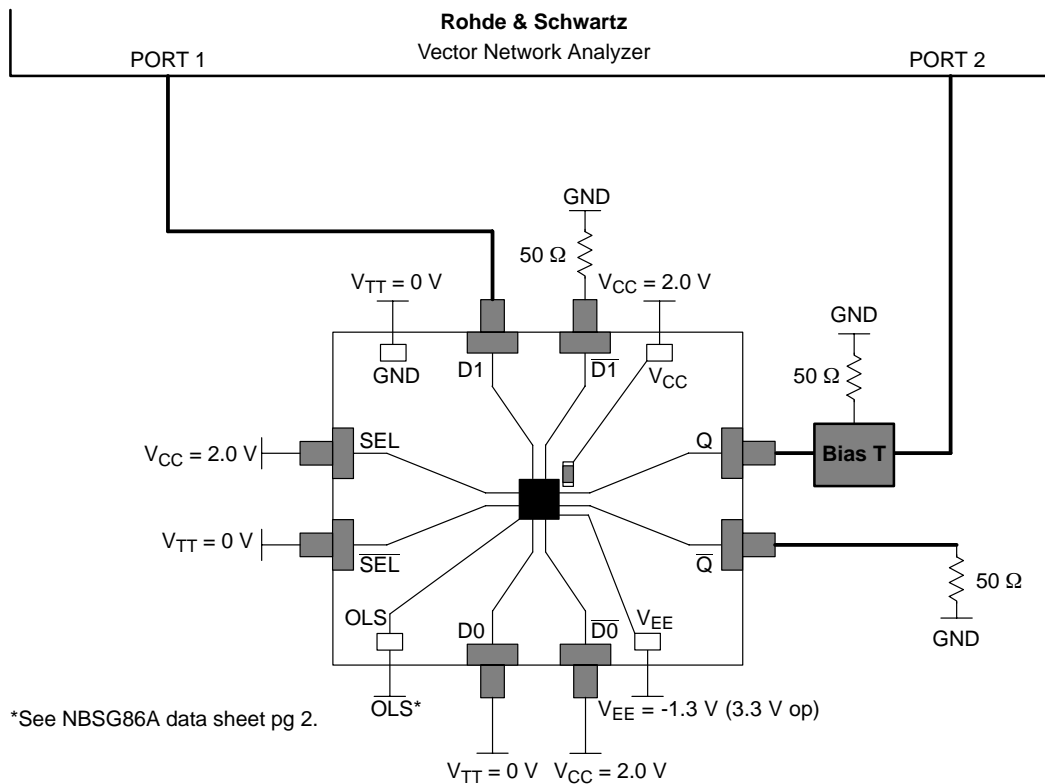


Figure 7. NBSG86A Board Setup - Frequency Domain (Differential 2:1 MUX Function - D1 Selected)

# NBSG86ABAEVB

## More Information About Evaluation Board

### Design Considerations for >10 GHz operation

While the NBSG86A is specified to operate at 12 GHz, this evaluation board is designed to support operating frequencies up to 20 GHz.

The following considerations played a key role to ensure this evaluation board achieves high-end microwave performance:

- Optimal SMA connector launch
- Minimal insertion loss and signal dispersion
- Accurate Transmission line matching ( $50\ \Omega$ )
- Distributed effects while bypassing and noise filtering

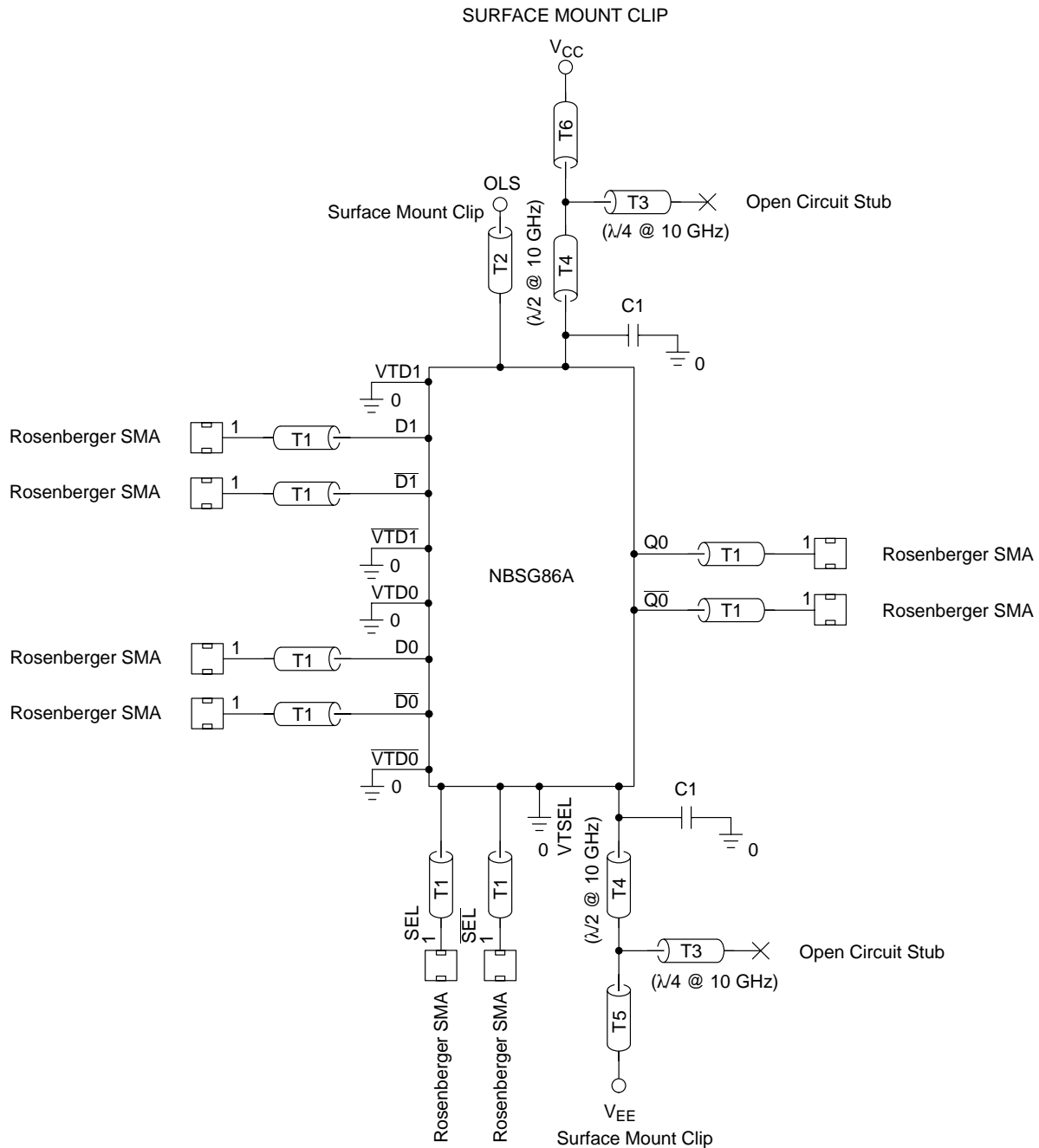


Figure 8. Evaluation Board Schematic

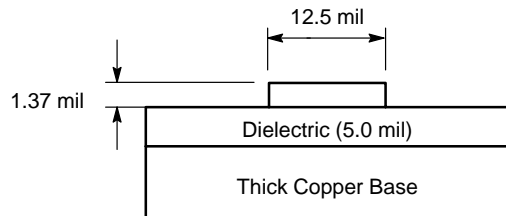
# NBSG86ABAEVB

**Table 3. Table 3. Parts List**

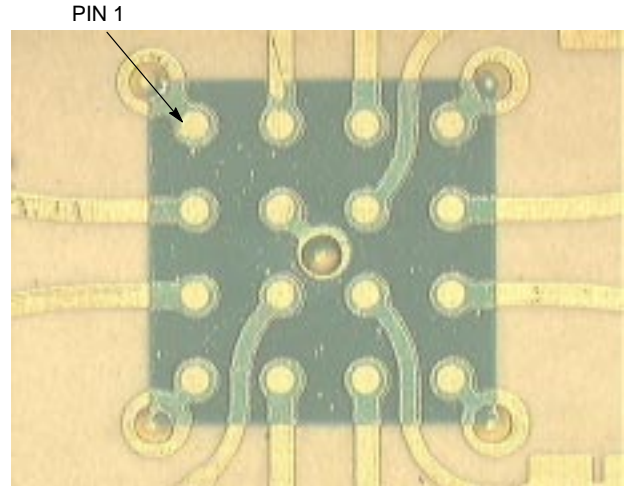
Part No	Description	Manufacturer	WEB address
NBSG86ABA	SiGe Differential Smart Gate with Output Level Select	ON Semiconductor	<a href="http://www.onsemi.com">http://www.onsemi.com</a>
32K243-40ME3	Gold plated connector	Rosenberger	<a href="http://www.rosenberger.de">http://www.rosenberger.de</a>
CO6BLBB2X5UX	2 MHz – 30 GHz capacitor	Dielectric Laboratories	<a href="http://www.dilabs.com">http://www.dilabs.com</a>

**Table 4. Board Material**

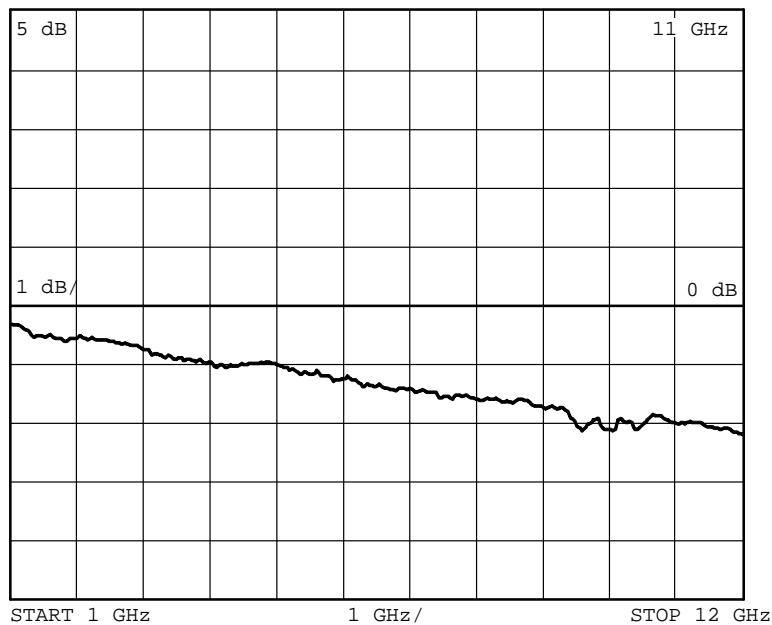
Material	Thickness
Rogers 6002	5.0 mil
Copper Plating	32 mil



**Figure 9. Board Stack-up**



**Figure 10. Layout Mask for NBSG86A**



NOTE: The insertion loss curve can be used to calibrate out board loss if testing under small signal conditions.

**Figure 11. Insertion Loss**

EXAMPLE TIME DOMAIN MEASUREMENT RESULTS

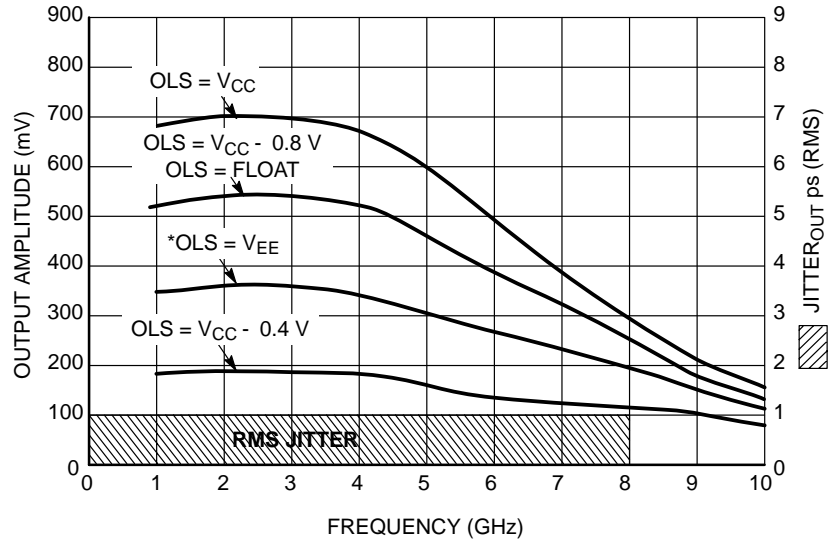


Figure 12.  $V_{OUT}$ /Jitter vs. Frequency (2:1 MUX Function)  
( $V_{CC} - V_{EE} = 3.3\text{ V}$  @  $25^\circ\text{C}$ ; Repetitive 1010 Input Data Pattern)

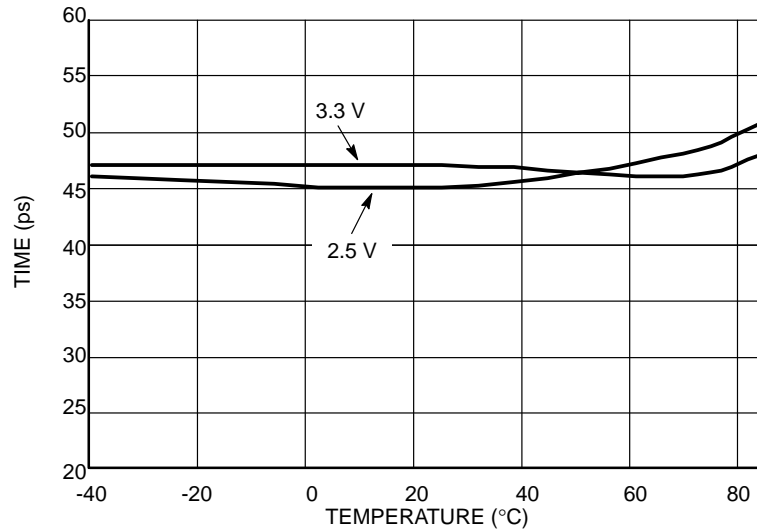


Figure 13.  $t_r$  vs. Temperature and Power Supply

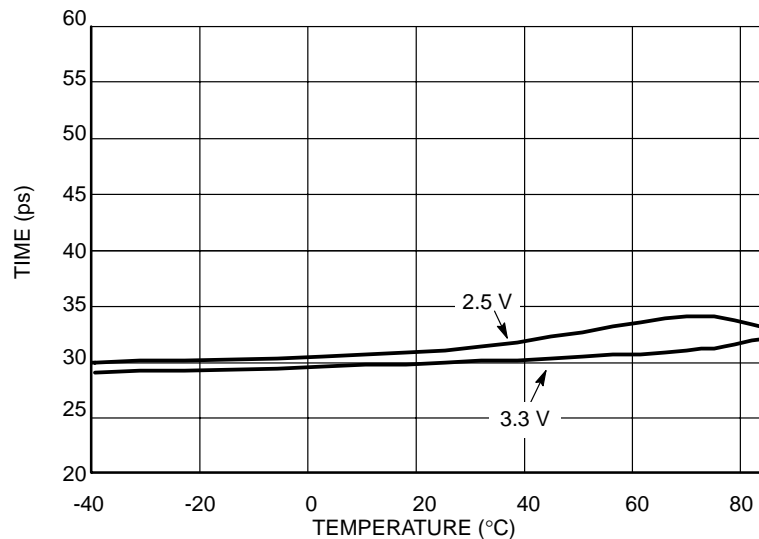
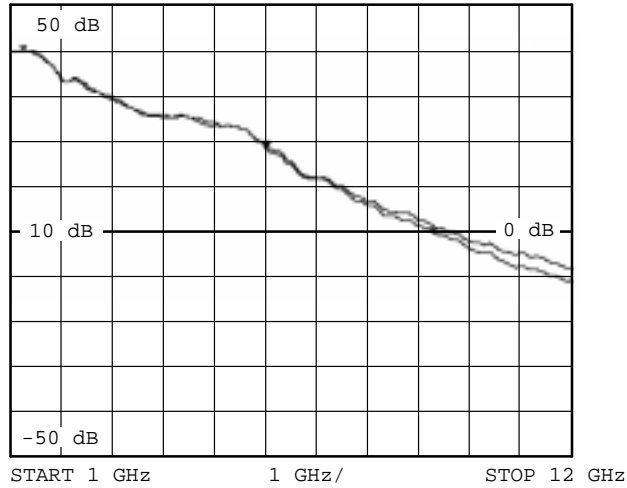


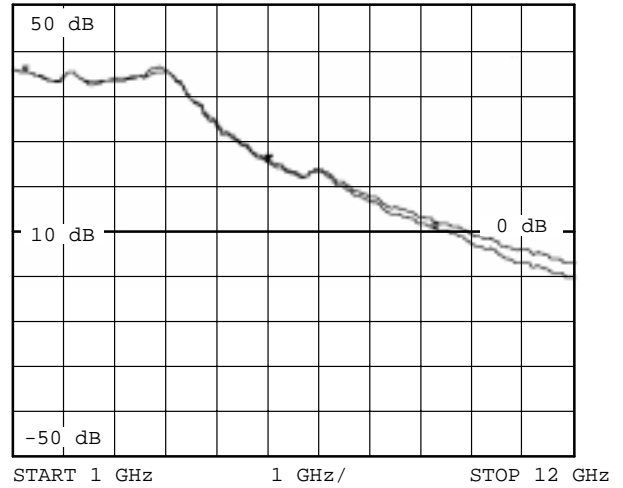
Figure 14.  $t_r$  vs. Temperature and Power Supply

# NBSG86ABAEVB

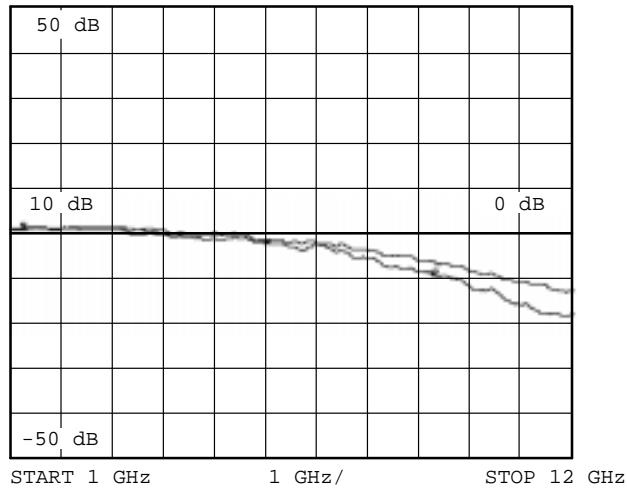
## EXAMPLE FREQUENCY DOMAIN MEASUREMENT RESULTS



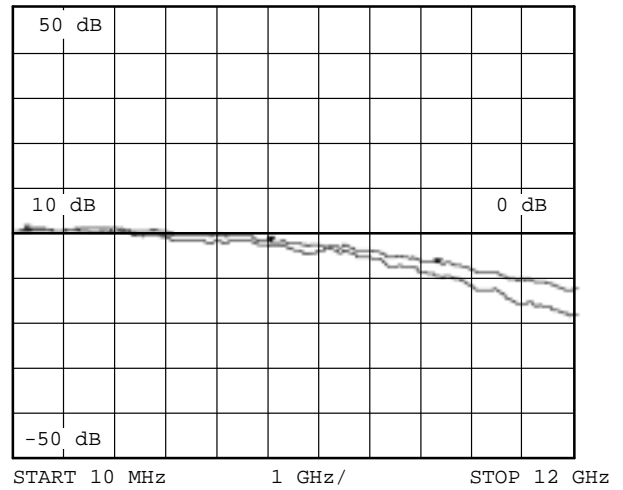
**Figure 15. NBSG86A: Small Signal Gain (S21)**  
**D0/D0 - Q0/Q0**



**Figure 16. NBSG86A: Small Signal Gain (S21)**  
**D1/D1 - Q0/Q0**



**Figure 17. NBSG86A: Large Signal Gain (S21)**  
**D0/D0 - Q0/Q0**



**Figure 18. NBSG86A: Large Signal Gain (S21)**  
**D1/D1 - Q0/Q0**



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- Sample orders for devices and boards
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AND8075/D, Application Note, *Board Mounting Considerations for the FCBGA Packages*

BRD8017/D, Brochure, *Clock and Data Management Solutions*

NBSG86A/D, Data Sheet, 2.5V/3.3V SiGe Differential Smart Gate with Output Level Select

#### References

AND8077/D, Application Note, *GigaComm™ (SiGe) SPICE Modeling Kit*


### ORDERING INFORMATION

Orderable Part No	Description	Package	Shipping
NBSG86ABA	SiGe Differential Smart Gate with Output Level Select	4X4 mm FCBGA/16	100 Units/Tray
NBSG86ABAR2	SiGe Differential Smart Gate with Output Level Select	4X4 mm FCBGA/16	500 Units/Reel
NBSG86ABAEVB	NBSG86A Evaluation Board		

## **Notes**

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