GN1052CW
10/11.3Gb/s
Transimpedance Amplifier

Features

- Single +3.3 V power supply
- Power dissipation =180mW (typ)
- Input Noise Density 10pA/√Hz
- Input noise current = 1µA rms when used with a 0.2pF detector and 1nH input bond wire
- Transimpedance gain = 4kΩ into a 100Ω load (differential)
- Input current overload = 2.6mA pk (+1.1dBm for 1A/W responsivity - meets 10 Gigabit Ethernet specification)
- Upper Bandwidth (-3dB) = 13GHz
- Lower Bandwidth (-3dB) = 24kHz
- Operates at OC-192/STM-64 up to 11.3Gb/s NRZ rates
- Power supply rejection at 100kHz = 16dB
- Optimized for PIN photodiodes
- Can be used with APD (0.4pF) at 10Gb/s
- RSSI (Receive Signal Strength Indicator), current output operates from sensitivity to overload
- Constant photodiode reverse bias voltage = 2V (anode to input, cathode to V_{CC})
- Minimal external components, supply decoupling only
- Operating junction temperature range = -40 to +125°C

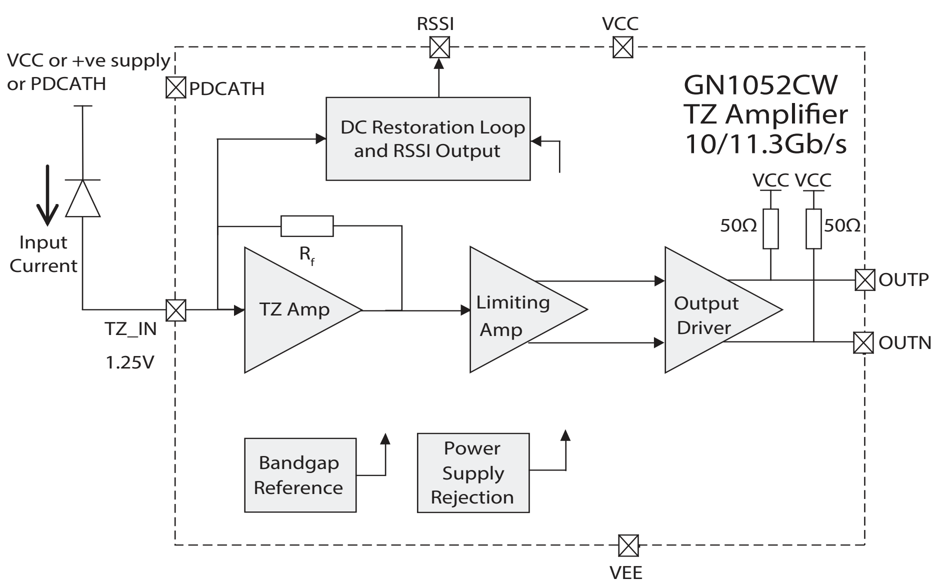
Applications

- SONET/SDH-based transmission systems, test equipment and modules
- OC-192 fibre optic modules and line termination
- 10 Gigabit Ethernet
- Fibre Channel
- Serial data systems up to 11.3Gb/s

Product Description

Semtech offers a portfolio of optical networking ICs for use in high-performance optical transmitter and receiver functions, from 155Mb/s up to 11.3Gb/s.

Semtech's GN1052CW is a fully integrated silicon germanium (Semtech) BiCMOS transimpedance amplifier, providing wideband, low noise preamplication of signal current from a PIN photodiode or APD. It features differential outputs. A decoupling capacitor on the supply is the only external component required. For a system block diagram, see Figure 3-1.



GN1052CW Functional Block Diagram

Revision History

Version	ECO	Date	Changes and / or Modifications
2	023379	January 2015	Removed section on waffle pack description and specs. Applied new template.
1	ECR-135704	January 2005	Changed values for VCC in Recommended Operating Conditions table
0	ECR-133861	May 2004	New document.

Contents

1. Bondpad

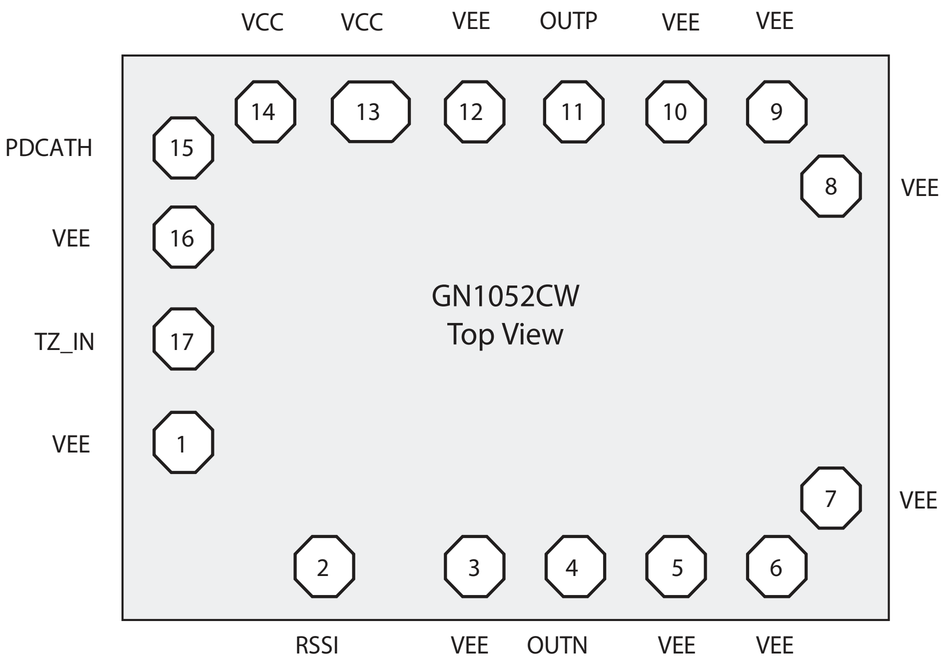


Figure 1-1: Bondpad Diagram

See Figure 4-1 for the bondpad configuration.

Table 1-1: Bondpad Description

Pad No.	Name	Description
1	VEE	Negative supply (0V)
2	RSSI	Received Signal Strength Indicator
3	VEE	Negative supply (0V)
4	OUTN	Negative differential voltage output
5 - 10	VEE	Negative supply (0V)
11	OUTP	Positive differential voltage output
12	VEE	Negative supply (0V)
13	VCC	Positive supply (+3.3 V)
14	VCC	Positive supply (+3.3 V)
15	PDCATH	Bond option: Provides a V_{CC} connection to photodetector cathode if unable to provide a decoupled V_{CC} supply
16	VEE	Negative supply (0V)
17	TZ_IN	Input pad (connect to photodetector anode only)

2. Electrical Characteristics

2.1 Absolute Maximum Ratings

Table 2-1 lists stress ratings only. Exposure to stresses beyond these maximum ratings may cause permanent damage to, or affect the reliability of the device. Avoid operating the device outside the recommended operating conditions defined in Table 2-2.

Table 2-1: Absolute Maximum Ratings

Symbol	Parameter	Min	Max	Unit
V_{CC}	Supply Voltage	-0.7	5.0	V
V_{IO}	Voltage at any input or output	-0.5	V_{CC}+0.5	V
I_{IO}	Current sourced into any input or output except TZ_IN	-20	20	mA
I_{IO}	Current sourced into pin TZ_IN	-5	5	mA
V_{ESD}	Electrostatic Discharge (100 pF, 1.5kΩ) except TZ_IN	-2	2	kV
V_{ESD}	Electrostatic Discharge (100 pF, 1.5kΩ) pin TZ_IN	-0.1	0.1	kV
T_{STG}	Storage Temperature	-65	150	°C

Table 2-2: Recommended Operating Conditions

Symbol	Parameter	Min	Typ	Max	Unit
V_{CC}	Supply Voltage	3.1	3.3	3.5	V
T_J	Operating Junction Temperature	-40	—	125	°C

2.2 DC Electrical Characteristics

Table 2-3: DC Electrical Characteristics

Conditions: V_{CC} = 3.1 to 3.5V, T_J = -40 to 125°C

Symbol	Parameter	Min	Typ	Max	Unit	Note
I_{CC}	Supply Current	43	55	73	mA	1
V_{IN}	Input Bias Voltage	V_{CC} -2.1	V_{CC} -2.05	V_{CC} -2.0	V	
V_{OUT}	Output Bias Voltage	—	V_{CC} -0.145	—	V	
R_{OUT}	Output Resistance	40	50	60	Ω	
V_{COMP}	Compliance Voltage for the RSSI output	—	—	V_{CC} -0.6	V	
$RSSI_s$	RSSI Sensitivity	0.5	1.0	1.5	mA/mA	2
$RSSI_o$	RSSI Output Offset	—	—	35	µA	3

Notes:

1. Maximum I_{CC} is 77mA if RSSI is connected under the condition of 1.3mA input mean current
2. Under the condition of IDC input current from 0 to 1.3mA
3. Under the condition of IDC input current of 0

2.3 AC Electrical Characteristics

Table 2-4: AC Electrical Characteristics

Conditions: V_{CC} = 3.1 to 3.5V, T_J = -40 to 125°C, R_L = 50Ω AC coupled via 100nF for each output, Cd (photodetector capacitance) = 0.2pF, Li (input bondwire inductance) = 1nH (see note 6), Photodiode responsivity = 1 A/W, Photodiode series resistance = 10Ω max.

Symbol	Parameter	Min	Typ	Max	Unit	Note
BW (3dB)	Small Signal Upper Bandwidth at –3dB point	9.0	12.9	15.0	GHz	1, 2, 6
T_Z	Differential Transimpedance (50Ω on each output, f = 100MHz)	2.3	4.0	5.7	kΩ	1, 7
Dri	Input Data Rate	—	—	11.3	Gb/s	
V_{OUTMAX}	Maximum Differential Output Voltage	—	—	330	mV pk-pk	1, 3
BW_{LF} (3dB)	Small Signal Lower Bandwidth at –3dB point	—	24	52	kHz	1, 4, 10
$RSSI_{BW}$	RSSI Bandwidth at -3dB point	—	—	38	KHz	
PSRR	Power Supply Rejection Ratio (differential) up to 100kHz	—	16	—	dB	1

Table 2-4: AC Electrical Characteristics (Continued)

Conditions: V_{CC} = 3.1 to 3.5V, T_J = -40 to 125°C, R_L = 50Ω AC coupled via 100nF for each output, Cd (photodetector capacitance) = 0.2pF, Li (input bondwire inductance) = 1nH (see note 6), Photodiode responsivity = 1 A/W, Photodiode series resistance = 10Ω max.

Symbol	Parameter	Min	Typ	Max	Unit	Note
O_{LIM}	Onset of Limiting (mean input current from photodiode)	30	41	—	µA mean	1, 5
I_{OL}	Input Current before overload (11.3Gb/s NRZ data)	2600	—	—	µA pk-pk	1
P_{OL}	Optical Overload	+1.1	—	—	dBm	1
td	Group Delay Ripple (100MHz to 10GHz)	—	35	—	ps pk-pk	1, 9
N_{RMS}	Input Noise Current (in 10 GHz noise bandwidth)	—	1.0	1.46	µA rms	1
N_{RMS}/°C	Input Noise Current Variation over Temperature	—	2.11	2.59	nA/°C	8

Notes:

1. Typical values defined as typical process, T_J at 27°C and V_{CC} at 3.3V while minimum and maximum values are under worst or best case process, power supply and junction temperature for the parameter specified.
2. Minimum bandwidth is due to slow process, T_J at 125°C and V_{CC} at 3.1V with the input bond wire increased to 1.3nH to provide less than 1dB gain peak. Maximum bandwidth is due to fast process, T_J at -40°C and V_{CC} at 3.5V with the input bond wire reduced to 600pH to provide less than 1dB gain peak.
3. Under the condition of 2.6mApp input current, 1.3mA mean (infinite extinction ratio).
4. Maximum lower bandwidth is under the conditions of 1.3mA mean input current.
5. Onset of limiting is defined as the 2nd derivative of the output voltage verse input current characteristic.
6. Input bond wire is defined as the sum of the bond wire from the anode to TZ_IN, and the cathode to an AC ground (ie. de-coupling capacitor or PDCATH, see Recommended Bonding Arrangement).
7. Measured at sensitivity (ie mean S/N x N_{RMS} =7.03 x 1µA).
8. Typical value defined as typical process, V_{CC} at 3.3V over a junction temperature range of -40°C to 125°C, while maximum value is defined as worst case process for noise, V_{CC} at 3.1V over a junction temperature range of -40°C to 125°C
9. Group Delay Ripple does not assume any transmission line delay as a result of connecting the output ports to an external connector. The group delay ripple is also a function of the input bond wire inductance used (see Bondwire Inductance Effects).
10. Lower bandwidth specified is represented by the device only, ie the AC coupling of the output ports is not included.

3. Detailed Description

3.1 Amplifier Front-End

The transimpedance front-end amplifies the current from a PIN photodetector (anode connected to pad TZ_IN), to produce a single-ended voltage with the feedback resistor Rf, determining the level of amplification (see GN1052CW Functional Block Diagram).

The input pad TZ_IN is biased at 2V below the supply voltage V_{CC}, allowing a photodetector to have a constant reverse bias by connecting the cathode to 3.3V. This enables full single rail operation and normally ensures that the photodetector operates in its constant, low-capacitance region.

3.2 DC Restoration Loop

A DC restoration loop is used to remove the DC component from the input signal. This has the desired effect of ensuring that the transimpedance front-end bias conditions are not altered even in the presence of high extinction ratios, thus reducing pulse width distortion.

3.3 Limiting Voltage Amplifier

The single ended voltage output from the transimpedance front-end is amplified by a high gain voltage amplification stage and converted to a differential signal to be applied to the output 50Ω driver stage.

3.4 Output Driver Stage

The output driver acts as a buffer stage, capable of swinging up to 330mV pk-pk differential into a 100Ω load. An increasing current sourced into TZ_IN results in a positive-going output signal on the OUTP pin.

It is recommended that the outputs be AC coupled into a fully balanced 100Ω output load.

3.5 Power Supply Rejection

An on-chip power supply rejection circuit is used to achieve a differential rejection from the +3.3V V_{CC} rail. This rejection ensures that performance is not degraded by noise on the power supply. The circuit achieves a power supply rejection on the outputs of 16dB for differential operation, up to 100kHz. The use of external decoupling will help to remove any unwanted signals at higher frequencies.

3.6 Received Signal Strength Indicator (RSSI)

A current output is provided which represents the mean current flowing through the photodiode detector (PIN diode or APD) with a 1:1 ratio of current. This mean current is provided from sensitivity to overload and can be terminated by an external precision resistor to ground provided the compliance voltage is adhered to. Alternatively the RSSI output may be connected to an input of a current mode ADC. A graph illustrating the RSSI function with mean input current and junction temperature is shown in Figure 3-2.

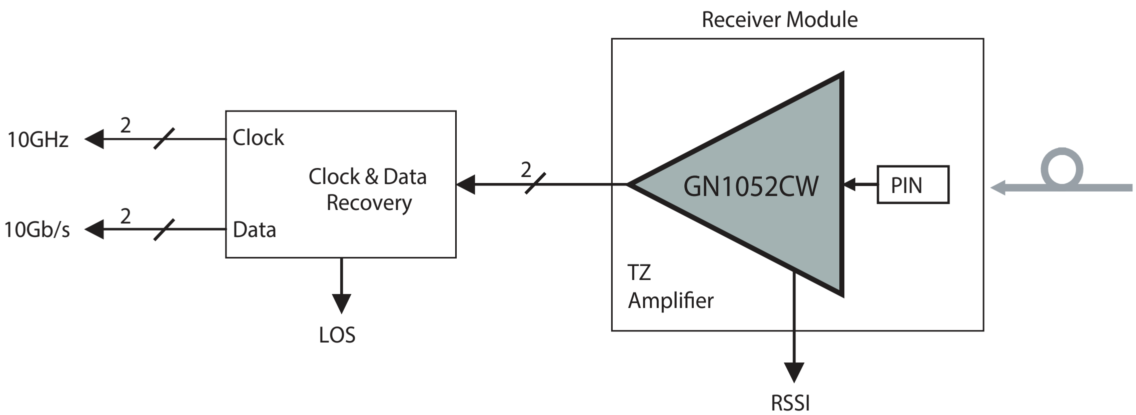


Figure 3-1: System Block Diagram

Figure 3-2 shown below illustrates the RSSI signal characteristic in operation from sensitivity to overload. The response is shown for 3 different temperatures.

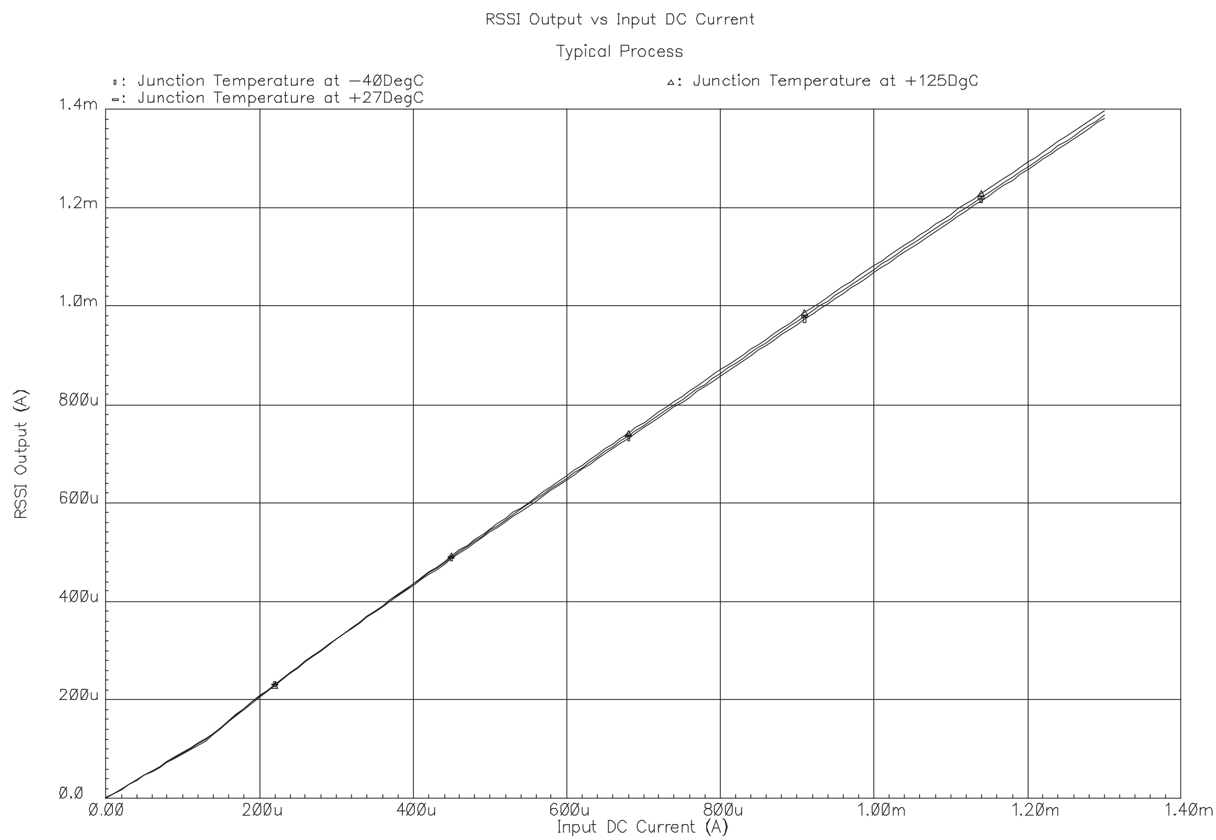


Figure 3-2: RSSI Response

4. Bondpad Configuration

The bondpad center coordinates in Table 4-1 are referenced to the center of the lower left pad (pad 1). All dimensions are in microns (µm).

Table 4-1: Bondpad Configuration

Pad No.	Name	X Coordinate (µm)	Y Coordinate (µm)
1	VEE	0	0
2	RSSI	205.00	-175.00
3	VEE	430.00	-175.00
4	OUTN	580.00	-175.00
5	VEE	730.00	-175.00
6	VEE	880.00	-175.00
7	VEE	960.00	-82.07
8	VEE	960.00	367.93
9	VEE	880.00	475.00
10	VEE	730.00	475.00
11	OUTP	580.00	475.00
12	VEE	430.00	475.00
13	VCC	270.50	475.00
14	VCC	125.00	475.00
15	PDCATH	0	425.00
16	VEE	0	300.00
17	TZ_IN	0	150.00

Figure 4-1 below shows the bondpad configuration of the GN1052CW Transimpedance Amplifier. Note that the diagram is not to scale. All bondpads are 78µm x 78µm apart from Pad 13 which is 120µm x 78µm. There are two V_{CC} pads which allow room for three VCC wire bonds. There are ten VEE pads. All VCC and all VEE pads respectively are connected on-chip.

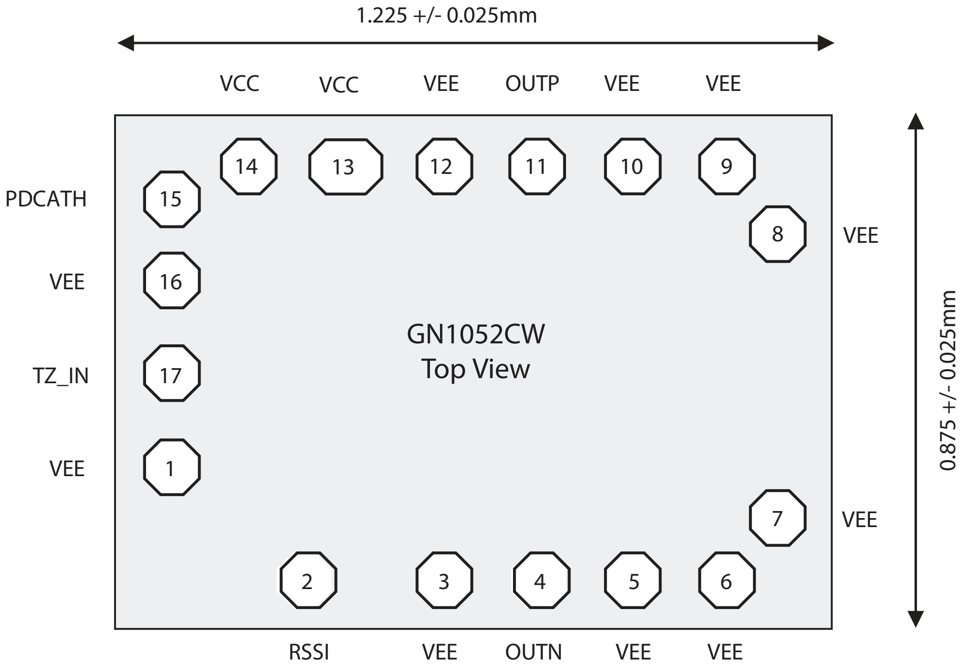


Figure 4-1: Bondpad Configuration

Note: Mechanical die visual inspection criteria per mil-std-883 method 2010.10 condition b class level b.

5. Applications Information

For optimum high frequency performance the bonding arrangement must comply with the diagram below. All VCC pads must be wire bonded with an inductance value no greater than the maximum shown. However, whilst it is recommended that all VEE pads are wire bonded, if this is not possible, a minimum of five pads (3 & 5 – 8) must be bonded. In addition, it is recommended that two de-coupling capacitors are used within the optical module; one to de-couple the IC, and the other to de-couple the photodiode using the recommended values and connectivity shown in Figure 5-1.

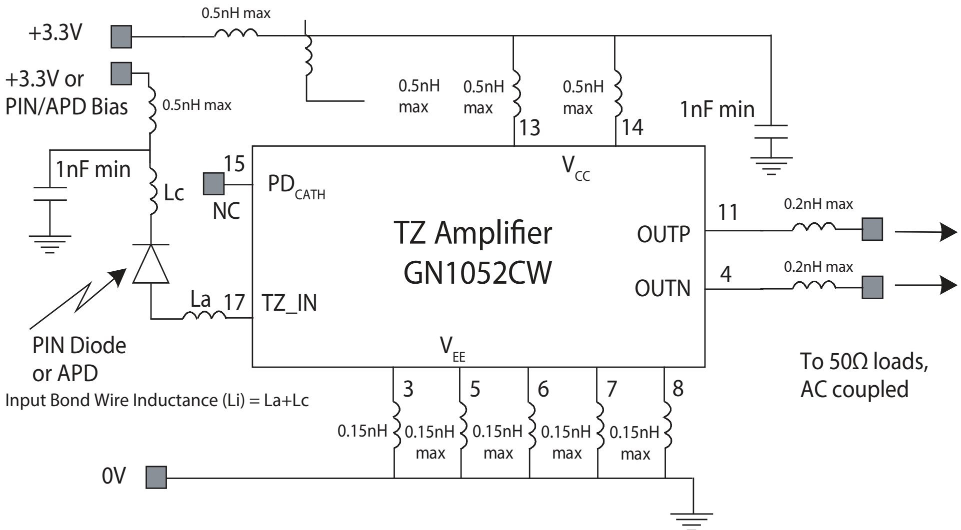


Figure 5-1: Bonding Arrangement for Optimum High-Frequency Performance

If using only one de-coupling capacitor within the optical module, the bonding arrangement must comply with Figure 5-2. All VCC pads must be wire bonded with an inductance not exceeding the maximum shown. However, whilst it is recommended that all VEE pads are wire bonded, if this is not possible, a minimum of six must be bonded.

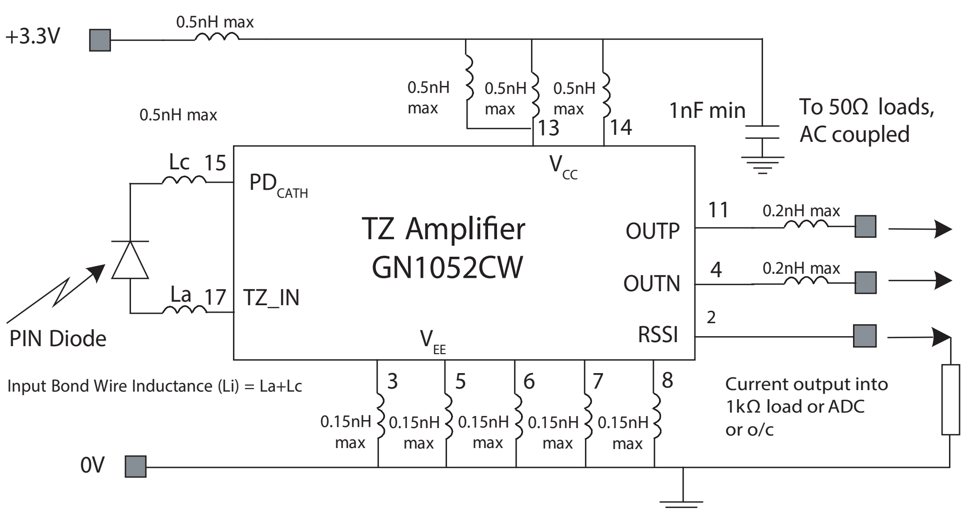


Figure 5-2: Bonding Arrangement if Using Only One De-Coupling Capacitor Within the Optical Module

As a guide to the effect of bondwire length on inductance, Table 5-1 gives some examples of observed inductance per millimeter for popular gold bondwire diameters. The effect of input bondwire inductance (Li) on Bandwidth, Input Referred Noise, Gain Peak and Peak-Peak Group Delay Ripple are shown in Figure 5-3.

Table 5-1: Observed Inductance for Three Bondwire Diameters

Bondwire Diameter (μm)	Inductance per mm (nH)
25	0.81
30	0.77
32	0.76

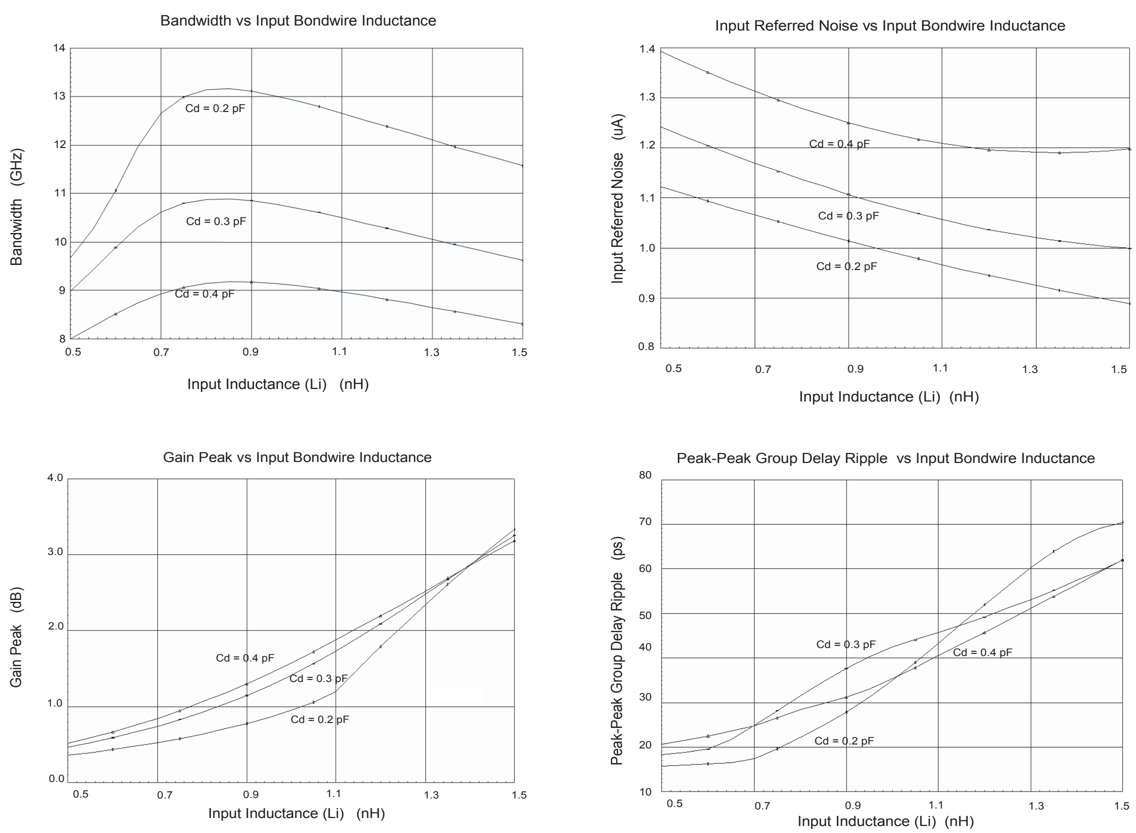


Figure 5-3: Bondwire Inductive Effects

6. Package & Ordering Information

6.1 Ordering Information

Table 6-1: Ordering Information

Part Number	Package
GN1052CW-CHIP	Bare Die

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