features

- **10.7-Gbps Operation**
- **116-mW Power Consumption**
- **Input Offset Cancellation**
- **High Input Dynamic Range**
- **Output Disable**
- **CML Data Outputs**
- **2-mV$_{p-p}$ Input Sensitivity**
- **Loss of Signal Detection**
- **Single 3.3-V Supply**
- **Surface Mount Small Footprint 4 mm × 4 mm, 20-Pin QFN Package**

applications

- **SONET/SDH Transmission Systems at OC−192**
- **10-Gbps Fibre Channel Receivers**
- **10-Gbps Ethernet Receivers**

description

The ONET9901PA is a versatile high-speed limiting amplifier for multiple fiber optic applications with data rates up to 10.7 Gbps.

This device provides a typical gain of about 42 dB, which ensures a fully differential output swing for input signals as low as 2 mV$_{p-p}$.

The high input signal dynamic range ensures low jitter output signals, even when overdriven with input signal swings as high as 1200 mV$_{p-p}$.

The ONET9901PA comprises an adjustable loss of signals detection. The threshold voltage can be defined by means of an external resistor.

The ONET9901PA is available in a small footprint 4 mm × 4 mm, 20-pin QFN package.

The ONET9901PA is a power efficient limiting amplifier with power dissipation as low as 116 mW typical from a single 3.3-V supply. The part is characterized for operation from 0°C to 85°C.

block diagram

A simplified block diagram of the ONET9901PA is shown in Figure 1.

These compact, low power 10.7-Gbps limiting amplifier consists of a high-speed data path with offset cancellation block, a loss of signal detection block, and a bandgap voltage reference and bias current generation block.

The limiting amplifier requires a single 3.3-V supply voltage. All circuit parts are described in detail below.

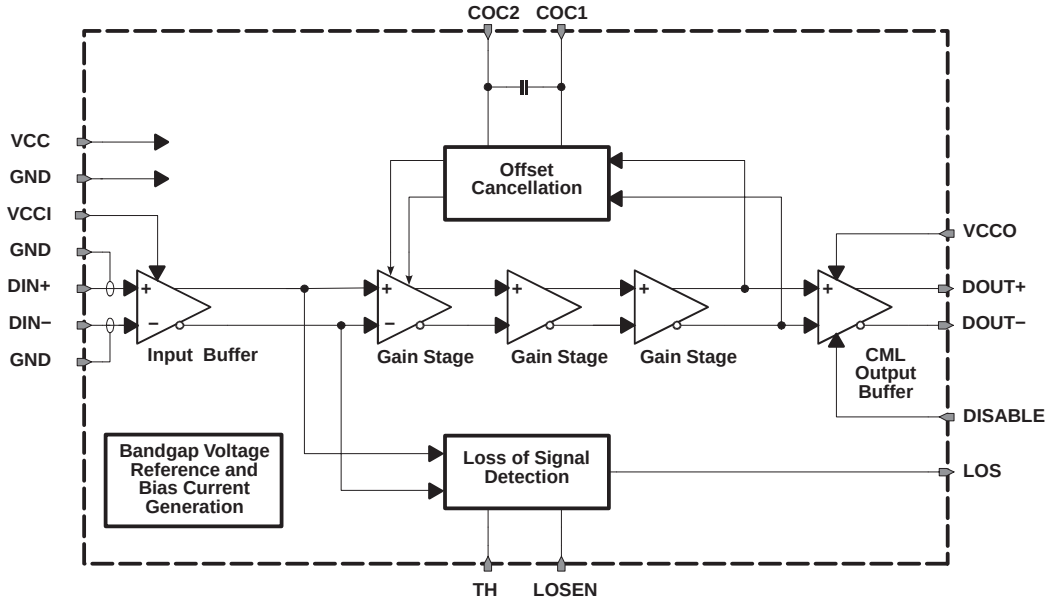


Figure 1. Block Diagram

high-speed data path

The high-speed data signal is applied to the data path by means of the input signal pins DIN+/DIN–. The data path consists of the input stage with 2 × 50-Ω on-chip line termination to VCCI, three gain stages, which provide the required typical gain of about 42 dB, and a CML output stage.

Next to the input signal pins shielding ground pins GND are provided. These pins must have a good external ground connection for best performance at low input signal amplitudes.

The amplified data output signal is available at the output pins DOUT+/DOUT–, which provide 2 × 50-Ω back-termination to VCCO. The output stage also includes a disable function, controlled by the signal applied to the DISABLE input pin.

An offset cancellation compensates inevitable internal offset voltages and thus ensures proper operation even for small input data signals.

The low frequency cutoff is as low as 42 kHz with the built-in filter capacitor.

For applications, which require even lower cutoff frequencies, an additional external filter capacitor may be connected to the COC1/COC2 pins.

loss of signal and RSSI detection

The output signal of the input buffer is monitored by the loss of signal detection circuitry. This circuit block compares the input signal to a threshold, which can be programmed by means of an external resistor connected to the TH pin. If the input signal falls below the specified threshold, a loss of signal is indicated at the LOS pin.

For use in applications, which do not require a loss of signal function, this circuit block can be shut down by connecting the LOSEN pin to GND.

bandgap voltage and bias generation

The ONET9901PA limiting amplifier is supplied by a single 3.3-V ±10% supply voltage connected to the VCC, VCCI, and VCCO pins. This voltage is referred to ground (GND).

An on-chip bandgap voltage circuitry generates a supply voltage independent reference from which all other internally required voltages and bias currents are derived.

package

For the ONET9901PA a small footprint 4 mm × 4 mm, 20-pin QFN package is used with a lead pitch of 0,5 mm. The pinout is shown in Figure 2.

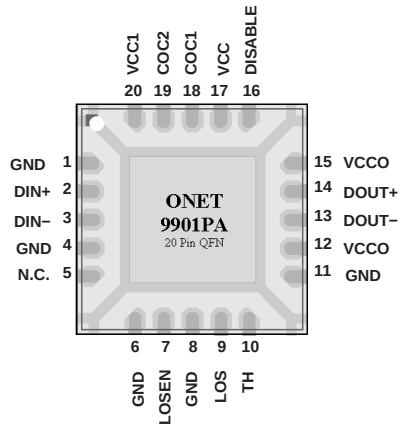


Figure 2. Pinout of ONET9901PA in a 4 mm × 4 mm 20-Pin QFN Package

terminal functions

The following table shows a pin description for the ONET9901PA in a 4 mm x 4 mm 20-pin QFN package.

TERMINAL		TYPE	DESCRIPTION
NAME	NO.		
GND	1, 4, 6, 8, 11, EP	Ground	Circuit ground. The exposed die pad (EP) must be grounded.
DIN+	2	Analog in	Noninverted data input. On-chip 50-Ω terminated to VCCI
DIN–	3	Analog in	Inverted data input. On-chip 50-Ω terminated to VCCI
NC	5		Not connected
LOSEN	7	CMOS in	Enables loss off signal circuitry when set to high level (VCC)
LOS	9	CMOS out	A high level indicates that the input signal amplitude is below the programmed threshold level.
TH	10	Analog in	LOS threshold adjustment with resistor to GND
VCCO	12, 15	Supply	3.3-V ±10% supply voltage for output stage
DOUT–	13	CML out	Inverted data output. On-chip 50-Ω back-terminated to VCCO
DOUT+	14	CML out	Noninverted data output. On-chip 50-Ω back-terminated to VCCO
DISABLE	16	CMOS in	Disables CML output stage when set to high level
VCC	17	Supply	3.3-V ±10% supply voltage
COC1	18	Analog	Offset cancellation filter capacitor terminal 1. Connect an additional filter capacitor between this pin and COC2 (pin 19). To disable the offset cancellation loop, connect COC1 and COC2 (pins 18 and 19).
COC2	19	Analog	Offset cancellation filter capacitor terminal 2. Connect an additional filter capacitor between this pin and COC1 (pin 18). To disable the offset cancellation loop, connect COC1 and COC2 (pins 18 and 19).
VCCI	20	Supply	3.3-V ±10% supply voltage for input stage.

absolute maximum ratings

over operating free-air temperature range unless otherwise noted†

		VALUE	UNIT
V_{CC}, V_{CCI}, V_{CCO}	Supply voltage, See Note 1	–0.3 to 4	V
V_{DIN+}, $V_{DIN–}$	Voltage at DIN+, DIN–, See Note 1	0.5 to 4	V
V_{TH}, $V_{DISABLE}$, V_{LOS}, V_{LOSEN}, V_{DOUT+}, $V_{DOUT–}$, V_{COC1}, V_{COC2}	Voltage at TH, DISABLE, LOS, LOSEN, DOUT+, DOUT–, COC1, COC2, See Note 1	–0.3 to 4	V
$V_{COC,DIFF}$	Differential voltage between COC1 and COC2	±1	V
$V_{DIN,DIFF}$	Differential voltage between DIN+ and DIN–	±2.5	V
I_{LOS}	Current into LOS	–1 to 9	mA
I_{DIN+}, $I_{DIN–}$, I_{DOUT+}, $I_{DOUT–}$	Continuous current at inputs and outputs	–25 to 25	mA
ESD	ESD rating at all pins except DIN+, DIN–, DOUT+, DOUT–	2	kV (HBM)
ESD	ESD rating at DIN+, DIN–, DOUT+, DOUT–	1	kV (HBM)
$T_{J(max)}$	Maximum junction temperature	125	°C
T_{stg}	Storage temperature range	−65 to 85	°C
T_A	Characterized free-air operating temperature range	0 to 85	°C
T_L	Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds	260	°C

† Stresses beyond those listed under “absolute maximum ratings” may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under “recommended operating conditions” is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

NOTE 1: All voltage values are with respect to network ground terminal.

recommended operating conditions

	MIN	TYP	MAX	UNIT
Supply voltage, V_{CC}, V_{CCI}, V_{CCO}	3	3.3	3.6	V
Operating free-air temperature, T_A	0		85	°C

dc electrical characteristics

over recommended operating conditions (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
V_{CC},V_{CCI},V_{CCO}	Supply voltage		3	3.3	3.6	V
I_{CC}	Supply current	LOSEN = high, DISABLE = low, V_{TH} = 50 mV_{p-p}		35	55	mA
		LOSEN = low, DISABLE = low		25	35	
V_{OD}	Differential data output voltage swing	DISABLE = high		0.25	10	mV_{p-p}
		DISABLE = low	190	240	400	
V_{OC}	Common-mode output voltage			V_{CC} – 0.075		V
r_o	Data output resistance	Single ended		50		Ω
$r_{(IND)}$	Data input resistance	Differential		100		Ω
$V_{(INMIN)}$	Data input sensitivity	$V_{OD(min)} \geq 0.95 \times V_{OD}$ (at V_{IN} = 10 mV)		2		mV_{p-p}
		BER < 10^{-12}, 2^{23}–1 PRBS, 10.7 Gbps		6		
$V_{(INMAX)}$	Data input overload		1200			mV_{p-p}
	CMOS input high voltage	DISABLE. LOSEN	2.1			V
	CMOS input low voltage	DISABLE, LOSEN			0.6	V
	LOS high voltage		2.4			V
	LOS low voltage				0.4	V
	LOS hysteresis	5 mV_{p-p} < V_{TH} < 40 mV_{p-p}	2.5	4.5	6.2	dB
V_{TH}	LOS assert threshold range			2–50		mV_{p-p}

ac electrical characteristics

over recommended operating conditions (unless otherwise noted) typical operating condition is at V_{CC} = 3.3 V and T_A = 25°C

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
BW	Small-signal bandwidth			10		GHz
	Low frequency −3-dB bandwidth	C_{OC} = open		42	75	kHz
				8		
	Data rate		10.7			Gb/s
DJ	Deterministic jitter	5 mV_{p-p}, 10-mV_{p-p} input, K28.5 pattern at 10.7 Gbps		5.2	16	ps_{p-p}
		800 mV_{p-p}, 1200-mV_{p-p} input, K28.5 pattern at 10.7 Gbps		1.8	11	
RJ	Random jitter	20 mV_{p-p} up to 1200-mV_{p-p} input		0.6	1.1	ps_{RMS}
t_r	Output rise time	20% to 80%		20		ps
t_f	Output fall time	20% to 80%		20		ps
t_{DIS}	Disable response time			20		ns
t_{LOS}	LOS assert/deassert time			250		ns

APPLICATION INFORMATION

Figure 3 shows the ONET9901PA in a 4 mm × 4 mm 20-pin package connected with an ac-coupled interface to the data signal source as well as to the output load.

Besides the ac-coupling capacitors C_1 through C_4 in the input and output data signal lines, the only required external component is the LOS threshold setting resistor R_{TH}. In addition, an optional external filter capacitor (C_{OC}) may be used if a lower cutoff frequency is desired.

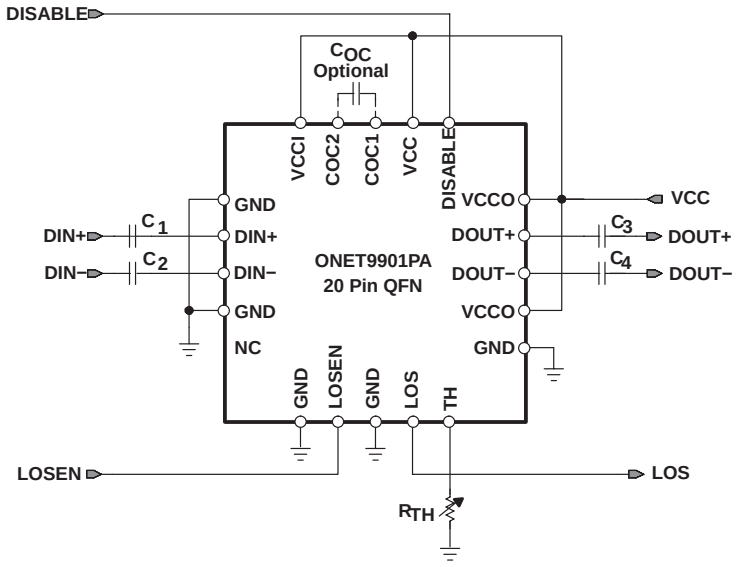


Figure 3. Basic Application Circuit for the ONET9901PA in a 4 mm × 4 mm, 20-Pin QFN Package With AC-Coupled I/Os

PACKAGING INFORMATION

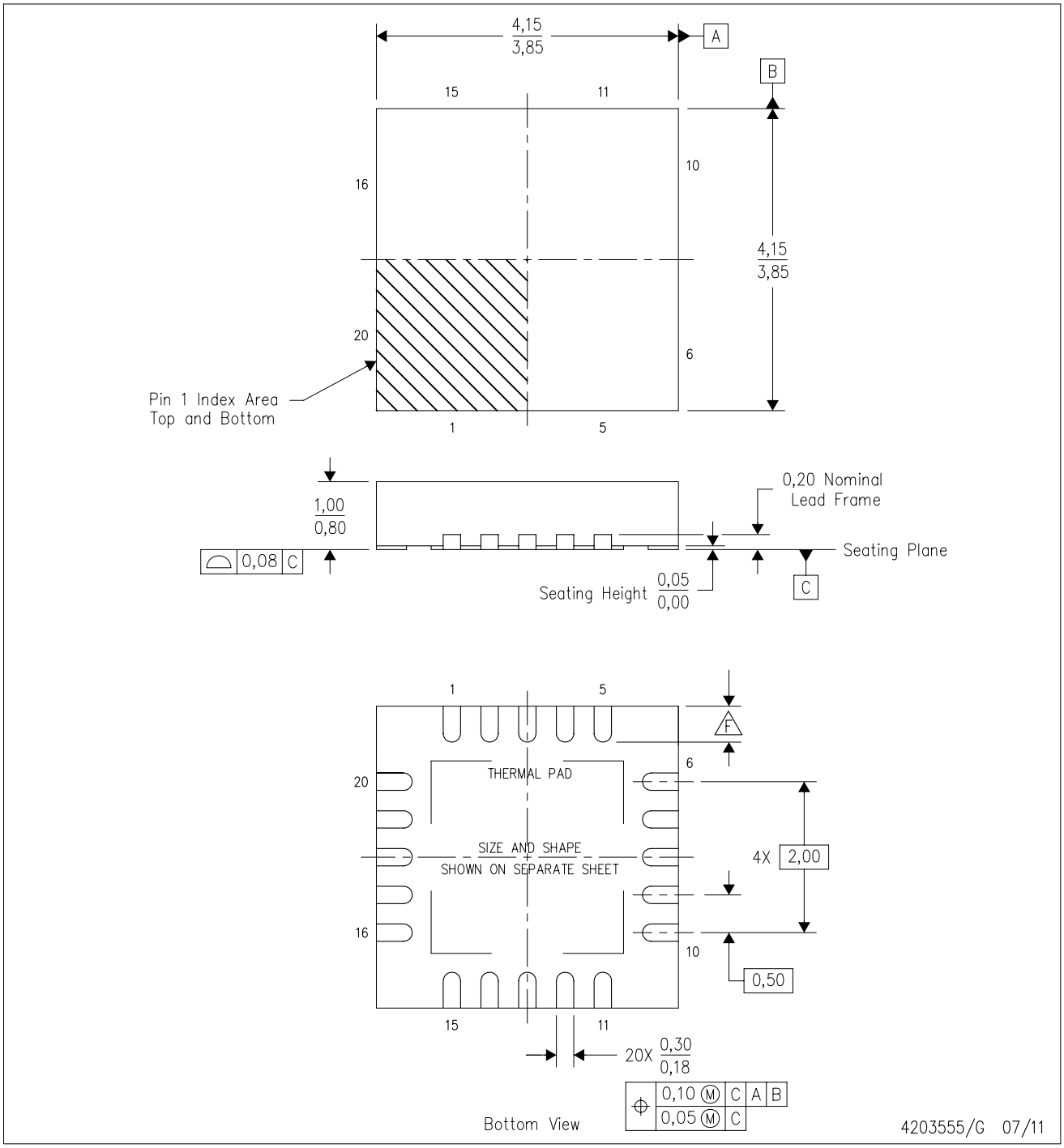
Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish	MSL Peak Temp (3)
ONET9901PARGP	NRND	QFN	RGP	20	91	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR
ONET9901PARGPG4	NRND	QFN	RGP	20	91	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1 YEAR

(1) The marketing status values are defined as follows:
ACTIVE: Product device recommended for new designs.
LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.
NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.
PREVIEW: Device has been announced but is not in production. Samples may or may not be available.
OBSOLETE: TI has discontinued the production of the device.

(2) Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check http://www.ti.com/productcontent for the latest availability information and additional product content details.
TBD: The Pb-Free/Green conversion plan has not been defined.
Pb-Free (RoHS): TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.
Pb-Free (RoHS Exempt): This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.
Green (RoHS & no Sb/Br): TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

(3) MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

RGP (S–PVQFN–N20) PLASTIC QUAD FLATPACK NO–LEAD



NOTES:
A. All linear dimensions are in millimeters. Dimensioning and tolerancing per ASME Y14.5M–1994.
B. This drawing is subject to change without notice.
C. QFN (Quad Flatpack No–Lead) package configuration.
D. The package thermal pad must be soldered to the board for thermal and mechanical performance.
E. See the additional figure in the Product Data Sheet for details regarding the exposed thermal pad features and dimensions.
F. Check thermal pad mechanical drawing in the product datasheet for nominal lead length dimensions.

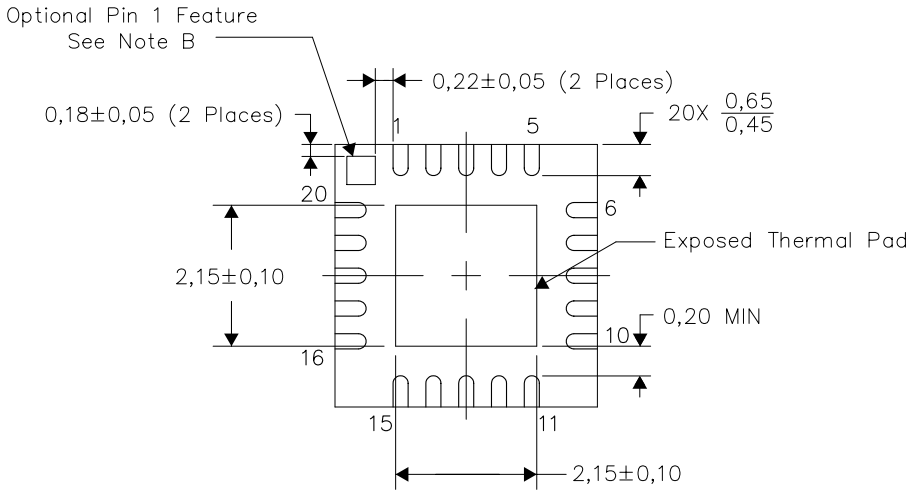
RGP (S–PVQFN–N20) PLASTIC QUAD FLATPACK NO–LEAD

THERMAL INFORMATION

This package incorporates an exposed thermal pad that is designed to be attached directly to an external heatsink. The thermal pad must be soldered directly to the printed circuit board (PCB). After soldering, the PCB can be used as a heatsink. In addition, through the use of thermal vias, the thermal pad can be attached directly to the appropriate copper plane shown in the electrical schematic for the device, or alternatively, can be attached to a special heatsink structure designed into the PCB. This design optimizes the heat transfer from the integrated circuit (IC).

For information on the Quad Flatpack No–Lead (QFN) package and its advantages, refer to Application Report, QFN/SON PCB Attachment, Texas Instruments Literature No. SLUA271. This document is available at www.ti.com.

The exposed thermal pad dimensions for this package are shown in the following illustration.



Bottom View

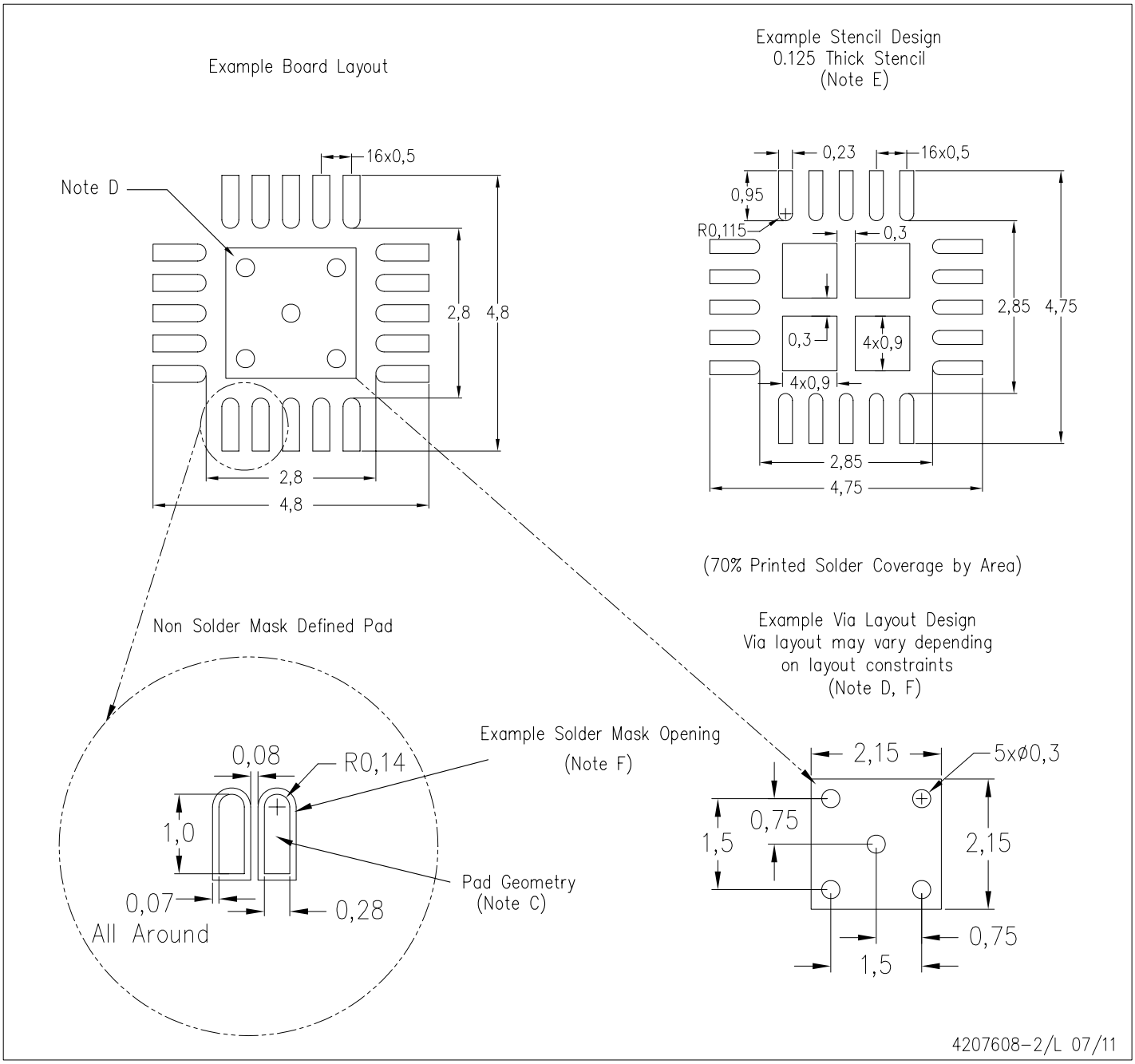
Exposed Thermal Pad Dimensions

4206346–2/W 07/11

NOTES: A. All linear dimensions are in millimeters

B. The Pin 1 Identification mark is an optional feature that may be present on some devices In addition, this Pin 1 feature if present is electrically connected to the center thermal pad and therefore should be considered when routing the board layout.

RGP (S–PVQFN–N20) PLASTIC QUAD FLATPACK NO–LEAD



NOTES:
A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
C. Publication IPC–7351 is recommended for alternate designs.
D. This package is designed to be soldered to a thermal pad on the board. Refer to Application Note, Quad Flat–Pack Packages, Texas Instruments Literature No. SLUA271, and also the Product Data Sheets for specific thermal information, via requirements, and recommended board layout. These documents are available at www.ti.com <http://www.ti.com>.
E. Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact their board assembly site for stencil design recommendations. Refer to IPC 7525 for stencil design considerations.
F. Customers should contact their board fabrication site for recommended solder mask tolerances and via tenting recommendations for vias placed in the thermal pad.

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