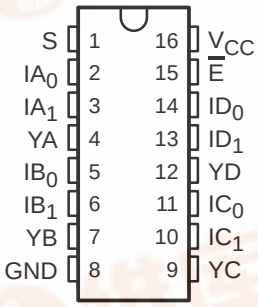
TS5L100
QUAD SPDT WIDE-BANDWIDTH LAN SWITCH WITH LOW ON-STATE RESISTANCE

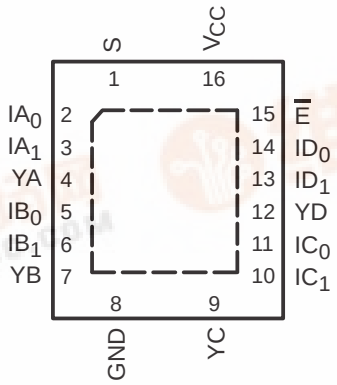
SCDS163A – MAY 2004 – REVISED MAY 2004

- Wide Bandwidth (BW = 300 MHz Min)
- Low Differential Crosstalk (X_{TALK} = −60 dB Typ)
- Low Power Consumption (I_{CC} = 3 μA Max)
- Bidirectional Data Flow, With Near-Zero Propagation Delay
- Low ON-State Resistance (r_{on} = 3 Ω Typ)
- V_{CC} Operating Range From 6 V to 6.5 V
- I_{off} Supports Partial-Power-Down Mode Operation
- Data and Control Inputs Provide Undershoot Clamp Diode
- Latch-Up Performance Exceeds 100 mA Per JESD 78, Class II
- ESD Performance Tested Per JESD 22
  - 2000-V Human-Body Model (A114-B, Class II)
  - 1000-V Charged-Device Model (C101)
- Suitable for Both 10 Base-T/100 Base-T Signaling

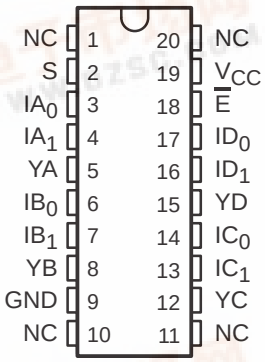
D OR DBQ PACKAGE
(TOP VIEW)



RGY PACKAGE
(TOP VIEW)



PW PACKAGE
(TOP VIEW)



NC – No internal connection

description/ordering information

The TI TS5L100 LAN switch is a 4-bit 1-of-2 multiplexer/demultiplexer with a single switch-enable ($\overline{E}$) input. When $\overline{E}$ is low, the switch is enabled and the I port is connected to the Y port. When $\overline{E}$ is high, the switch is disabled and the high-impedance state exists between the I and Y ports. The select (S) input controls the data path of the multiplexer/demultiplexer.

ORDERING INFORMATION

T_A	PACKAGE†		ORDERABLE PART NUMBER	TOP-SIDE MARKING
0°C to 70°C	QFN – RGY	Tape and reel	TS5L100RGYR	TG100
	SOIC – D	Tube	TS5L100D	TS5L100
		Tape and reel	TS5L100DR	
	SSOP (QSOP) – DBQ	Tape and reel	TS5L100DBQR	TG100
	TSSOP – PW	Tube	TS5L100PW	TG100
		Tape and reel	TS5L100PWR	

† Package drawings, standard packing quantities, thermal data, symbolization, and PCB design guidelines are available at www.ti.com/sc/package.

description/ordering information (continued)

This device can be used to replace mechanical relays in LAN applications. This device has low r_{on}, wide bandwidth, and low differential crosstalk, making it suitable for 10 Base-T, 100 Base-T, and various other LAN applications.

This device is fully specified for partial-power-down applications using I_{off}. The I_{off} feature ensures that damaging current will not backflow through the device when it is powered down. The device has isolation during power off.

To ensure the high-impedance state during power up or power down, $\overline{E}$ should be tied to V_{CC} through a pullup resistor; the minimum value of the resistor is determined by the current-sinking capability of the driver.

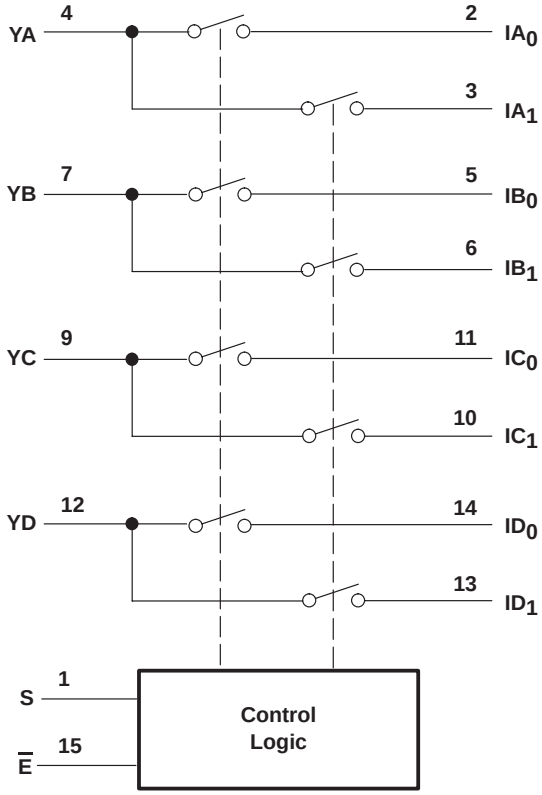
FUNCTION TABLE

INPUTS		INPUT/OUTPUT YX	FUNCTION
$\overline{E}$	S		
L	L	IX_0	$YX = IX_0$
L	H	IX_1	$YX = IX_1$
H	X	Z	Disconnect

PIN DESCRIPTIONS

PIN NAME	DESCRIPTION
IAn−IDn	Data I/Os
S	Select input
$\overline{E}$	Enable input
YA−YD	Data I/Os

logic diagram (positive logic)



absolute maximum ratings over operating free-air temperature range (unless otherwise noted)†

Supply voltage range, V_{CC} . . . . . −0.5 V to 7 V
Control input voltage range, V_{IN} (see Notes 1 and 2) . . . . . −0.5 V to 7 V
Switch I/O voltage range, $V_{I/O}$ (see Notes 1, 2, and 3) . . . . . −0.5 V to 7 V
Control input clamp current, I_{IK} (V_{IN} < 0) . . . . . −50 mA
I/O port clamp current, $I_{I/OK}$ ($V_{I/O}$ < 0) . . . . . −50 mA
ON-state switch current, $I_{I/O}$ (see Note 4) . . . . . ±128 mA
Continuous current through V_{CC} or GND terminals . . . . . ±100 mA
Package thermal impedance, θ_{JA} (see Note 5): D package . . . . . 73°C/W
(see Note 5): DBQ package . . . . . 90°C/W
(see Note 5): PW package . . . . . 83°C/W
(see Note 6): RGY package . . . . . 39°C/W
Storage temperature range, T_{stg} . . . . . −65°C to 150°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.

NOTES: 1. All voltages are with respect to ground, unless otherwise specified.
2. The input and output voltage ratings may be exceeded if the input and output clamp-current ratings are observed.
3. V_I and V_O are used to denote specific conditions for $V_{I/O}$.
4. I_I and I_O are used to denote specific conditions for $I_{I/O}$.
5. The package thermal impedance is calculated in accordance with JESD 51-7.
6. The package thermal impedance is calculated in accordance with JESD 51-5.

recommended operating conditions (see Note 7)

		MIN	MAX	UNIT
V_{CC}	Supply voltage	6	6.5	V
V_{IH}	High-level control input voltage ($\overline{E}$, S)	2.5	6.5	V
V_{IL}	Low-level control input voltage ($\overline{E}$, S)	0	0.8	V
T_A	Operating free-air temperature	0	70	°C

NOTE 7: All unused control inputs of the device must be held at V_{CC} or GND to ensure proper device operation. Refer to the TI application report, *Implications of Slow or Floating CMOS Inputs*, literature number SCBA004.

electrical characteristics over recommended operating free-air temperature range, V_{CC} = 6 V to 6.5 V (unless otherwise noted)

PARAMETER		TEST CONDITIONS			MIN	TYP†	MAX	UNIT
V_{IK}	$\overline{E}$, S	V_{CC} = 6 V,	I_{IN} = −18 mA				−1.8	V
V_{hys}	$\overline{E}$, S					150		mV
V_O		V_I = 4.5 V,	$\overline{E}$ = low,	R_L = 100 Ω, see Figure 11	3.7	4.06		V
I_{IH}	$\overline{E}$, S	V_{CC} = 6.5 V,	V_{IN} = V_{CC}				±1	µA
I_{IL}	$\overline{E}$, S	V_{CC} = 6.5 V,	V_{IN} = GND				±1	µA
I_{OZ}‡		V_{CC} = 6.5 V,	V_O = 0 to 6.5 V, V_I = 0,	Switch OFF			±1	µA
I_{OS}§		V_{CC} = 6.5 V,	V_O = 0 to 0.5 V_{CC}, V_I = 0,	Switch ON	50			mA
I_{off}		V_{CC} = 0,	V_O = 0 to 6.5 V,	V_I = 0			1	µA
I_{CC}		V_{CC} = 6.5 V,	$I_{I/O}$ = 0,	Switch ON or OFF			3	µA
ΔI_{CC}	$\overline{E}$, S	V_{CC} = 6.5 V,	One input at 3.4 V,	Other inputs at V_{CC} or GND			6	mA
I_{CCD}		V_{CC} = 6.5 V,	I and Y ports open,	V_{IN} input switching 50% duty cycle			0.35	mA/ MHz
C_{IN}	$\overline{E}$, S	f = 1 MHz				3.5		pF
C_{OFF}	I port	V_I = 0,	f = 1 MHz, Outputs open,	Switch OFF		4.5		pF
	Y port					6.5		
C_{ON}		V_I = 0,	f = 1 MHz, Outputs open,	Switch ON		14		pF
r_{on}	M1	V_I = 4.5 V,	Switch ON,	R_L = 100 Ω, see Figure 11	7.5	11.2	19	Ω
	M2				2	3	6	
Δr_{on}		V_I = 4.5 V,	Switch ON			1	2	Ω

V_I, V_O, I_I, and I_O refer to I/O pins. V_{IN} refers to the control inputs.
† All typical values are at V_{CC} = 6.2 V (unless otherwise noted), T_A = 25°C.
‡ For I/O ports, I_{OZ} includes the input leakage current.
§ The I_{OS} test is applicable to only one ON channel at a time. The duration of this test is less than one second.

switching characteristics over recommended operating free-air temperature range, V_{CC} = 6 V to 6.5 V, R_L = 100 Ω, C_L = 35 pF (unless otherwise noted) (see Figure 7)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	MIN	MAX	UNIT
t_{ON}	S	Y		7	ns
t_{OFF}	S	Y		4	ns

† All typical values are at V_{CC} = 6.2 V (unless otherwise noted), T_A = 25°C.

dynamic characteristics over recommended operating free-air temperature range, V_{CC} = 6 V to 6.5 V (unless otherwise noted)

PARAMETER	TEST CONDITIONS			MIN	TYP†	MAX	UNIT
X_{TALK}(Diff)	R_L = 100 Ω,	f = 10 MHz, see Figure 12,	t_r = t_f = 2 ns	−40	−60		dB
X_{TALK}	R_L = 100 Ω,	f = 30 MHz, see Figure 9			−50		dB
O_{IRR}	R_L = 100 Ω,	f = 30 MHz, see Figure 10			−40		dB
BW	R_L = 100 Ω, see Figure 8				350		MHz

† All typical values are at V_{CC} = 6.2 V (unless otherwise noted), T_A = 25°C.

OPERATING CHARACTERISTICS

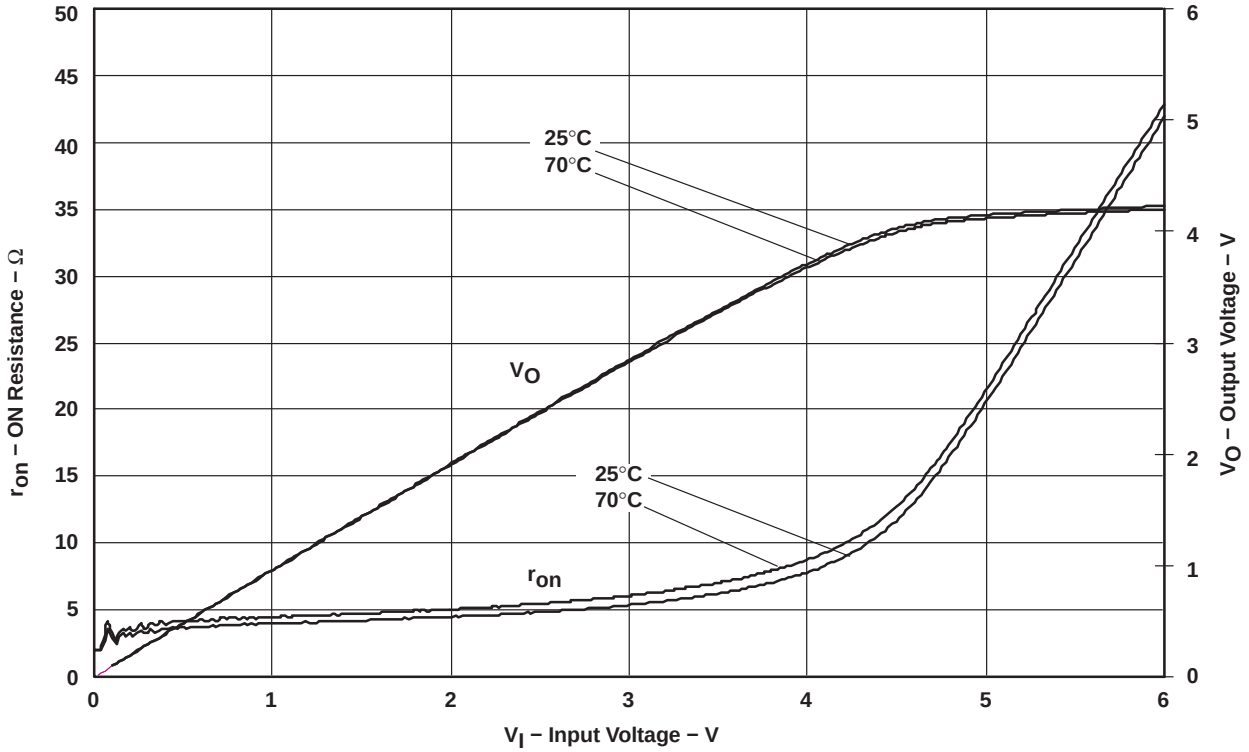


Figure 1. r_{on} and V_O vs V_I Over Temperature (V_{CC} = 6 V)

OPERATING CHARACTERISTICS

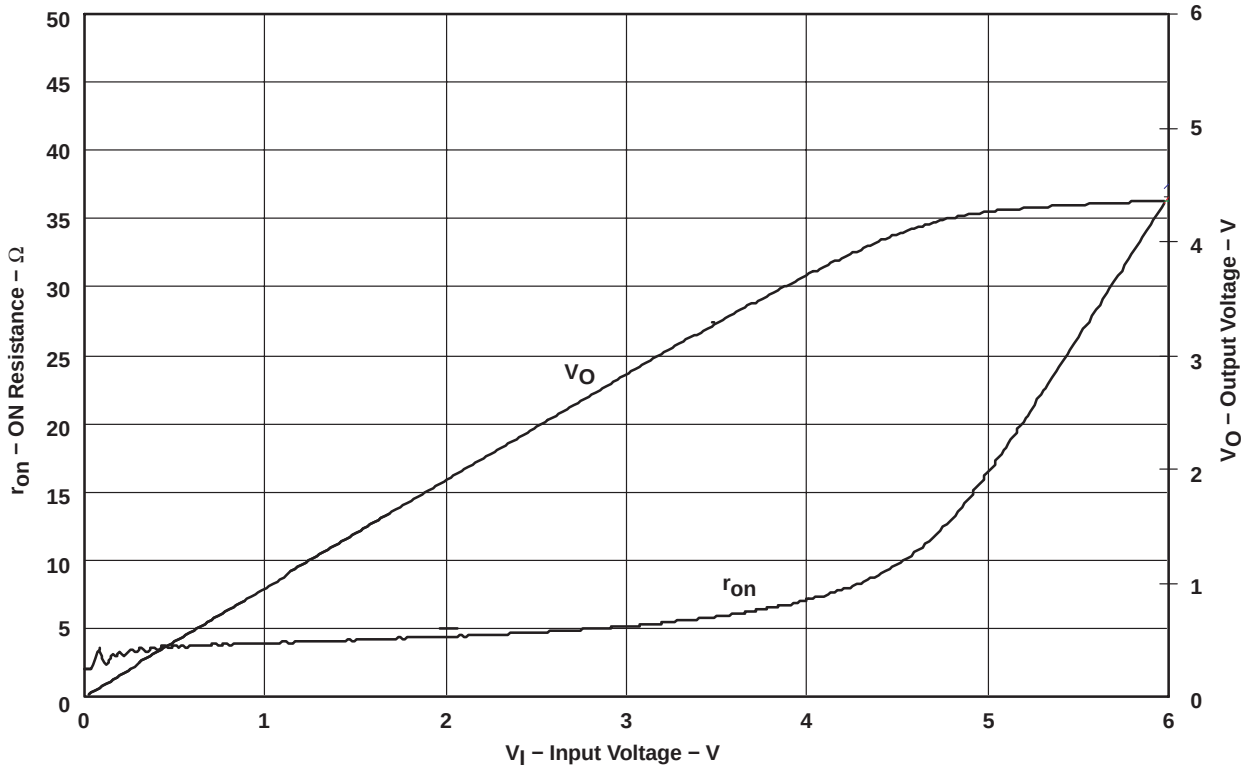
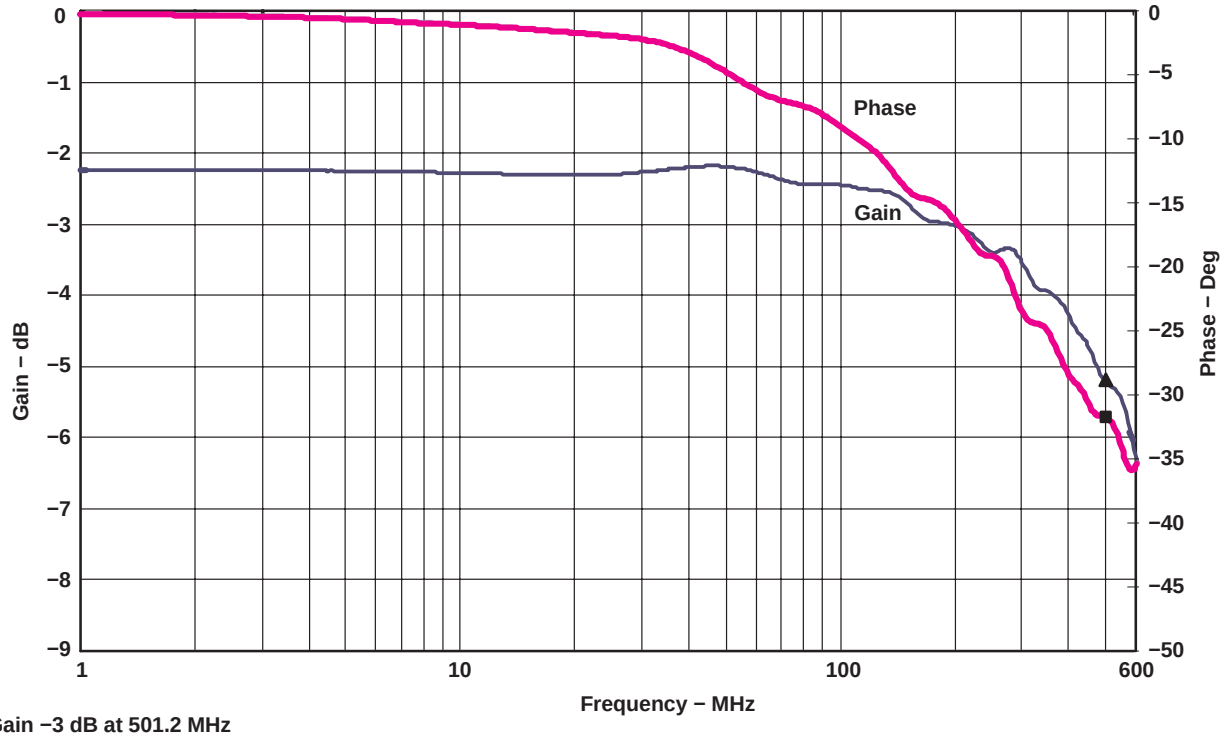


Figure 2. r_{on} and V_O vs V_I (V_{CC} = 6.2 V and T_A = 25°C)

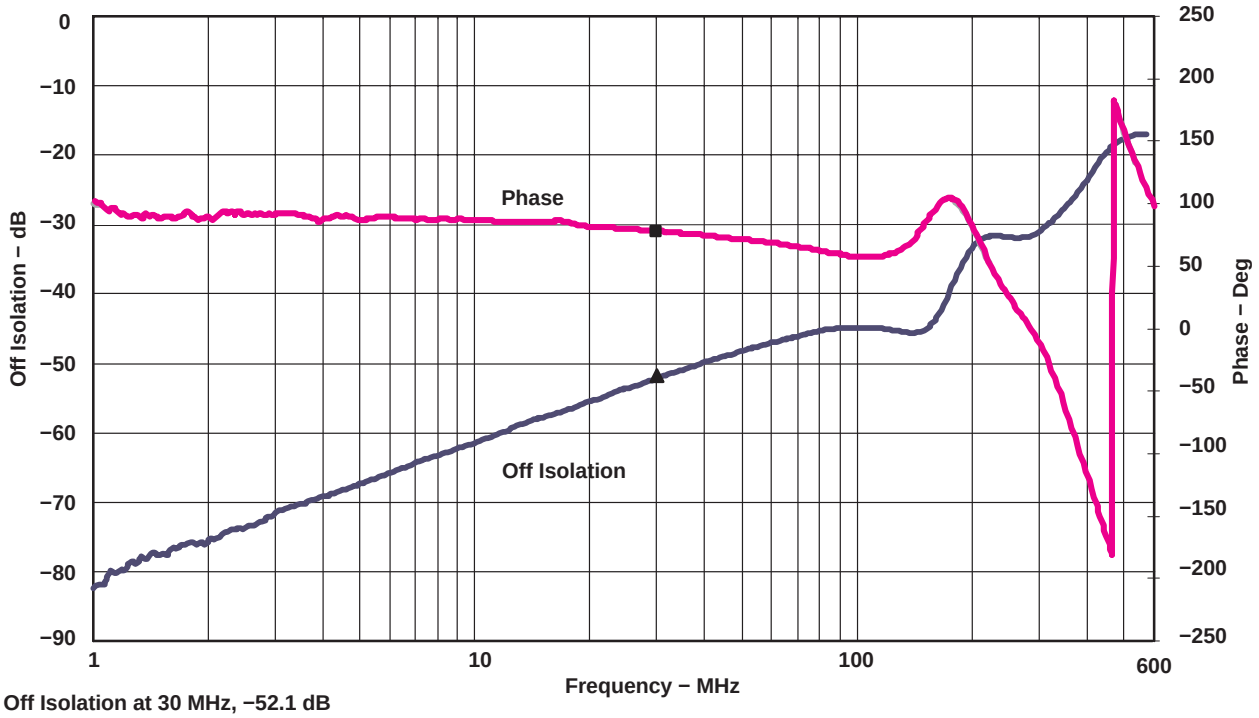
OPERATING CHARACTERISTICS



▲ Gain −3 dB at 501.2 MHz
■ Phase at −3-dB Frequency, −31.7 Degrees

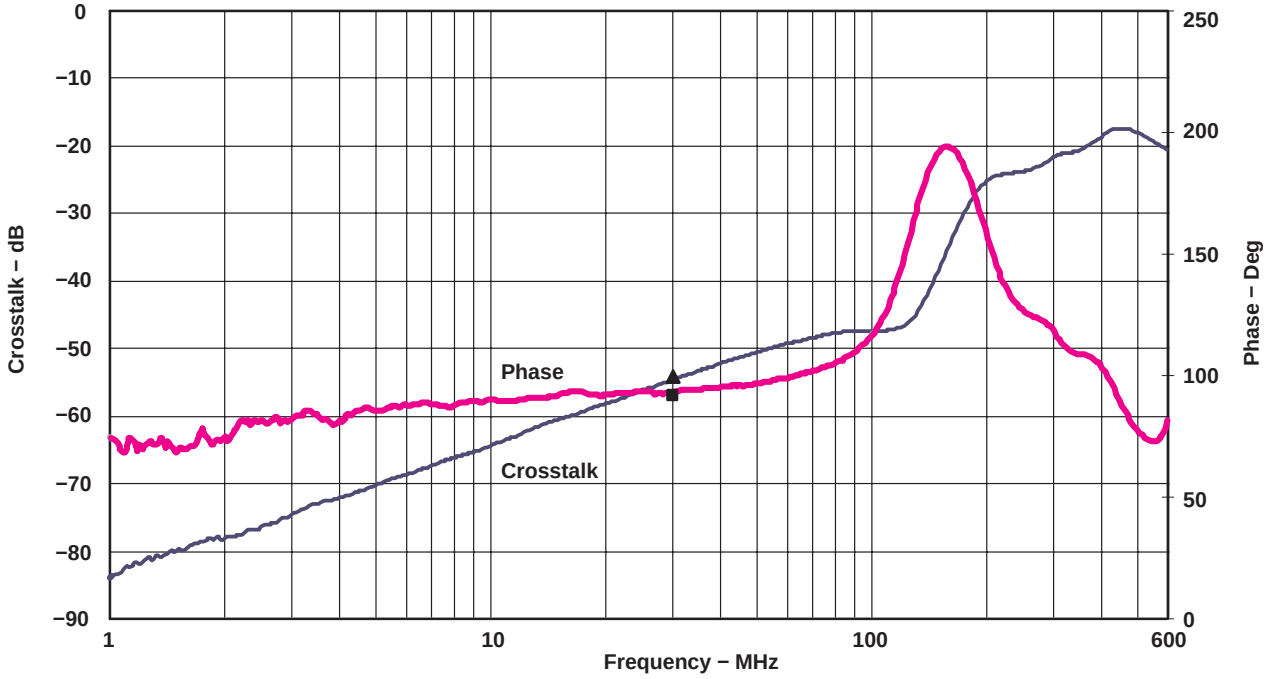
Figure 3. Gain/Phase vs Frequency

OPERATING CHARACTERISTICS



▲ Off Isolation at 30 MHz, −52.1 dB
■ Phase at 30 MHz, 77 Degrees

Figure 4. Off Isolation vs Frequency



▲ Crosstalk at 30 MHz, −54 dB
■ Phase at 30 MHz, 93.2 Degrees

Figure 5. Crosstalk vs Frequency

OPERATING CHARACTERISTICS

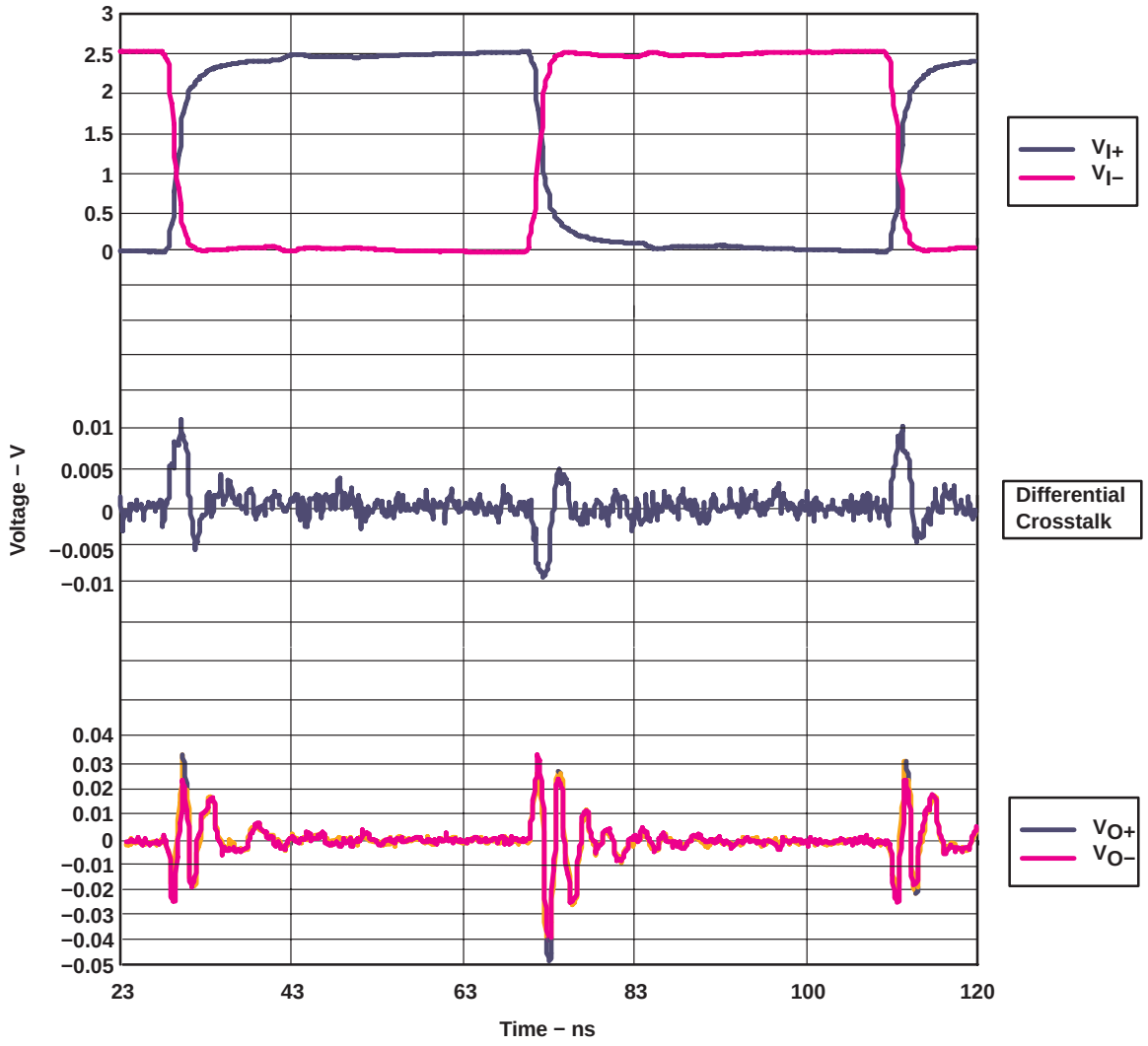
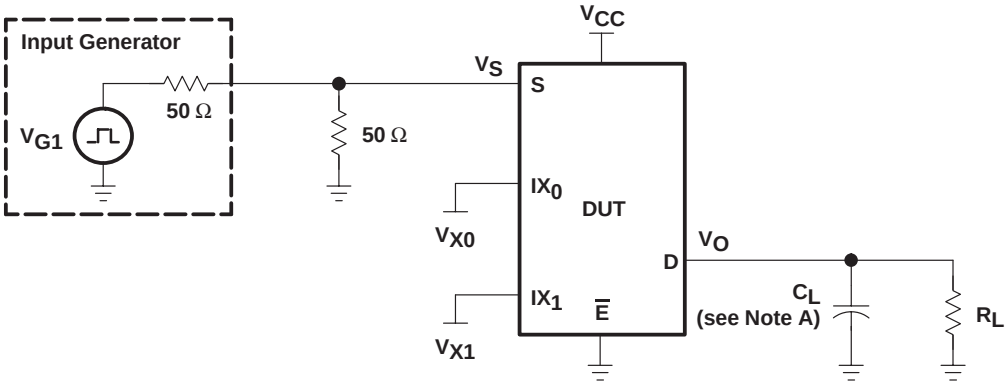
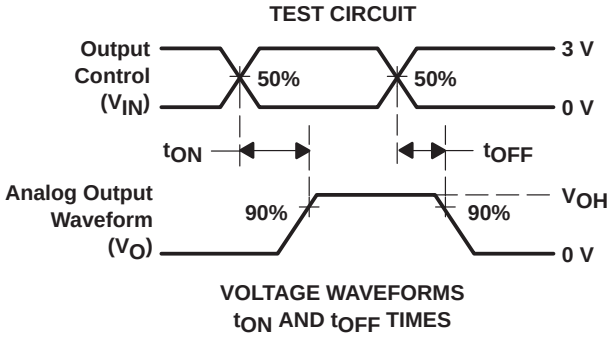


Figure 6. Differential Crosstalk

PARAMETER MEASUREMENT INFORMATION



TEST	V_{CC}	R_L	C_L	V_{X0}	V_{X1}
t_{ON}	6.2 V 6.2 V	100 Ω 100 Ω	35 pF 35 pF	GND 4.5 V	4.5 V GND
t_{OFF}	6.2 V 6.2 V	100 Ω 100 Ω	35 pF 35 pF	GND 4.5 V	4.5 V GND



NOTES: A. C_L includes probe and jig capacitance.
B. All input pulses are supplied by generators having the following characteristics: PRR ≤ 10 MHz, Z_O = 50 Ω, t_r ≤ 2.5 ns, t_f ≤ 2.5 ns.
C. The outputs are measured one at a time, with one transition per measurement.

Figure 7. Test Circuit and Voltage Waveforms

PARAMETER MEASUREMENT INFORMATION

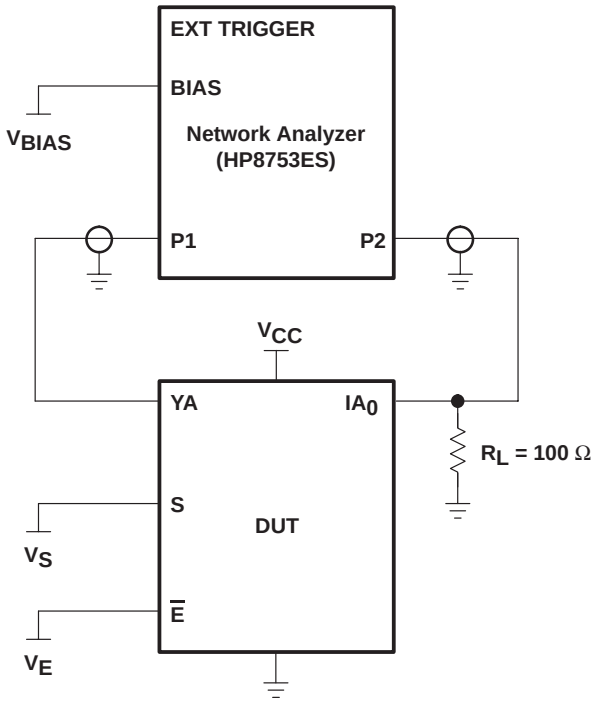


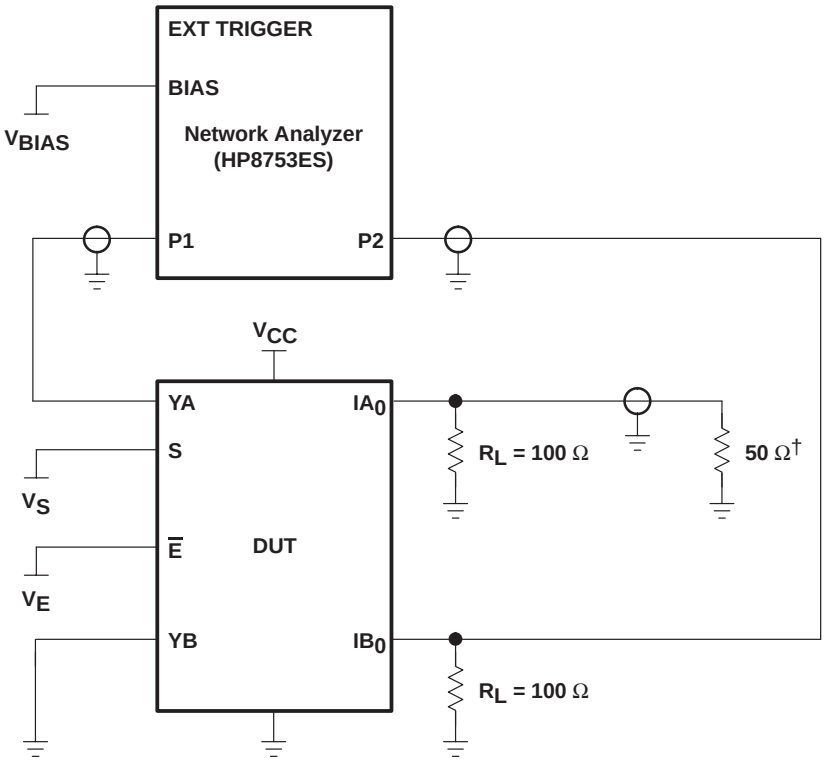
Figure 8. Test Circuit for Frequency Response (BW)

Frequency response is measured at the output of the ON channel. For example, when V_S = 0, V_E = 0, and YA is the input, the output is measured at IA_0. All unused analog I/O ports are left open.

HP8753ES setup

Average = 4
RBW = 3 kHz
V_{BIAS} = 0.35 V
ST = 2 s
P1 = 0 dBM

PARAMETER MEASUREMENT INFORMATION



† A 50-Ω termination resistor is needed for the network analyzer.

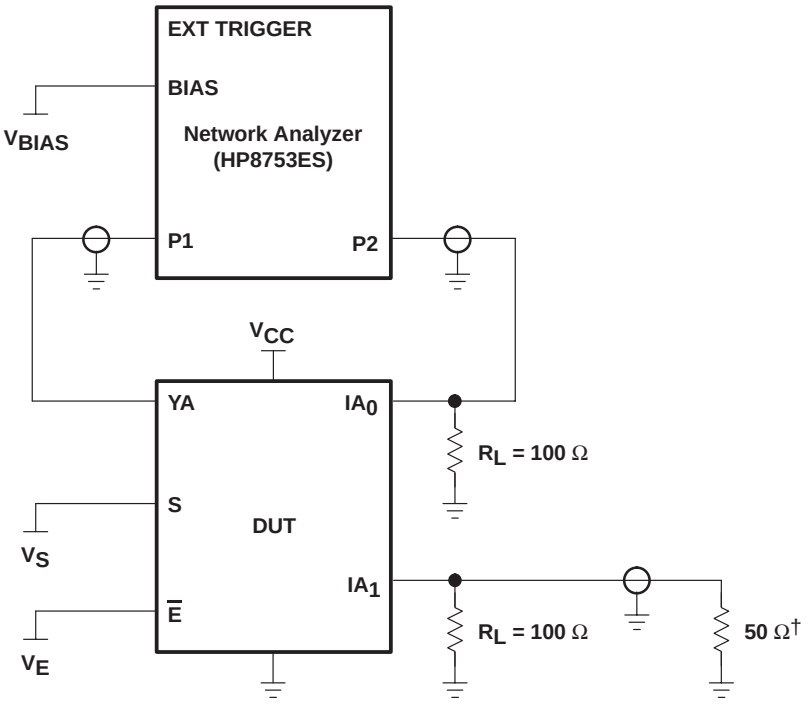
Figure 9. Test Circuit for Crosstalk (X_{TALK})

Crosstalk is measured at the output of the nonadjacent ON channel. For example, when V_S = 0, V_E = 0, and YA is the input, the output is measured at IB_0. All unused analog input (Y) ports are connected to GND, and output (A) ports are connected to GND through 50-Ω pulldown resistors.

HP8753ES setup

Average = 4
RBW = 3 kHz
V_{BIAS} = 0.35 V
ST = 2 s
P1 = 0 dBM

PARAMETER MEASUREMENT INFORMATION



† A 50-Ω termination resistor is needed for the network analyzer.

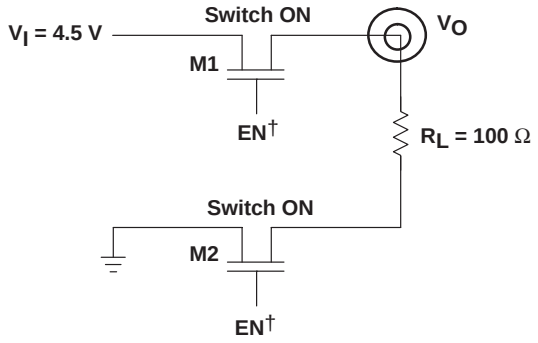
Figure 10. Test Circuit for Off Isolation (O_{IRR})

Off isolation is measured at the output of the OFF channel. For example, when $V_S = V_{CC}$, $V_E = 0$, and YA is the input, the output is measured at IA_0. All unused analog input (Y) ports are left open, and output (A) ports are connected to GND through 50-Ω pulldown resistors.

HP8753ES setup

Average = 4
RBW = 3 kHz
V_{BIAS} = 0.35 V
ST = 2 s
P1 = 0 dBM

PARAMETER MEASUREMENT INFORMATION



† EN is the internal enable signal applied to the switch.
NOTE A: r_{on} (M1) and r_{on} (M2) are calculated from the voltage drop and current across the two terminals of M1 and M2, respectively.

Figure 11. Test Circuit for V_O and r_{on}

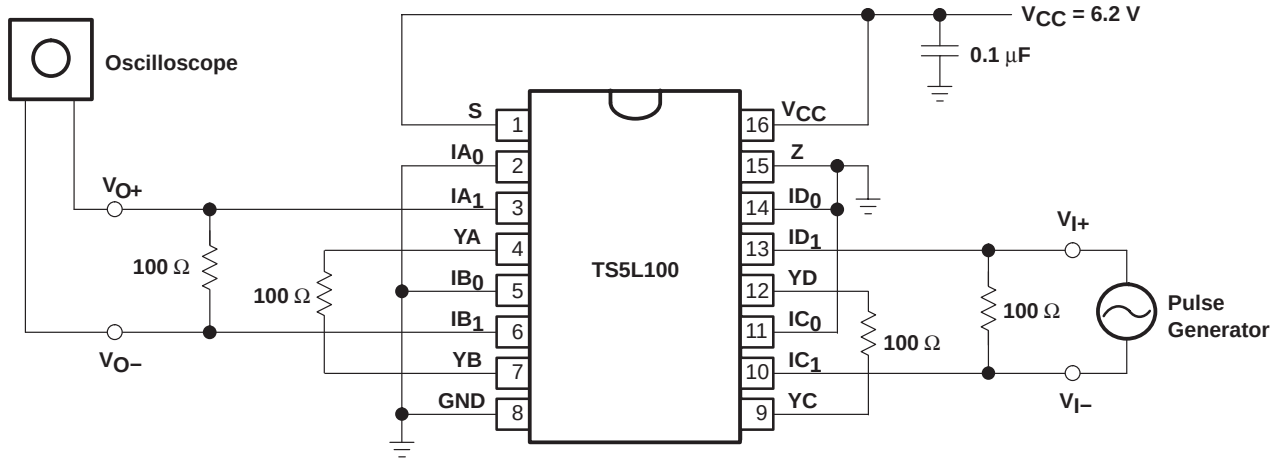


Figure 12. Differential Crosstalk Measurement

Differential crosstalk is a measure of coupling noise between a transmit and receive pair in the LAN application. Differential crosstalk depends on the edge rate, frequency, and load. This is calculated from the equation, X_{TALK}(Diff) db = 20 log V_O(Diff)/V_I(Diff), where V_O(Diff) is the differential output voltage and V_I(Diff) is the differential input voltage.

PACKAGING INFORMATION

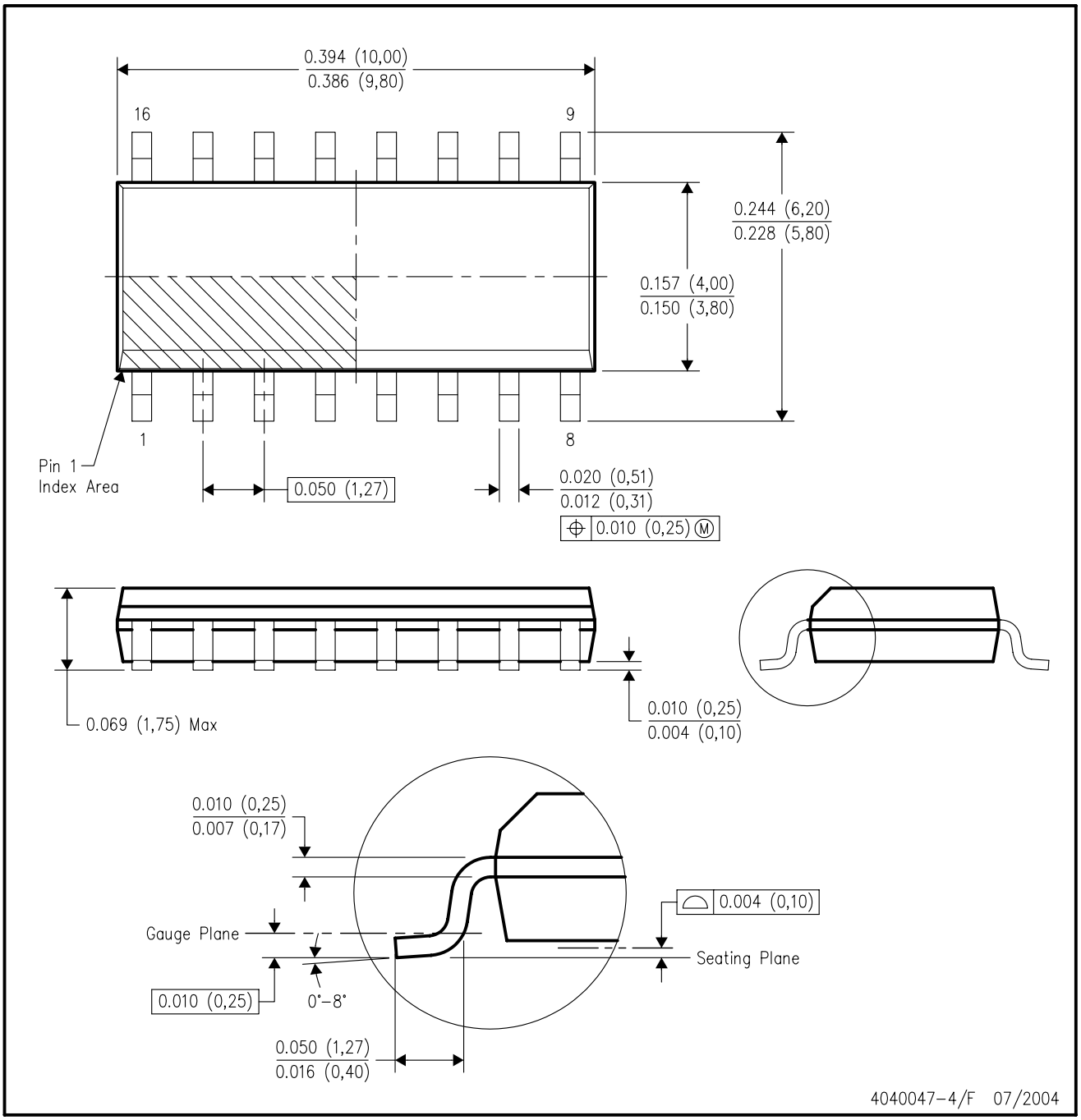
Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish	MSL Peak Temp (3)
TS5L100D	ACTIVE	SOIC	D	16	40	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TS5L100DBQR	ACTIVE	SSOP/ QSOP	DBQ	16	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1YEAR
TS5L100DBQRE4	ACTIVE	SSOP/ QSOP	DBQ	16	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1YEAR
TS5L100DE4	ACTIVE	SOIC	D	16	40	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TS5L100DR	ACTIVE	SOIC	D	16	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TS5L100DRE4	ACTIVE	SOIC	D	16	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TS5L100PW	ACTIVE	TSSOP	PW	20	70	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TS5L100PWE4	ACTIVE	TSSOP	PW	20	70	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TS5L100PWR	ACTIVE	TSSOP	PW	20	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TS5L100PWRE4	ACTIVE	TSSOP	PW	20	2000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
TS5L100RGYR	ACTIVE	QFN	RGY	16	1000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1YEAR
TS5L100RGYRG4	ACTIVE	QFN	RGY	16	1000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-2-260C-1YEAR

(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) 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.
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)

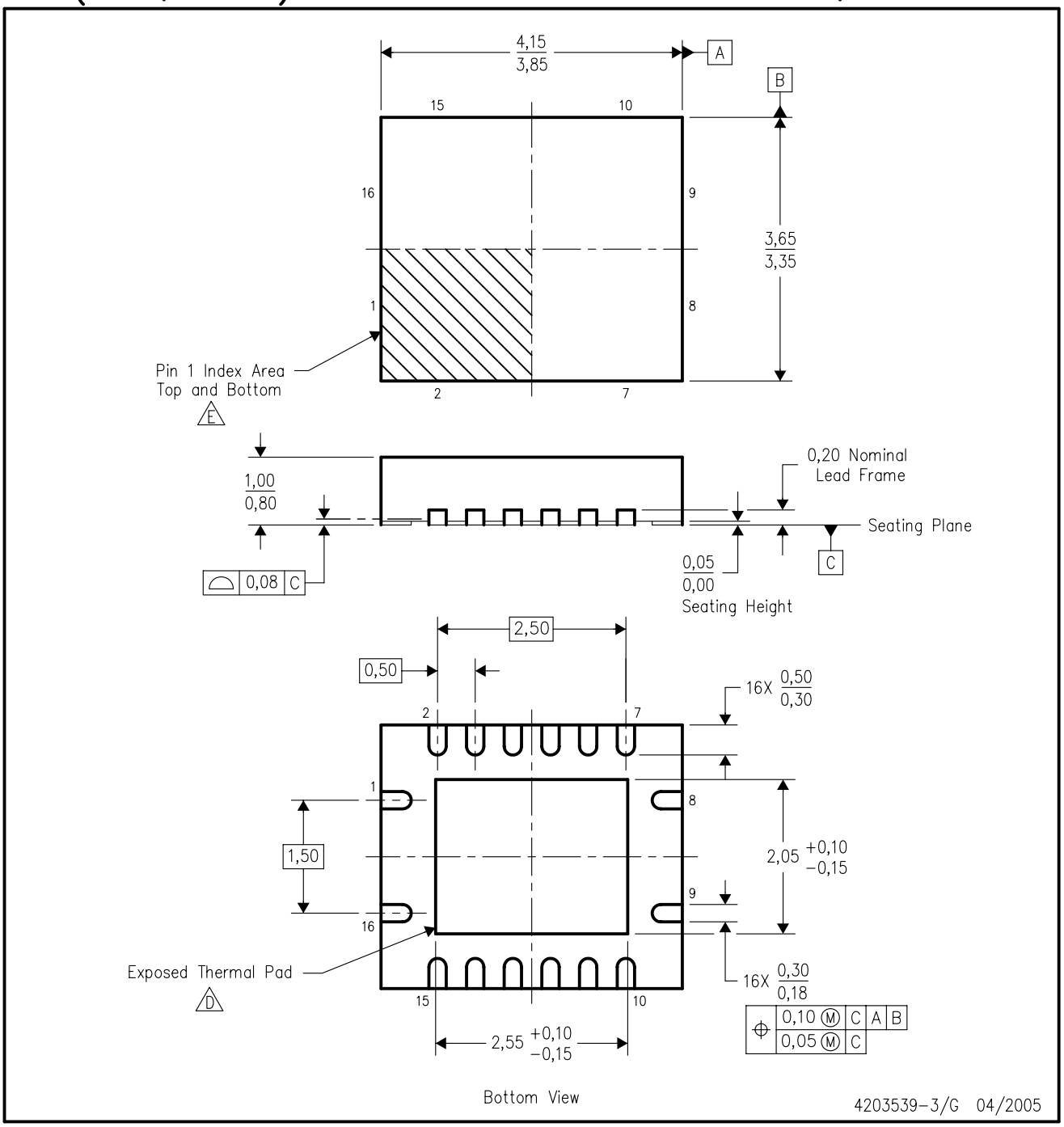
(3) MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

D (R–PDSO–G16) PLASTIC SMALL–OUTLINE PACKAGE



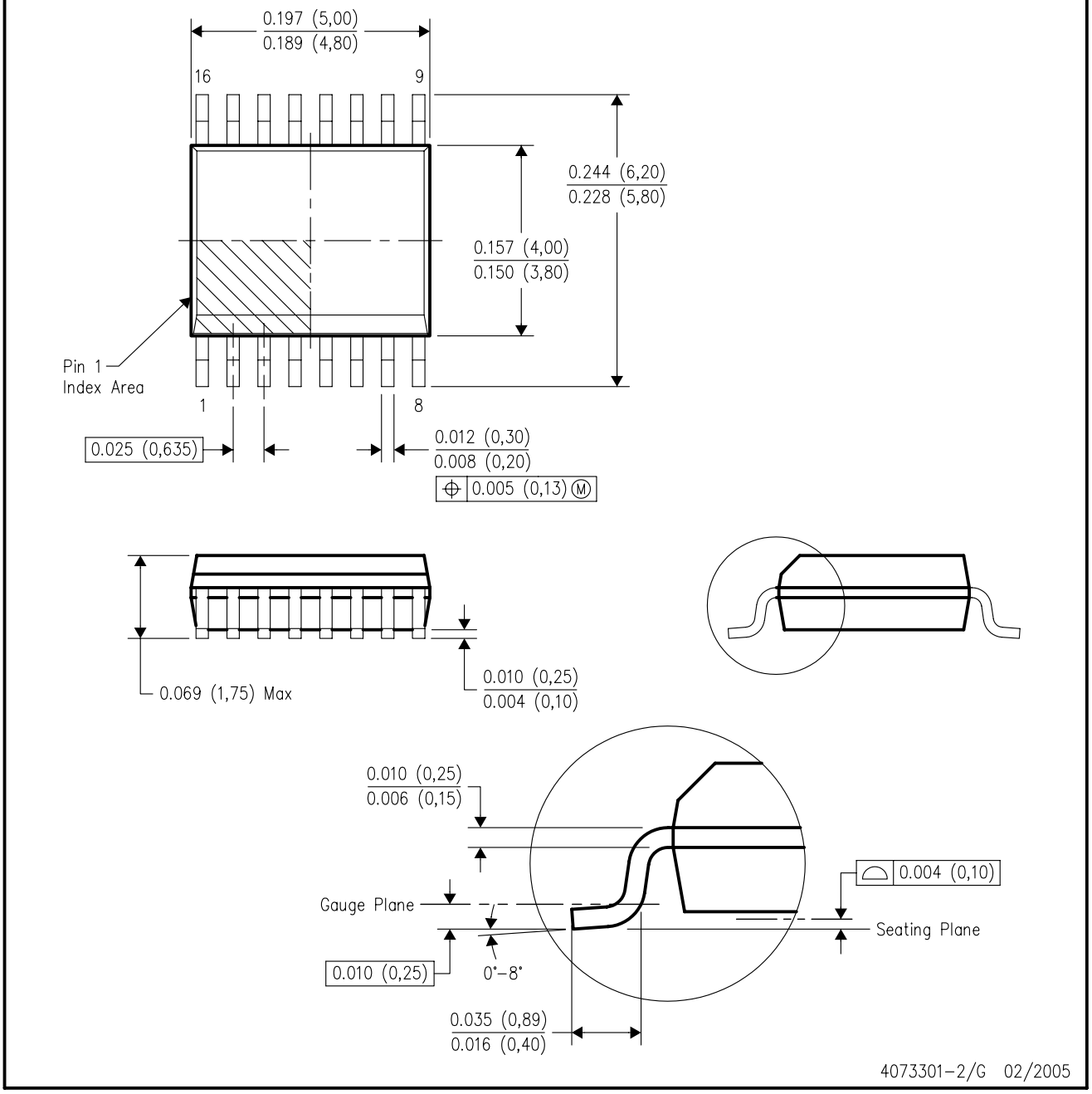
NOTES:
A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
C. Body dimensions do not include mold flash or protrusion not to exceed 0.006 (0,15).
D. Falls within JEDEC MS–012 variation AC.

RGY (R–PQFP–N16) PLASTIC QUAD FLATPACK



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. Pin 1 identifiers are located on both top and bottom of the package and within the zone indicated. The Pin 1 identifiers are either a molded, marked, or metal feature.
F. Package complies to JEDEC MO–241 variation BB.

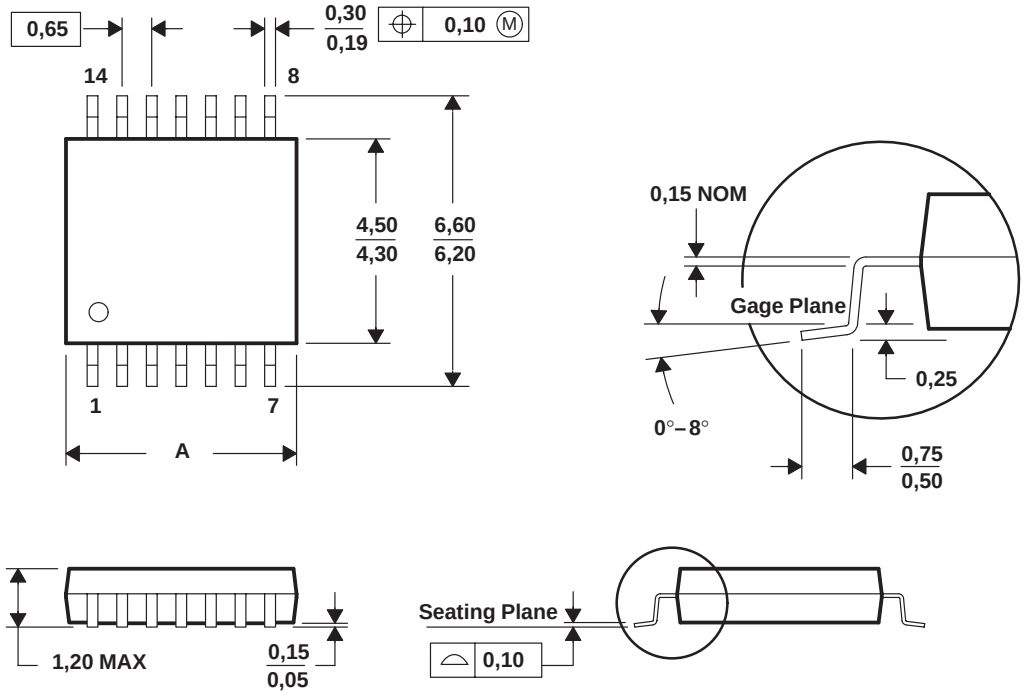
DBQ (R–PDSO–G16) PLASTIC SMALL–OUTLINE PACKAGE



NOTES:
A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
C. Body dimensions do not include mold flash or protrusion not to exceed 0.006 (0,15) per side.
D. Falls within JEDEC MO–137 variation AB.

PW (R-PDSO-G)** **PLASTIC SMALL-OUTLINE PACKAGE**

14 PINS SHOWN



DIM \ PINS **	8	14	16	20	24	28
A MAX	3,10	5,10	5,10	6,60	7,90	9,80
A MIN	2,90	4,90	4,90	6,40	7,70	9,60

4040064/F 01/97

NOTES: A. All linear dimensions are in millimeters.
B. This drawing is subject to change without notice.
C. Body dimensions do not include mold flash or protrusion not to exceed 0,15.
D. Falls within JEDEC MO-153

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