19-2529; Rev 2; 7/04

可提供评估板

2.7Gbps，低功耗，SFP激光驱动器

概述

MAX3735/MAX3735A为+3.3V激光驱动器，用于155Mbps至2.7Gbps的SFP/SFF系统。该芯片接收差分输入数据，并提供驱动激光器的偏置电流和调制电流。与激光器的直流耦合允许多速率应用，并减少外围元件的数量。MAX3735/MAX3735A完全满足SFP MSA时序要求和SFF-8472 发送诊断要求。

自动功率控制 (APC)反馈回路使平均光功率在整个温度范围和芯片使用期限内保持恒定。可提供10mA至60mA的宽范围调制电流 (交流耦合时可达85mA)和1mA至100mA的偏置电流，非常适合驱动光纤模块中FP/DFB激光二极管。用于设置激光器电流的电阻阻值范围经过优化，便于和DS1858 SFP控制器IC接口。

MAX3735/MAX3735A提供发射禁止控制、带锁存的单点发送故障监视输出、光电流监视和用来指示APC环路无法维持平均光功率的偏置电流监视功能。MAX3735A还具有改进的多速率工作特性。

MAX3735/MAX3735A提供封装或裸片形式，工作在-40°C至+85°C扩展级温度范围。

应用

千兆以太网SFP/SFF 收发模块

1G/2G 光纤信道SFP/SFF 收发模块

多速率OC3至OC48-FEC SFP/SFF收发模块

特性

- 提供SFP参考设计
- 完全兼容SFP和SFF-8472 MSA
- 10mA至60mA可编程调制电流 (直流耦合)
- 10mA至85mA可编程调制电流 (交流耦合)
- 1mA至100mA可编成偏置电流
- 边沿转换时间<51ps
- 27mA (典型值)电源电流
- 多速率工作：155Mbps至2.7Gbps
- 自动平均功率控制
- TX_DISABLE (发送禁止)内置上拉电阻
- 24引脚 4mm x 4mm QFN封装

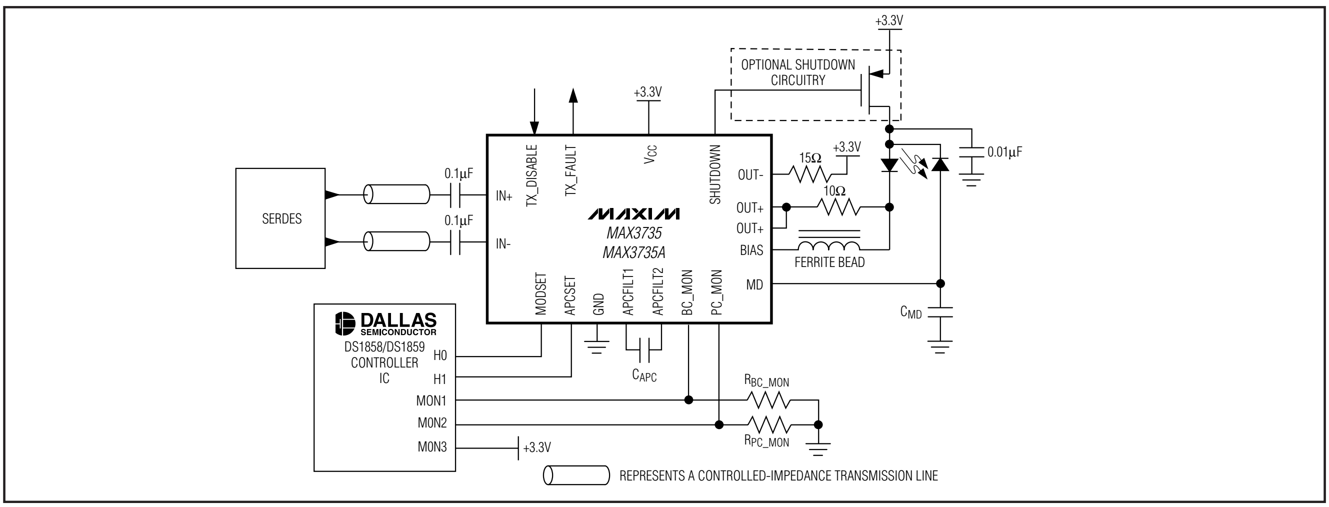
定购信息

PART	TEMP RANGE	PIN-PACKAGE
MAX3735E/D	-40°C to +85°C	Dice*
MAX3735ETG	-40°C to +85°C	24 Thin QFN-EP**
MAX3735EGG	-40°C to +85°C	24 QFN-EP**
MAX3735AETG	-40°C to +85°C	24 Thin QFN-EP**
MAX3735AETG+	-40°C to +85°C	24 Thin QFN-EP**

*Dice are designed to operate from -40°C to +85°C, but are tested and guaranteed only at T_A = +25°C.
**EP = Exposed pad.
+Denotes lead-free package.

引脚配置在本数据资料末尾。

典型应用电路



ABSOLUTE MAXIMUM RATINGS

Supply Voltage, V_{CC} ....-0.5V to +6.0V
Current into BIAS, OUT+, OUT- ....-20mA to +150mA
Current into MD ....-5mA to +5mA
Voltage at IN+, IN-, TX_DISABLE, TX_FAULT,
SHUTDOWN ....-0.5V to (V_{CC} + 0.5V)
Voltage at BIAS, PC_MON, BC_MON,
MODSET, APCSET ....-0.5V to (V_{CC} + 0.5V)
Voltage at OUT+, OUT- ....+0.5V to (V_{CC} + 1.5V)
Voltage at APCFILT1, APCFILT2 ....-0.5V to +3V

Continuous Power Dissipation (T_A = +85°C)
24-Lead Thin QFN (derate 20.8mW/°C
above +85°C)..............................1354mW
24-Lead QFN (derate 20.8mW/°C
above +85°C)..............................1354mW
Operating Ambient Temperature Range (T_A)......-40°C to +85°C
Storage Ambient Temperature Range..............-55°C to +150°C
Die Attach Temperature..............................+400°C
Lead Temperature (soldering, 10s) ....+300°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 in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

ELECTRICAL CHARACTERISTICS

(V_{CC} = +2.97V to +3.63V, T_A = -40°C to +85°C. Typical values at V_{CC} = +3.3V, I_{BIAS} = 20mA, I_{MOD} = 30mA, T_A = +25°C, unless otherwise noted.) (Note 1)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
POWER SUPPLY							
Power-Supply Current	I_{CC}	Excludes the laser bias and modulation currents (Note 2)			27	50	mA
I/O SPECIFICATIONS							
Differential Input Voltage	V_{ID}	V_{ID} = (V_{IN+}) - (V_{IN-}), Figure 1		200		2400	mV_{P-P}
Common-Mode Input Voltage					0.6 × V_{CC}		V
Differential Input Resistance				85	100	115	Ω
TX_DISABLE Input Pullup Resistance	R_{PULL}			4.7	7.4	10.0	kΩ
TX_DISABLE Input Current		V_{HIGH} = V_{CC}				15	µA
		V_{LOW} = GND, V_{CC} = 3.3V, R_{PULL} = 7.4kΩ			-450		
TX_DISABLE Input High Voltage	V_{IH}			2			V
TX_DISABLE Input Low Voltage	V_{IL}					0.8	V
TX_FAULT Output High Voltage	V_{OH}	I_{OH} = 100µA sourcing (Note 3)		2.4			V
TX_FAULT Output Low Voltage	V_{OL}	I_{OL} = 1mA sinking (Note 3)				0.4	V
SHUTDOWN Output High Voltage	V_{OH}	I_{OH} = 100µA sourcing		V_{CC} - 0.4			V
SHUTDOWN Output Low Voltage	V_{OL}	I_{OL} = 100µA sinking				0.4	V
BIAS GENERATOR							
Bias On-Current Range	I_{BIAS}	Current into BIAS pin		1		100	mA
Bias Off-Current	$I_{BIASOFF}$	Current into BIAS pin during TX_FAULT or TX_DISABLE				100	µA
Bias Overshoot		During SFP module hot plugging (Notes 4, 5, 11)				10	%
Bias-Current Monitor Gain	I_{BC_MON}	External resistor to GND defines the voltage gain, I_{BIAS} = 1mA, R_{BC_MON} = 69.28kΩ		10.0	12	13.5	mA/A
		I_{BIAS} = 100mA, R_{BC_MON} = 693.25Ω		11.5	13	13.5	
Bias-Current Monitor Gain Stability		1mA ≤ I_{BIAS} ≤ 100mA (Notes 4, 6)	MAX3735	-8		+8	%
			MAX3735A	-6		+6	

ELECTRICAL CHARACTERISTICS (continued)

(V_{CC} = +2.97V to +3.63V, T_A = -40°C to +85°C. Typical values at V_{CC} = +3.3V, I_{BIAS} = 20mA, I_{MOD} = 30mA, T_A = +25°C, unless otherwise noted.) (Note 1)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
AUTOMATIC POWER-CONTROL LOOP							
MD Reverse Bias Voltage		18µA ≤ I_{MD} ≤ 1500µA		1.6			V
MD Average Current Range	I_{MD}	Average current into MD pin		18		1500	µA
Average Power-Setting Stability		APC closed loop (Notes 4, 7)	I_{BIAS} = 1mA (MAX3735)	-880		+880	ppm/°C
			I_{BIAS} = 1mA (MAX3735A)	-110		+110	
			I_{BIAS} = 100mA	-650		+650	
Average Power Setting Accuracy		APC Closed Loop 1mA ≤ I_{BIAS} ≤ 100mA (Note 8)		-16		+16	%
MD-Current Monitor Gain	I_{PC_MON}	External resistor to GND defines the voltage gain; I_{MD} = 18µA, R_{PC_MON} = 50kΩ	MAX3735	0.8	1	1.23	A/A
			MAX3735A	0.9		1.1	
		I_{MD} = 1.5mA, R_{PC_MON} = 600Ω		0.95	1	1.05	
MD-Current Monitor Gain Stability		18µA ≤ I_{MD} ≤ 1500µA (Notes 4, 6)	MAX3735	-10		+10	%
			MAX3735A	-4		+4	
LASER MODULATOR							
Modulation On-Current Range	I_{MOD}	Current into OUT+ pin; R_L ≤ 15Ω, V_{OUT+}, V_{OUT-} ≥ 0.6V (DC-coupled)		10		60	mA
		Current into OUT+ pin; R_L ≤ 15Ω_, V_{OUT+}, V_{OUT-} ≥ 2.0V (AC-coupled)		10		85	
Modulation Off-Current	I_{MODOFF}	Current into OUT+ pin during TX_FAULT or TX_DISABLE				100	µA
Modulation-Current Stability (Note 4)		I_{MOD} = 10mA		-480		+480	ppm/°C
		I_{MOD} = 60mA		-255		+255	
Modulation-Current Absolute Accuracy		10mA ≤ I_{MOD} ≤ 60mA (Note 8)		-15		+15	%
Modulation-Current Rise Time	t_R	20% to 80%, 10mA ≤ I_{MOD} ≤ 60mA (Note 4)			42	65	ps
Modulation-Current Fall Time	t_F	20% to 80%, 10mA ≤ I_{MOD} ≤ 60mA (Note 4)			50	80	ps
Deterministic Jitter		10mA ≤ I_{MOD} ≤ 60mA at 2.67Gbps (Notes 4, 9, 10)			18	38	ps
		At 1.25Gbps (K28.5 pattern)			11.5		
		At 622Mbps (Note 9)			18		
		At 155Mbps (Note 9)			40		
Random Jitter	RJ	10mA ≤ I_{MOD} ≤ 60mA (Note 4)			0.7	1.0	ps_{RMS}

ELECTRICAL CHARACTERISTICS (continued)

(V_{CC} = +2.97V to +3.63V, T_A = -40°C to +85°C. Typical values at V_{CC} = +3.3V, I_{BIAS} = 20mA, I_{MOD} = 30mA, T_A= +25°C, unless otherwise noted.) (Note 1)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
SAFETY FEATURES						
Excessive Bias-Current Comparator Threshold Range		TX_FAULT always occurs for V_{BC_MON} ≥ 1.38V, TX_FAULT never occurs for V_{BC_MON} ≤ 1.22V	1.22	1.30	1.39	V
Excessive MD-Current Comparator Threshold Range		TX_FAULT always occurs for V_{PC_MON} ≥ 1.38V, TX_FAULT never occurs for V_{PC_MON} ≤ 1.22V	1.22	1.30	1.39	V
SFP TIMING REQUIREMENTS						
TX_DISABLE Assert Time	t_off	Time from rising edge of TX_DISABLE to I_{BIAS} = $I_{BIASOFF}$ and I_{MOD} = I_{MODOFF} (Note 4)		0.14	5	µs
TX_DISABLE Negate Time	t_on	Time from falling edge of TX_DISABLE to I_{BIAS} and I_{MOD} at 95% of steady state when TX_FAULT = 0 before reset: C_{APC} = 2.7nF, MAX3735 (Note 4)			1	ms
		Time from falling edge of TX_DISABLE to I_{BIAS} and I_{MOD} at 95% of steady state when TX_FAULT = 0 before reset: MAX3735A (Note 11)			600	µs
TX_DISABLE Negate Time During FAULT Recovery	t_onFAULT	Time from falling edge of TX_DISABLE to I_{BIAS} and I_{MOD} at 95% of steady state when TX_FAULT = 1 before reset (Note 4)		60	200	ms
TX_FAULT Reset Time or Power-On Time	t_init	From power-on or negation of TX_FAULT using TX_DISABLE (Note 4)		60	200	ms
TX_FAULT Assert Time	t_fault	Time from fault to TX_FAULT on, C_{FAULT} ≤ 20pF, R_{FAULT} = 4.7kΩ (Note 4)		3.3	50	µs
TX_DISABLE to Reset		Time TX_DISABLE must be held high to reset TX_FAULT (Note 4)			5	µs

Note 1: Specifications at -40°C are guaranteed by design and characterization. Dice are tested at T_A = +25°C only.
Note 2: Maximum value is specified at I_{MOD} = 60mA, I_{BIAS} = 100mA.
Note 3: TX_FAULT is an open-collector output and must be pulled up with a 4.7kΩ to 10kΩ resistor.
Note 4: Guaranteed by design and characterization.
Note 5: V_{CC} turn-on time must be ≤ 0.8s, DC-coupled interface.
Note 6: Gain stability is defined by the digital diagnostic document (SFF-8472, rev. 9.0) over temperature and supply variation.
Note 7: Assuming that the laser diode to photodiode transfer function does not change with temperature.
Note 8: Accuracy refers to part-to-part variation.
Note 9: Deterministic jitter is measured using a 2^{23} - 1 PRBS or equivalent pattern.
Note 10: Broadband noise is filtered through the network as shown in Figure 3. One capacitor, C < 0.47µF, and one 0603 ferrite bead or inductor can be added (optional). This supply voltage filtering reduces the hot-plugging inrush current. The supply noise must be < $100mV_{P-P}$ up to 2MHz.
Note 11: C_{APC} values chosen as shown in Table 4 (MAX3735A).

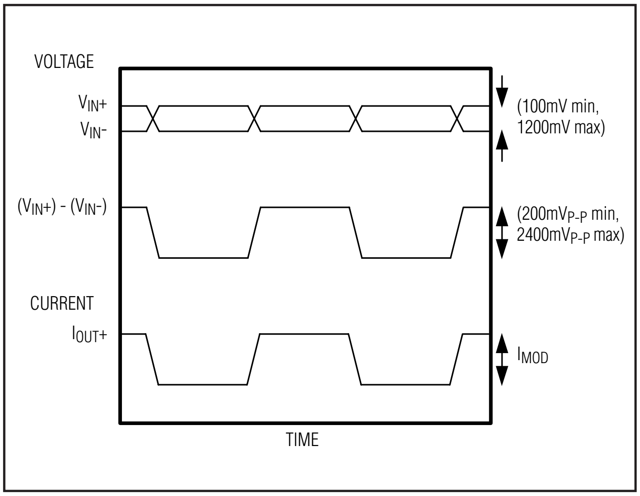


图 1. 要求的输入信号和输出极性

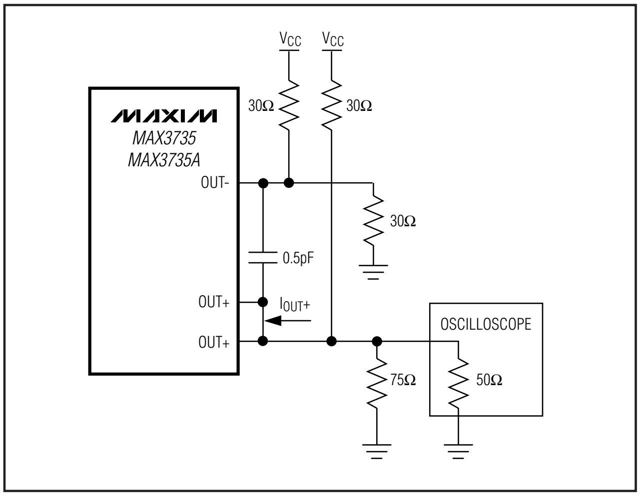


图 2. 电路输出匹配

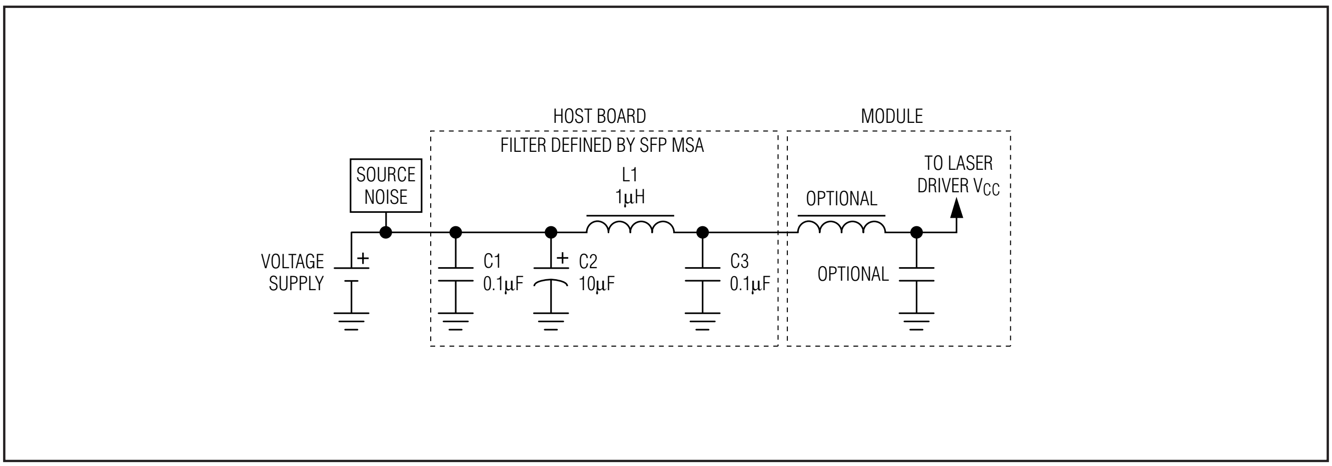
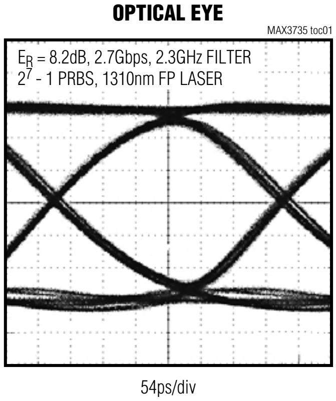


图 3. 电源滤波器

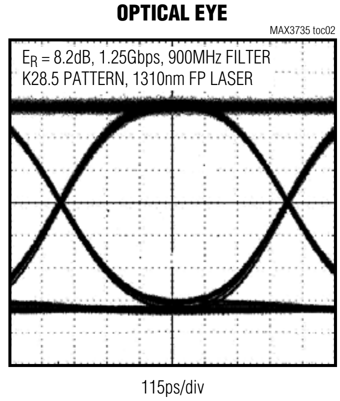
典型工作特性

(V_{CC} = +3.3V, C_{APC} = 0.01µF, I_{BIAS} = 20mA, and I_{MOD} = 30mA, T_A = +25°C, unless otherwise noted.)

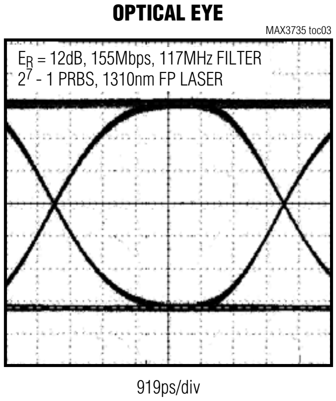
OPTICAL EYE



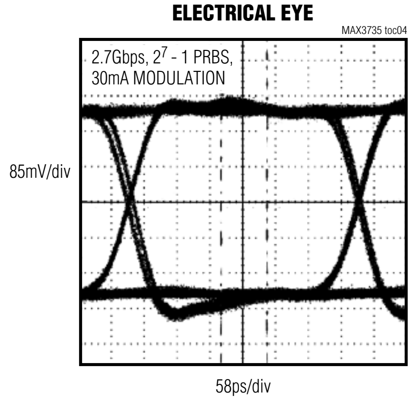
OPTICAL EYE



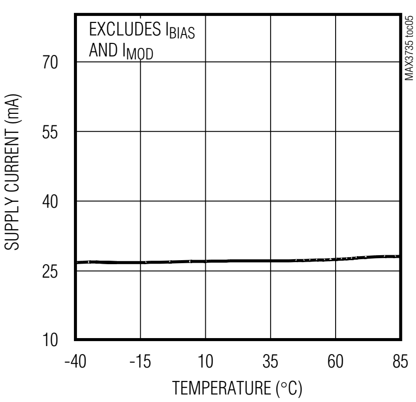
OPTICAL EYE



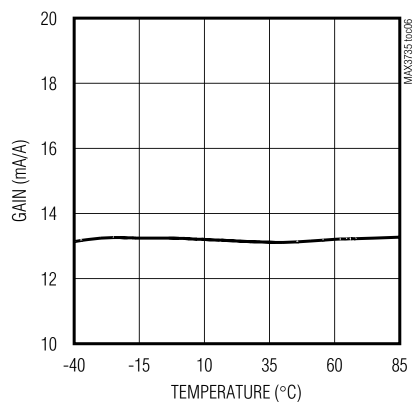
ELECTRICAL EYE



SUPPLY CURRENT vs. TEMPERATURE



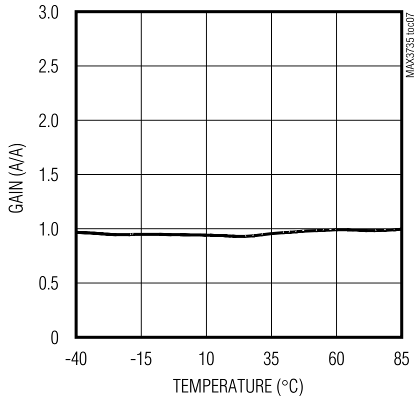
BIAS-CURRENT MONITOR GAIN vs. TEMPERATURE



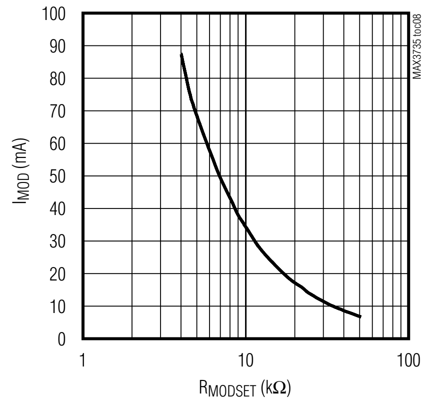
典型工作特性 (续)

(V_{CC} = +3.3V, C_{APC} = 0.01µF, I_{BIAS} = 20mA, and I_{MOD} = 30mA, T_A = +25°C, unless otherwise noted.)

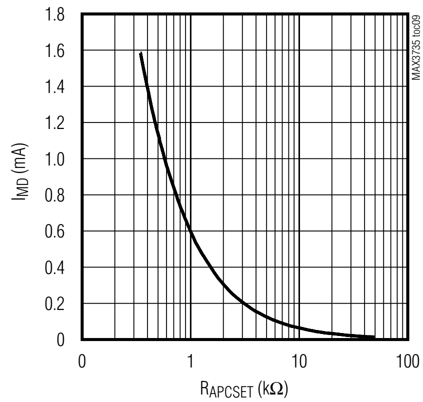
PHOTOCURRENT MONITOR GAIN vs. TEMPERATURE



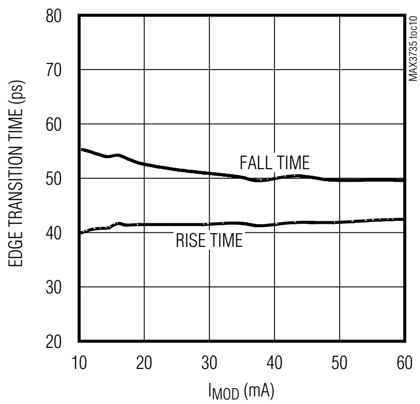
MODULATION CURRENT vs. R_{MODSET}



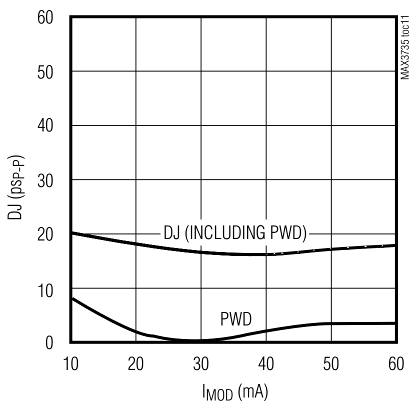
MONITOR DIODE CURRENT vs. R_{APCSET}



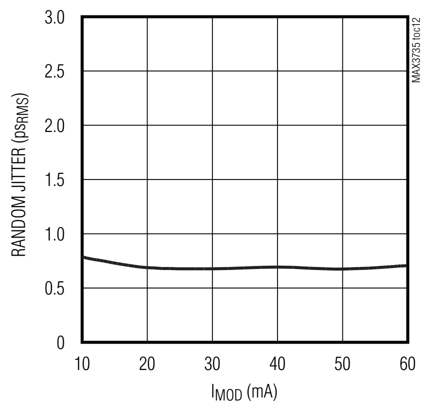
EDGE TRANSITION TIME vs. MODULATION CURRENT



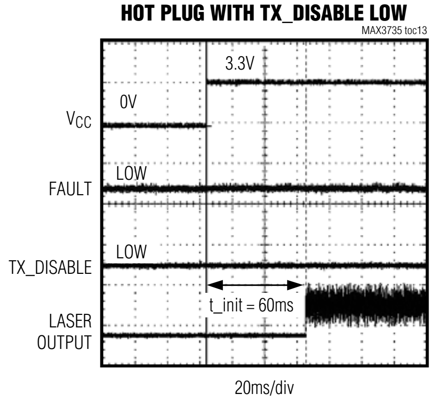
DETERMINISTIC JITTER vs. MODULATION CURRENT



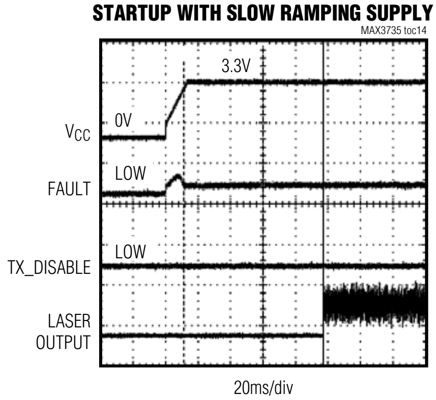
RANDOM JITTER vs. MODULATION CURRENT



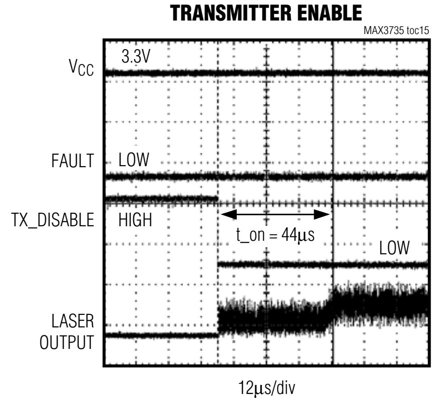
HOT PLUG WITH TX_DISABLE LOW



STARTUP WITH SLOW RAMPING SUPPLY

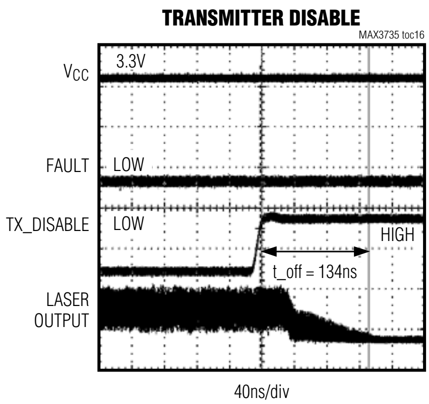


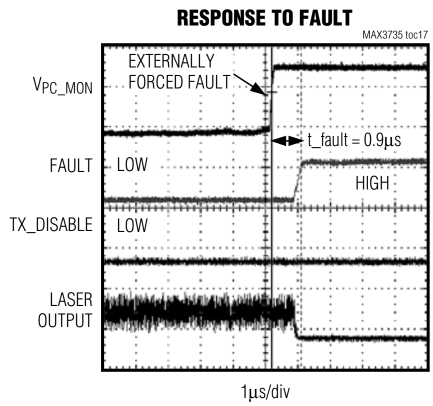
TRANSMITTER ENABLE

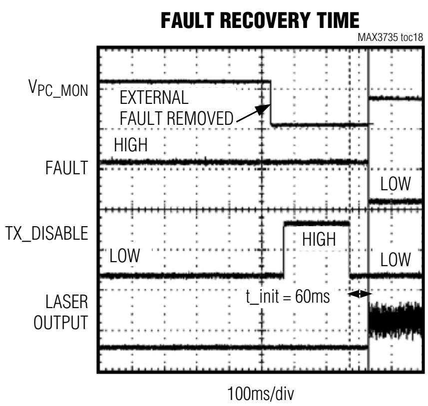


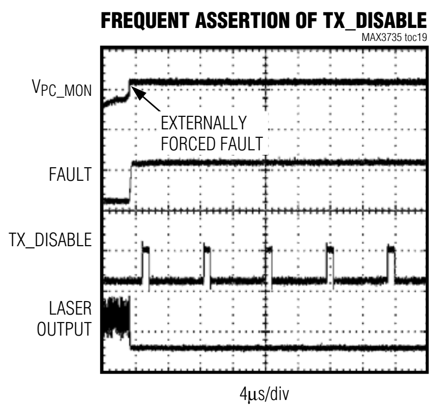
典型工作特性 (续)

(V_{CC} = +3.3V, C_{APC} = 0.01µF, I_{BIAS} = 20mA, and I_{MOD} = 30mA, T_A = +25°C, unless otherwise noted.)









引脚说明

引脚	名称	功能
1, 4, 8, 14, 18	V_{CC}	+3.3V电源电压
2	IN+	同相数据输入
3	IN-	反相数据输入
5	PC_MON	光电二级管电流监视器输出。该引脚的输出电流通过外接电阻产生以地为参考的电压，该电压与监测二极管电流成正比。
6	BC_MON	偏置电流监视器输出。该引脚的输出电流通过外接电阻产生以地为参考的电压，该电压与偏置电流成正比。
7, 12, 22	GND	地
9	SHUTDOWN	关断驱动器输出。输出电压可控制外部晶体管，构成关断电路。
10	TX_FAULT	发送故障指示器，集电极开路输出 (见表1)
11	MODSET	该引脚和地之间外接一只电阻，设置所需的调制电流。
13	BIAS	激光器偏置电流输出
15, 16	OUT+	同相调制电流输出。外部连接第15、16引脚，使封装的寄生电感最小。当输入数据为高时，I_{MOD}流入该引脚。
17	OUT-	反相调制电流输出。当输入数据为低时，I_{MOD}流入该引脚。
19	MD	监测二极管输入。该引脚与监测光电二极管的阳极连接。需外接电容到地，以滤除监视电流的高速交流成分。
20	APCFILT1	在引脚20 (APCFILT1)和引脚21 (APCFILT2)之间接一只电容C_{APC}，设置APC反馈回路的主极点。
21	APCFILT2	参考APCFIL1
23	APCSET	该引脚和地之间接一只电阻，设置所需的平均光功率。
24	TX_DISABLE	发送器禁止，TTL电平。当TX_DISABLE引脚置高或浮空时，激光器输出被禁止。该引脚置低时，激光器输出有效。
EP	Exposed Pad	地。必须焊接到电路板的地层，以获得良好的散热和电气性能。(参考*裸露焊盘封装*部分)

详细说明

MAX3735/MAX3735A激光驱动器包含三个部分：高速调制驱动器、带有自动功率控制 (APC)的激光器偏置电路和保护电路 (见图4)。电路设计优化于高速、低压 (+3.3V) 应用。

高速调制驱动器

输出级由高速差分对和可编程调制电流源组成。MAX3735/MAX3735A针对驱动15Ω负载进行优化；要求OUT+的最低瞬态电压为0.6V。当激光二极管直流耦合到驱动器时，调制电流摆幅可以达到60mA；采用交流耦合时，电流摆幅可达85mA。

为了与激光二极管连接，需采用一只阻尼电阻 (R_D)进行阻抗匹配。串联阻尼电阻与激光二极管的等效串联电阻应等于15Ω。为减小由激光二极管寄生电感引起的光输出偏差和占空比失真，可能需要一个RC并联网络。详细信息，请参考Maxim应用笔记HFAN-02.0：*Interfacing Maxim's Laser Drivers to Laser Diodes (Maxim激光驱动器与激光二极管接口)*。

数据速率为2.7Gbps时，任何加载在激光二极管阴极的电容都会恶化光输出性能。由于BIAS输出直接与激光二极极管阴极连接，可利用电感将BIAS引脚的寄生效应与激光器阴极隔离开，使该引脚的寄生电容最小。

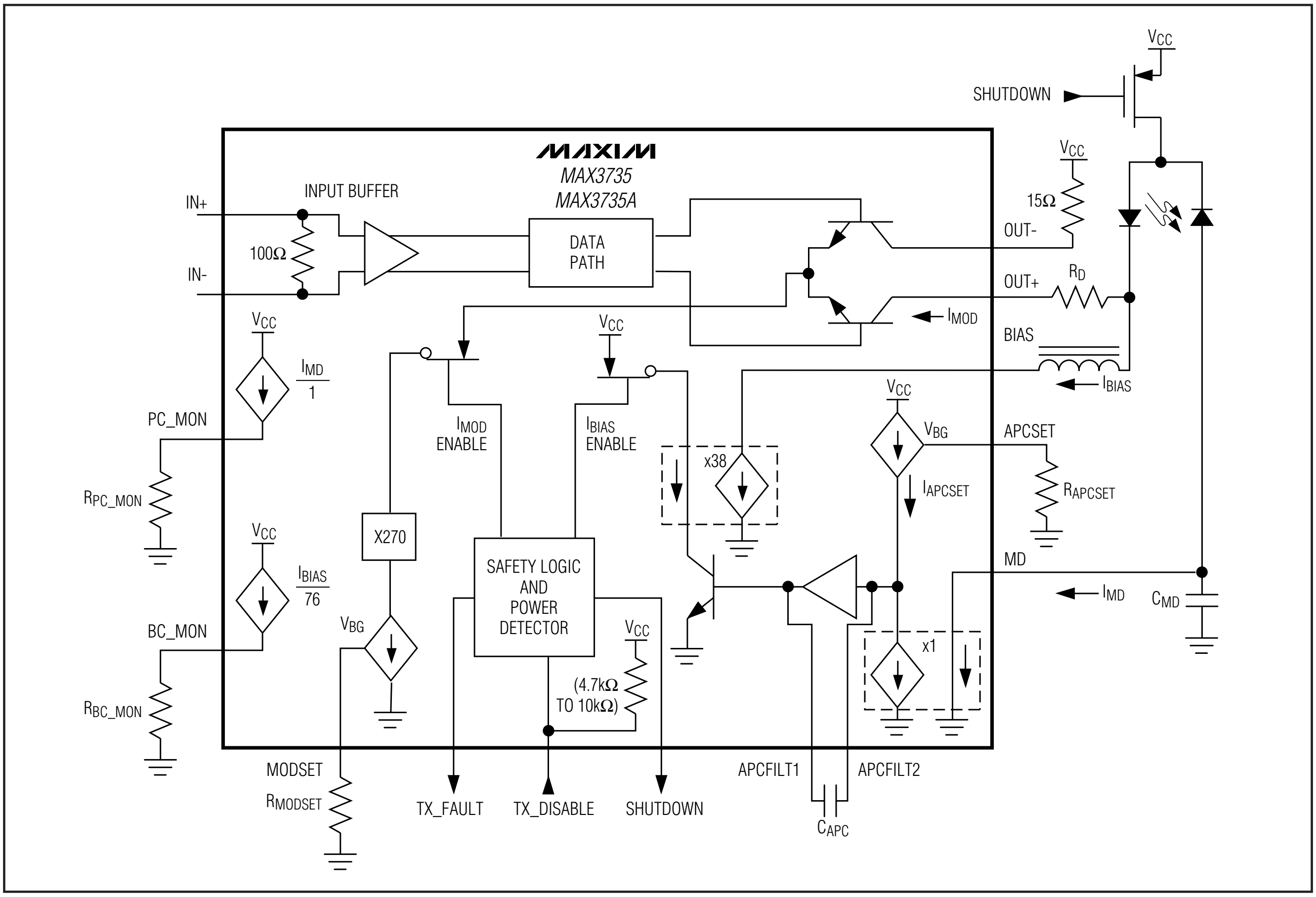


图 4. 功能图

激光器偏置与APC

为保持稳定的平均光功率，MAX3735/MAX3735A集成了一个APC环路，以补偿激光器门限电流在整个温度范围和有效期内的变化。利用激光器封装内的背向光电二极管将光功率转化成光电流。APC环路调节激光器偏置电流，以便使监测器电流与R_{APCSET}设置的参考电流相匹配。APC环路的时间常数由外部电容C_{APC}设定。有关C_{APC}的容值选择，参见*应用信息*部分。

保护电路

保护电路包括输出禁止 (TX_DISABLE)、输出故障锁定(TX_FAULT)和故障检测器 (见图5)。这部分电路监测激光驱动器的运行，一旦检测到故障状态，就强行关断驱动器 (见表1)。单点故障可以是与V_{CC}或GND短路。有关电路对不同单点故障的响应情况参见表2。发送故障状态会一直被锁定，直到TX_DISABLE或V_{CC}引脚被触发复位。利用可选的关断电路，激光驱动器提供备用的激光二极管关断功能 (参见*典型应用电路*)。按照SFP MSA的要求，应该将TX_FAULT引脚通过4.7kΩ至10kΩ电阻上拉至V_{CC}。

保护电路电流监视器

MAX3735/MAX3735A能够监视 (BC_MON、PC_MON) 偏置电流 (I_{BIAS})和光电流 (I_{MD})。通过映射部分电流，并在外部接地电阻产生电压实现监视功能。当PC_MON或BC_MON的电压大于1.38V时，进入故障状态。例如，在每个监测器输出端接100Ω的电阻到地，可以得到以下电压：

$$V_{BC\_MON} = (I_{BIAS} / 76) \times 100\Omega$$

$$V_{PC\_MON} = I_{MD} \times 100\Omega$$

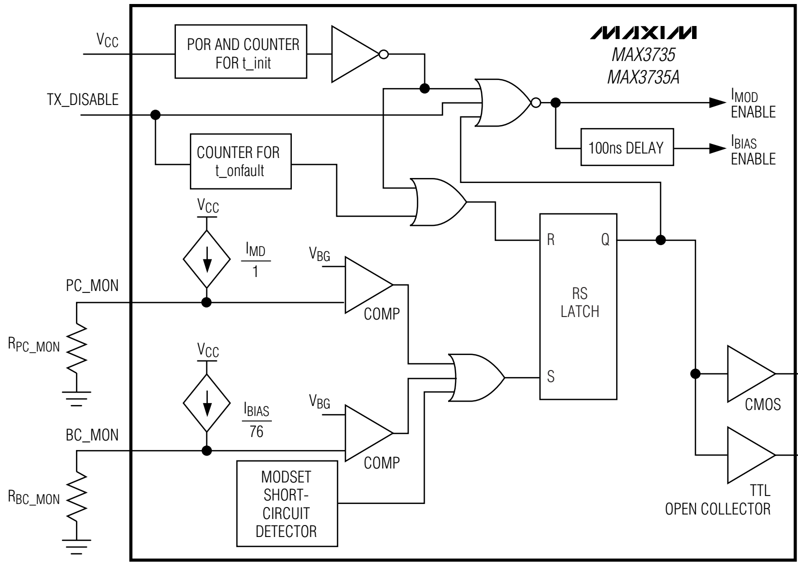


图5. 保护电路

表1. 典型故障状态

1.	If any of the I/O pins is shorted to GND or V_{CC} (single-point failure, see Table 2), and the bias current or the photocurrent exceed the programmed threshold.
2.	End-of-life (EOL) condition of the laser diode. The bias current and/or the photocurrent exceed the programmed threshold.
3.	Laser cathode is grounded and the photocurrent exceeds the programmed thresholds.
4.	No feedback for the APC loop (broken interconnection, defective monitor photodiode), and the bias current exceeds the programmed threshold.

设计步骤

设计激光发送器时，通常用平均功率和消光比表示光输出。表3列出的关系式有助于平均光功率和调制电流之间的换算。在光信号波的符号密度和占空比为50%时，这些关系式有效。

设置调制电流

给定激光功率 (P_{AVG})、斜率效率 (η)和消光比 (r_e)，可根据表3计算调制电流。参见*典型工作特性*中的调制电流与R_{MODSET}关系曲线图，选择+25°C时电流值所对应的R_{MODSET}。

设置APC环路

通过调节R_{APCSET}设置平均光功率。合理选择电阻，确定在整个温度范围和有效期内希望保持的监视电流值。参考*典型工作特性*中的监测二极管电流与R_{APCSET}关系曲线图，选择电流所对应的R_{APCSET}。

与激光器二极管接口

信号在激光器二极管电接口处的反射会引起光输出偏差，为减少偏差，需要串联一只阻尼电阻 (R_D) (见图4)。另外，MAX3735/MAX3735A输出优化于15Ω负载。因此，R_D与R_L串联等效电阻应等于15Ω，R_L表示激光二极管阻值。R_D的典型值为8Ω至13Ω。为获得最佳性能，在靠近激光二极管阳极处接一旁路电容 (典型值为0.01µF)。在激光器负极与地之间接RC并联网络，使光输出偏差最小。对于大多数同轴激光器，可选择RC的初始值为：R_{COMP} = 50Ω，C_{COMP} = 8pF。可以通过实验调整这两个值，直至光输出波形得到优化。有关详细信息，请参考Maxim应用笔记HFAN-02.0：*Interfacing Maxim's Laser Drivers to Laser Diodes (Maxim激光驱动器与激光二极管接口)*。

表2. 不同单点故障的电路响应

PIN NAME	CIRCUIT RESPONSE TO OVERVOLTAGE OR SHORT TO V_{CC}	CIRCUIT RESPONSE TO UNDERVOLTAGE OR SHORT TO GROUND
TX_FAULT	Does not affect laser power.	Does not affect laser power.
TX_DISABLE	Modulation and bias currents are disabled.	Normal condition for circuit operation.
IN+	The optical average power increases and a fault occurs if V_{PC_MON} exceeds the threshold. The APC loop responds by decreasing the bias current.	The optical average power decreases and the APC loop responds by increasing the bias current. A fault state occurs if V_{BC_MON} exceeds the threshold voltage.
IN-	The optical average power decreases and the APC loop responds by increasing the bias current. A fault state occurs if V_{BC_MON} exceeds the threshold voltage.	The optical average power increases and a fault occurs if V_{PC_MON} exceeds the threshold. The APC loop responds by decreasing the bias current.
MD	Disables bias current. A fault state occurs.	The APC circuit responds by increasing bias current until a fault is detected, then a fault state* occurs.
SHUTDOWN	Does not affect laser power. If the shutdown circuitry is used, laser current is disabled and a fault state* occurs.	Does not affect laser power.
BIAS	In this condition, laser forward voltage is 0V and no light is emitted.	Fault state* occurs. If the shutdown circuitry is used, the laser current is disabled.
OUT+	The APC circuit responds by increasing the bias current until a fault is detected, then a fault state* occurs.	Fault state* occurs. If the shutdown circuitry is used, laser current is disabled.
OUT-	Does not affect laser power.	Does not affect laser power.
PC_MON	Fault state* occurs.	Does not affect laser power.
BC_MON	Fault state* occurs.	Does not affect laser power.
APCFILT1	IBIAS increases until V_{BC_MON} exceeds the threshold voltage.	IBIAS increases until V_{BC_MON} exceeds the threshold voltage.
APCFILT2	IBIAS increases until V_{BC_MON} exceeds the threshold voltage.	IBIAS increases until V_{BC_MON} exceeds the threshold voltage.
MODSET	Does not affect laser power.	Fault state* occurs.
APCSET	Does not affect laser power.	Fault state* occurs.

**A fault state asserts the TX_FAULT pin, disables the modulation and bias currents, and asserts the SHUTDOWN pin.*

表3. 光功率定义

PARAMETER	SYMBOL	RELATION
Average Power	P_{AVG}	$P_{AVG} = (P_0 + P_1) / 2$
Extinction Ratio	r_e	$r_e = P_1 / P_0$
Optical Power High	P_1	$P_1 = 2P_{AVG} \times r_e / (r_e + 1)$
Optical Power Low	P_0	$P_0 = 2P_{AVG} / (r_e + 1)$
Optical Amplitude	P_{P-P}	$P_{P-P} = P_1 - P_0$
Laser Slope Efficiency	η	$\eta = P_{P-P} / I_{MOD}$
Modulation Current	I_{MOD}	$I_{MOD} = P_{P-P} / \eta$

模板相关抖动

为使与APC环路时间常数相关的模板相关抖动最小，保证环路的稳定，在APCFILT1与APCFILT2之间接一只电容 (C_{APC}的容值选择请参考*应用信息*部分)。同样建议在光电二极管阳极添加一只电容 (C_{MD})，以滤除由光电二极管产生的瞬态电流。为保持稳定，并留有适当的相位裕量 (对应于C_{APC}和C_{MD}产生的两个极点)，MAX3735的C_{APC}应该比C_{MD}大20倍，MAX3735A的C_{APC}应该比C_{MD}大4到20倍。

输入匹配要求

MAX3735/MAX3735A数据输入与SFP MSA兼容。为获得最佳终端匹配，片内集成了100Ω的差分输入阻抗 (见表6)。由于内置偏置网络，MAX3735/MAX3735A输入能自偏置在恰当的工作点，以符合交流耦合的要求。

可选关断输出电路

激光器阴极接地时，SHUTDOWN控制输出能够提供增强的视觉保护功能。实现该电路需外接晶体管 (见图4)。发生故障时，SHUTDOWN置高，将可选的关断晶体管置于截止模式，从而关闭激光器电流。

应用信息

以下为MAX3735/MAX3735A的设置范例：

选择一个2.488Gbps的通信级激光器。假设激光器输出平均功率：P_{AVG} = 0dBm，工作温度为-40°C至+85°C，最小消光比为6.6 (8.2dB)，并且激光二极管具有以下特性：

波长：λ = 1.3µm

电流门限：I_{TH} = 22mA ，+25°C时

温度系数门限：β_{TH} = 1.3%/°C

激光器至监测器转换系数：ρ_{MON} = 0.2A/W

激光器斜率效率：η = 0.05mW/mA (+25°C时)

确定R_{APCSET}值

所需的监测二极管电流由式$I_{MD} = P_{AVG} \times \rho_{MON}$ = 200µA估算。在*典型工作特性*部分，由监测二极管与R_{APCSET}关系曲线可知，R_{APCSET}应等于3kΩ。该值也可由下式估算：

$$I_{MD} = 1.23 / (2 \times R_{APCSET})$$

确定R_{MODSET}值

为在整个温度范围和有效期内得到6.6的最小消光比 (r_e)，计算+25°C时所需消光比。假设25°C时，r_e的计算结果等于20，根据表3，光功率峰值P_{P-P} = 1.81mW。所需的调制电流为1.81mW/(0.05mW/mA) = 36.2mA。在*典型工作特性*部分，由调制电流与R_{MODSET}关系曲线可知R_{MODSET}应为9.5kΩ。该值也可由下式估算：

$$I_{MOD} = 1.23 / (0.0037 \times R_{MODSET})$$

确定C_{APC}

为满足SFP时序要求，并使模板相关抖动最小，C_{APC}的容值应该由激光器至监视器的转换系数及其它变量确定。利用下式和表格可分别选择MAX3735和MAX3735A的C_{APC}。公式和表格都假定采用直流耦合激光器。有关选择直流和交流耦合激光器接口的C_{APC}的详细信息，请参考Maxim应用笔记HFDN-23.0: *Choosing the APC Loop Capacitors Used with MAX3735/MAX3735A SFP Module*

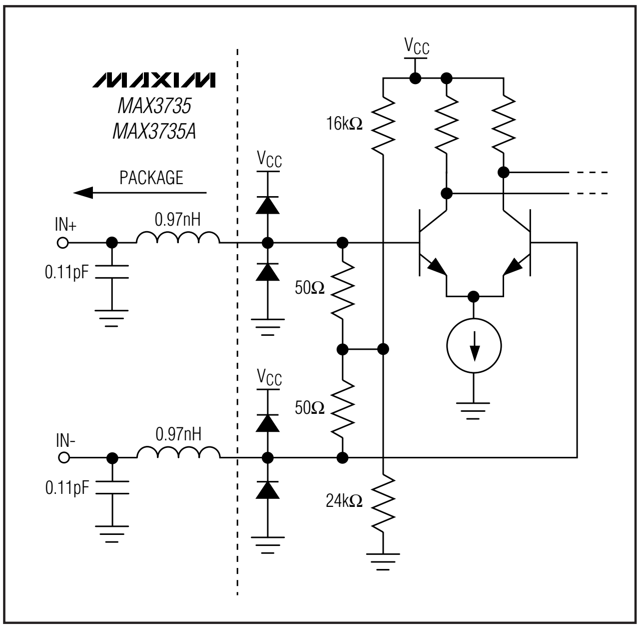


图6. 简化的输入结构

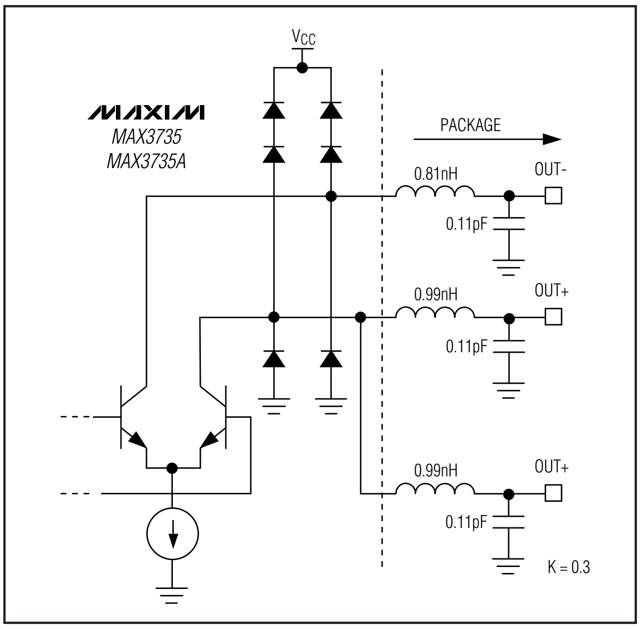


图7. 简化的输出结构

Designs (在MAX3735和MAX3735A SFP模块设计中选择APC环路电容)。

MAX3735

采用MAX3735时，利用以下公式计算C_{APC}容值：

$$C_{APC} = 4.04 \times 10^{-9} \times t_{on} \times \eta \times \rho_{MON} (29.3 + 20.6 I_{TH} - 0.22 I_{TH}^2) \times (1947 + 833 I_{MOD} - 7.78 I_{MOD}^2 + 0.103 I_{MOD}^3)$$

单位：

C_{APC}为μF，I_{TH}和I_{MOD}为mA，t_{ON}为μs。MAX3735的C_{MD}值应约小于C_{APC}的20倍。

MAX3735A

当采用MAX3735A时，参照表4选择C_{APC}。C_{APC}应该由激光器的最高增益确定 (通常在低温状态下)。选择C_{APC}时，假定激光器在+85°C时的增益比低温 (-40°C)时的增益小34%。

表4. MAX3735A的C_{APC}选择

LASER GAIN (A/A)	C_{APC} (F)
0.005	0.039
0.007	0.047
0.010	0.068
0.020	0.100
0.030	0.120
0.040	0.120

其中，直流耦合激光器增益Gain = $I_{MD}/(I_{BIAS} - I_{TH} + 0.5 \times I_{MOD})$。所选择的MAX3735A的$C_{MD}$值约小于$C_{APC}$的4倍到20倍。

MAX3735/MAX3735A与数字电位器配合使用

有关MAX3735/MAX3735A与Dallas DS1858/DS1859 SFP控制器配合使用的详细信息，请参考Maxim应用笔记HFAN-2.3.3：*Optimizing the Resolution of Laser Driver Setting Using Linear Digital Potentiometers (采用线性数字电位器优化激光驱动器设置的解决方案)*。

调制电流超过60mA

需要高于60mA的调制电流时，如果激光器采用直流耦合，留出的空间将不足以保证激光器的正常运行。为避免该问题的发生，MAX3735/MAX3735A的调制输出可通过交流耦合至激光二极管的阴极。这就需要一只外部上拉电感，将调制输出直流偏置在V_{CC}。这种配置将激光器正向电压与输出电路隔离，并允许OUT+输出在供电电压 (V_{CC})处上下波动。采用交流耦合时，MAX3735/MAX3735A调制电流可以设定为10mA至85mA。有关交流耦合激光驱动器与激光二极管的详细信息，请参考Maxim应用笔记HFAN-02.0：*Interfacing Maxim's Laser Driver to Laser Diodes (Maxim激光驱动器与激光二极管接口)*。

接口模块

图6和图7给出了MAX3735/MAX3735A激光驱动器的简化输入、输出电路。若使用裸片，用绑定线的寄生参数替代封装的寄生参数。

绑定裸片引线

MAX3735采用厚度为5μm (典型值)的金箔。Maxim为这个电路提供金线焊球绑定 (线直径为1mil)，裸片尺寸为94mil (2388μm)的正方形，厚度为15mil (381μm)。详细信息，请参考Maxim应用笔记HFAN-08.0.1：*Understanding Bonding Coordinates and Physical Die Size*。

布线考虑

为使电感最小，应使MAX3735输出引脚与激光二极管之间的连线尽可能短。靠近激光器阳极放置一只旁路电容，优化激光二极管的性能。采用良好的高频布线技术以及具有连续接地平面的多层板可以降低EMI和串扰。

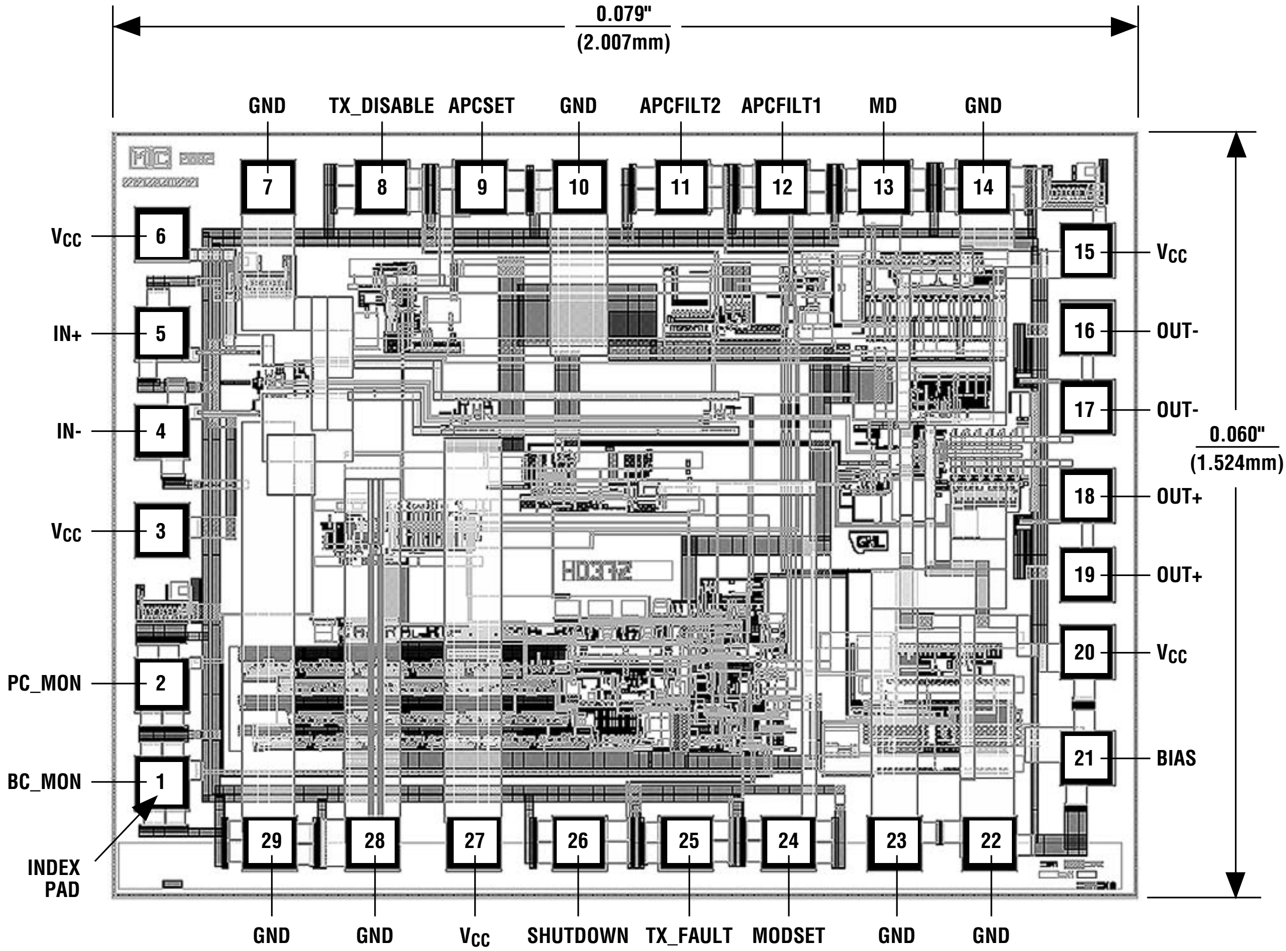
裸露焊盘封装

24引脚QFN的裸露焊盘提供了一个很低的热阻通路，有助于IC散热。该焊盘同时也是MAX3735/MAX3735A的电气地，必须被焊接至电路板地，以获得良好的散热性能和电气性能。详细信息，请参考Maxim应用笔记HFAN-08.1：*Thermal Consideration for QFN and Other Exposed-Pad Packages*。

激光器安全性和IEC 825

单独采用MAX3735/MAX3735A激光驱动器并不保证发射器的设计符合IEC825标准。必须仔细考虑整个发射器电路及器件选择。每个用户必须明确具体应用所要求的容错等级，确保Maxim产品不会作为系统的一个部分被设计或使用到外科移植手术，用于支撑或维持生命，或其它任何可能因为Maxim产品失效所导致的人体伤害、甚至死亡的应用领域。

MAX3735芯片拓扑



绑定坐标

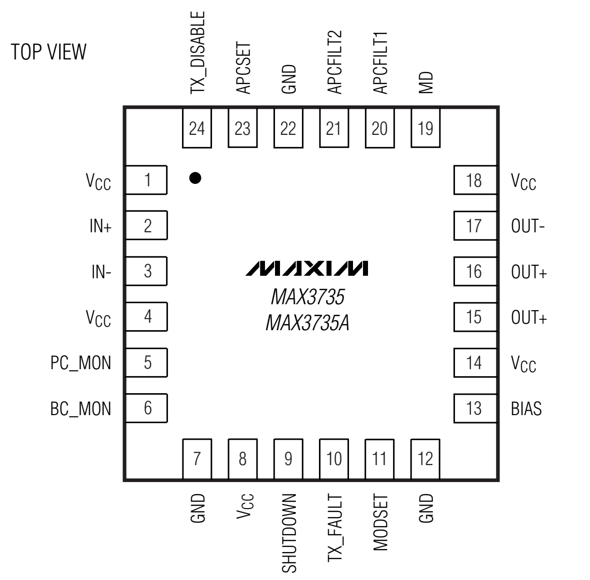
表5. MAX3735绑定位置

PAD	NAME	COORDINATES	
		X	Y
1*	BC_MON	47	47
2	PC_MON	47	229
3	V_{CC}	47	514
4	IN-	47	696
5	IN+	47	878
6	V_{CC}	47	1063
7	GND	242	1149
8	TX_DISABLE	452	1149
9	APCSET	636	1149
10	GND	819	1149
11	APCFILT2	1008	1149
12	APCFILT1	1193	1149
13	MD	1383	1149
14	GND	1567	1149
15	V_{CC}	1758	1032
16**	OUT-	1758	888
17**	OUT-	1758	742
18**	OUT+	1758	579
19**	OUT+	1758	433
20	V_{CC}	1758	289
21	BIAS	1758	93
22	GND	1578	-64
23	GND	1401	-64
24	MODSET	1205	-64
25	TX_FAULT	1016	-64
26	SHUTDOWN	818	-64
27	V_{CC}	623	-64
28	GND	435	-64
29	GND	245	-64

**Index pad. Orient the die with this pad in the lower-left corner.*

***Bond out both pairs of OUT- and OUT+ to minimize series inductance.*

引脚配置



Thin QFN*
(4mm x 4mm)

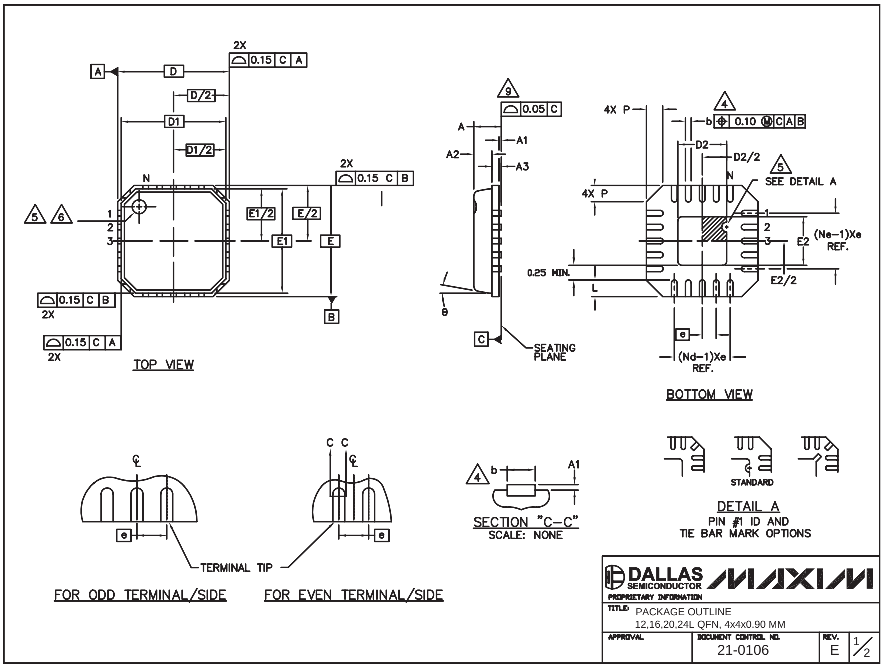
*THE EXPOSED PAD MUST BE CONNECTED TO CIRCUIT BOARD GROUND FOR PROPER THERMAL AND ELECTRICAL PERFORMANCE.

芯片信息

TRANSISTOR COUNT: 327
SUBSTRATE CONNECTED TO GND
DIE SIZE: 60 mils x 79 mils
PROCESS: SiGe Bipolar

封装信息

(本数据资料提供的封装图可能不是最近的规格，如需最近的封装外型信息，请查询 **www.maxim-ic.com.cn/packages**。)



NOTES:

1. DIE THICKNESS ALLOWABLE IS 0.305mm MAXIMUM (.012 INCHES MAXIMUM).
2. DIMENSIONING & TOLERANCES CONFORM MUST TO ASME Y14.5M. – 1994.
3. N IS THE NUMBER OF TERMINALS.
   Nd IS THE NUMBER OF TERMINALS IN X-DIRECTION &
   Ne IS THE NUMBER OF TERMINALS IN Y-DIRECTION.
4. DIMENSION b APPLIES TO PLATED TERMINAL AND IS MEASURED BETWEEN 0.20 AND 0.25mm FROM TERMINAL TIP.
5. THE PIN #1 IDENTIFIER MUST BE EXISTED ON THE TOP SURFACE OF THE PACKAGE BY USING INDENTATION MARK OR INK/LASER MARKED. DETAILS OF PIN #1 IDENTIFIER IS OPTIONAL, BUT MUST BE LOCATED WITHIN ZONE INDICATED.
6. EXACT SHAPE AND SIZE OF THIS FEATURE IS OPTIONAL.
7. ALL DIMENSIONS ARE IN MILLIMETERS.
8. PACKAGE WARPAGE MAX 0.05mm.
9. APPLIED FOR EXPOSED PAD AND TERMINALS.
   EXCLUDE EMBEDDING PART OF EXPOSED PAD FROM MEASURING.
10. MEETS JEDEC MO220; EXCEPT DIMENSION "b".
11. THIS PACKAGE OUTLINE APPLIES TO PUNCHED QFN (STEPPED SIDES).

SYMBOL	COMMON DIMENSIONS MIN.	NOM.	MAX.	NOTE
A	0.80	0.90	1.00	
A1	0.00	0.01	0.05	
A2	0.00	0.65	0.80	
A3		0.20 REF.		
D		4.00 BSC		
D1		3.75 BSC		
E		4.00 BSC		
E1		3.75 BSC		
θ	0°	–	12°	
P	0.24	0.42	0.60	

SYMBOL	PITCH VARIATION A MIN.	NOM.	MAX.	NOTE	SYMBOL	PITCH VARIATION B MIN.	NOM.	MAX.	NOTE
e		0.80 BSC			e		0.65 BSC		
N		12		3	N		16		3
Nd		3		3	Nd		4		3
Ne		3		3	Ne		4		3
L	0.50	0.60	0.75		L	0.50	0.60	0.75	
b	0.28	0.33	0.40	4	b	0.23	0.28	0.35	4

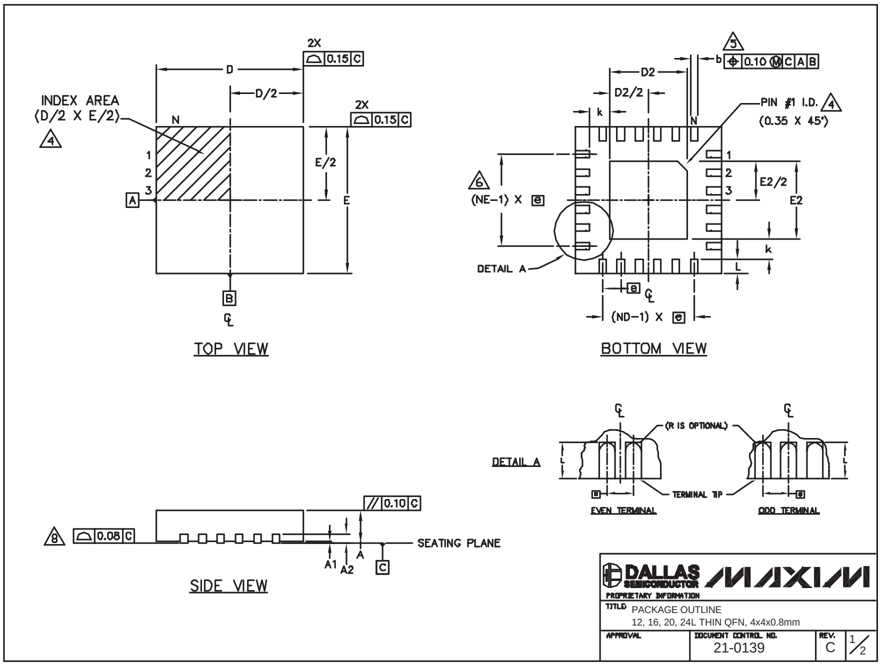
SYMBOL	PITCH VARIATION C MIN.	NOM.	MAX.	NOTE	SYMBOL	PITCH VARIATION D MIN.	NOM.	MAX.	NOTE
e		0.50 BSC			e		0.50 BSC		
N		20		3	N		24		3
Nd		5		3	Nd		6		3
Ne		5		3	Ne		6		3
L	0.50	0.60	0.75		L	0.30	0.40	0.50	
b	0.18	0.23	0.30	4	b	0.18	0.23	0.30	4

PKG. CODE	EXPOSED PAD VARIATION D2 MIN.	D2 NOM.	D2 MAX.	E2 MIN.	E2 NOM.	E2 MAX.
G1244–2	1.95	2.10	2.25	1.95	2.10	2.25
G1644–1	1.95	2.10	2.25	1.95	2.10	2.25
G2044–3	1.95	2.10	2.25	1.95	2.10	2.25
G2044–4	1.55	1.70	1.85	1.55	1.70	1.85
G2444–1	1.95	2.10	2.25	1.95	2.10	2.25

DALLAS SEMICONDUCTOR MAXIM
PROPRIETARY INFORMATION
TITLE: PACKAGE OUTLINE
12,16,20,24L QFN, 4x4x0.90 MM
APPROVAL | DOCUMENT CONTROL NO. 21-0106 | REV. E | 2/2

封装信息 (续)

(本数据资料提供的封装图可能不是最近的规格，如需最近的封装外型信息，请查询 www.maxim-ic.com.cn/packages。)



COMMON DIMENSIONS												
PKG	12L 4x4			16L 4x4			20L 4x4			24L 4x4		
REF.	MIN.	NOM.	MAX.	MIN.	NOM.	MAX.	MIN.	NOM.	MAX.	MIN.	NOM.	MAX.
A	0.70	0.75	0.80	0.70	0.75	0.80	0.70	0.75	0.80	0.70	0.75	0.80
A1	0.0	0.02	0.05	0.0	0.02	0.05	0.0	0.02	0.05	0.0	0.02	0.05
A2	0.20 REF			0.20 REF			0.20 REF			0.20 REF		
b	0.25	0.30	0.35	0.25	0.30	0.35	0.20	0.25	0.30	0.18	0.23	0.30
D	3.90	4.00	4.10	3.90	4.00	4.10	3.90	4.00	4.10	3.90	4.00	4.10
E	3.90	4.00	4.10	3.90	4.00	4.10	3.90	4.00	4.10	3.90	4.00	4.10
e	0.80 BSC.			0.65 BSC.			0.50 BSC.			0.50 BSC.		
k	0.25	-	-	0.25	-	-	0.25	-	-	0.25	-	-
L	0.45	0.55	0.65	0.45	0.55	0.65	0.45	0.55	0.65	0.30	0.40	0.50
N	12			16			20			24		
ND	3			4			5			6		
NE	3			4			5			6		
Jedec Var.	WGGB			WGGC			WGGD-1			WGGD-2		

EXPOSED PAD VARIATIONS							
PKG. CODES	D2			E2			DOWN BONDS ALLOWED
	MIN.	NOM.	MAX.	MIN.	NOM.	MAX.	
T1244-2	1.95	2.10	2.25	1.95	2.10	2.25	NO
T1244-3	1.95	2.10	2.25	1.95	2.10	2.25	YES
T1244-4	1.95	2.10	2.25	1.95	2.10	2.25	NO
T1644-2	1.95	2.10	2.25	1.95	2.10	2.25	NO
T1644-3	1.95	2.10	2.25	1.95	2.10	2.25	YES
T1644-4	1.95	2.10	2.25	1.95	2.10	2.25	NO
T2044-1	1.95	2.10	2.25	1.95	2.10	2.25	NO
T2044-2	1.95	2.10	2.25	1.95	2.10	2.25	YES
T2044-3	1.95	2.10	2.25	1.95	2.10	2.25	NO
T2444-1	2.45	2.60	2.63	2.45	2.60	2.63	NO
T2444-2	1.95	2.10	2.25	1.95	2.10	2.25	YES
T2444-3	2.45	2.60	2.63	2.45	2.60	2.63	YES
T2444-4	2.45	2.60	2.63	2.45	2.60	2.63	NO

NOTES:

1. DIMENSIONING & TOLERANCING CONFORM TO ASME Y14.5M-1994.
2. ALL DIMENSIONS ARE IN MILLIMETERS. ANGLES ARE IN DEGREES.
3. N IS THE TOTAL NUMBER OF TERMINALS.
4. THE TERMINAL #1 IDENTIFIER AND TERMINAL NUMBERING CONVENTION SHALL CONFORM TO JESD 95-1 SPP-012. DETAILS OF TERMINAL #1 IDENTIFIER ARE OPTIONAL, BUT MUST BE LOCATED WITHIN THE ZONE INDICATED. THE TERMINAL #1 IDENTIFIER MAY BE EITHER A MOLD OR MARKED FEATURE.
5. DIMENSION b APPLIES TO METALLIZED TERMINAL AND IS MEASURED BETWEEN 0.25 mm AND 0.30 mm FROM TERMINAL TIP.
6. ND AND NE REFER TO THE NUMBER OF TERMINALS ON EACH D AND E SIDE RESPECTIVELY.
7. DEPOPULATION IS POSSIBLE IN A SYMMETRICAL FASHION.
8. COPLANARITY APPLIES TO THE EXPOSED HEAT SINK SLUG AS WELL AS THE TERMINALS.
9. DRAWING CONFORMS TO JEDEC MO220, EXCEPT FOR T2444-1, T2444-3 AND T2444-4.

DALLAS SEMICONDUCTOR MAXIM
PROPRIETARY INFORMATION
TITLE: PACKAGE OUTLINE
12, 16, 20, 24L THIN QFN, 4x4x0.8mm
APPROVAL | DOCUMENT CONTROL NO. 21-0139 | REV. C | 2/2