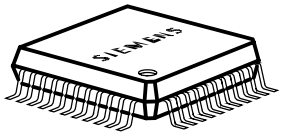
2.5 Gb/s Laser Driver

Preliminary Data **Bipolar IC**

Features



P-MQFP-44-2

- Data rate up to 2.5 Gb/s
- Supply range from + 3.0 V to + 5.0 V
- Maximum power consumption typically 50 mA
- Modulation current programmable up to 60 mA
- DC offset programmable up to 60 mA
- Temperature coefficient of the laser diode adjustable
- Integrated bias control
- Integrated laser supervisor for all vital laser functions

Applications

- Fiber optics data communication systems
- SONET OC-48, SDH STM-16

Type	Ordering Code	Package
FOA2251A1	Q67000-Hxxxx	P-MQFP-44-2
FOA2252A1	Q67000-Hxxxx	bare die

GENERAL

This document defines the ratings and characteristics of a laser driver circuit dedicated for applications within data communication modules with respect to various transmission standards and laser safety requirements.
A block diagram of this circuit is shown in figure 1. The laser driver mainly consists of a modulator, a laser diode bias current controller and a laser- / V_{CC} supervisor circuit.

Modulator:
The modulator is capable of driving modulation currents up to 60 mA. The modulation current is adjustable by an external resistor (R_{MOD}). Furthermore there is a control input which defines the modulation current temperature dependency. The IC has an internal temperature compensation circuit for compensating the temperature characteristic of laser diode slope efficiency. With the external resistor (R_{TC}), the modulation current temperature coefficient is adjustable. The temperature input itself derives from chip junction temperature. An input signal monitor circuit delivers an internal signal which is used for laser disabling, if data input is constantly high or low.

Bias Controller:
The bias controller controls the laser diode's optical output power by adjusting the bias current. The controller cutoff frequency is adjustable by external capacitor (C_{BIAS}). The laser bias current will start at < 300µA after laser enable.

Laser Supervisor / V_{CC} Supervisor:
The laser supervisor circuit monitors the laser output power by the means of monitor diode feedback. The voltage generated by monitor diode circuit is compared to a reference. If the input voltage deviates more than ± 2dB (optical power ± 1dB) from this reference, the laser diode is switched off and a fault indication is generated. The V_{CC} supervisor monitors the circuit power supply and switches off the laser if the V_{CC} level is below the reset threshold. It is keeping the laser output down for the adjusted delay time (Power On Delay) after V_{CC} has risen above the V_{CC} reset threshold.

BLOCK DIAGRAM

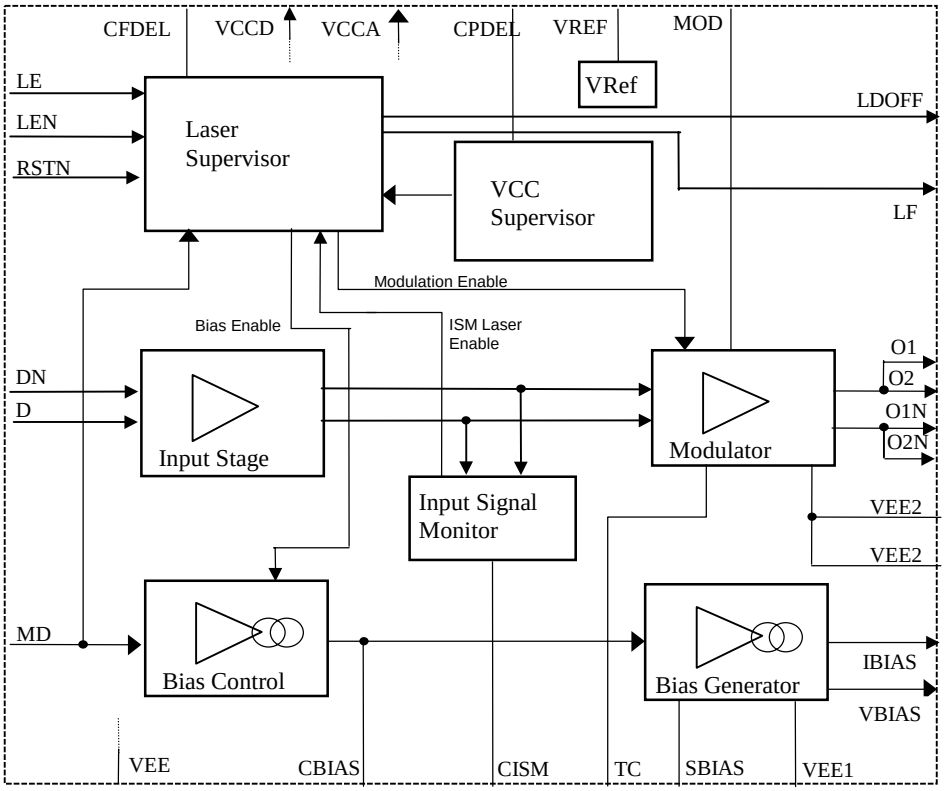


Figure 1: General Circuit Block Diagram

ABSOLUTE MAXIMUM RATINGS

Stresses above the ones listed below may cause permanent damage to the device. Exposure to these values for extended periods may effect device reliability. If the device is operated beyond the range of operating conditions and characteristics, functionality cannot be guaranteed. All voltages given within this data sheet are referred to GND if not otherwise mentioned.

Rating	*Unit*	*Min*	*Max*	*Note*
Supply Voltage	V	-0.5	5.5	
Output Voltage at O, ON, BIAS, LD_{OFF}, S_{BIAS}	V	-0.5	V_{CC} +0.7V	
Output Voltage at Logic Output LF	V	-0.7	V_{CC} +0.7V	Note 1
Input Voltage at MD	V	-0.5	5.5	
Input Voltage at Logic Inputs LE, LEN, RSTN	V	-0.7	V_{CC} +0.7V	
Differential Data Input Voltage $\lvert V_D - V_{DN} \rvert$	V		2.5	
LDOFF Low Output Voltage	V	V_{CC} - 1.2		
Modulation Current at O,ON	mA		80	
Bias Current at IBIAS	mA		80	
Output Current Low at LF	mA		3	
Junction Temperature	°C	-40	125	
Storage Temperature	°C	-55	150	
Relative Humidity (non-condensing)	%		95	
Electrostatic Discharge Voltage Capability	kV		2	D/DN and O/ON excluded
Electrostatic Discharge Voltage Capability	kV		1	D/DN Note 2

Notes:

1. A short-circuit at these outputs, either at logic high or low level, will not damage the device.

2. The input capacitance at these inputs will not exceed 0.6 pF.

OPERATING CONDITIONS

Under operating conditions defined below all specified characteristics will be met unless otherwise noted.

Condition	*Unit*	*Min*	*Max*	*Note*
Environmental				
Junction Temperature	°C	-40	125	Note1
Relative Humidity (non-condensing)	%		95	
Supply Voltage				
Range	V	3	5.5	

Notes:

1. Between -40°C to -20°C only the laser safety has to be guaranteed, all other parameters between -20°C and +125°C.

CHARACTERISTICS

SP	*Characteristic*	*Symbol*	*Unit*	*Min*	*Typ.*	*Max*	*Note*
	Laser Modulator						
1	Data Transmission Rate	DR	GBd	0		2.5	into 10Ω Load
2	Supply Current	I_{CC}	mA		50	75	Note 1
3	Modulation Current Range at Data Input High for Vcc≥3.7V and Tj=-40...125°C or for Vcc≥3.15V and Tj≥25°C	$I_{mod_{high}}$ - $I_{mod_{low}}$	mA	0		60	Note 2
4	Modulation Current at Data Input Low	$I_{mod_{low}}$	mA	0		2	Note 3, Offset
5	Modulation Current at Laser Shut Down	$I_{mod_{SD}}$	mA	0		2	Note 4
6	O, ON Output Voltage Range	V_O,V_{ON}	V	1.5		4	
7	Modulation Current Control Resistor Range (MOD-Resistor)	R_{MOD}	kΩ	0		4	Note 5 Note19

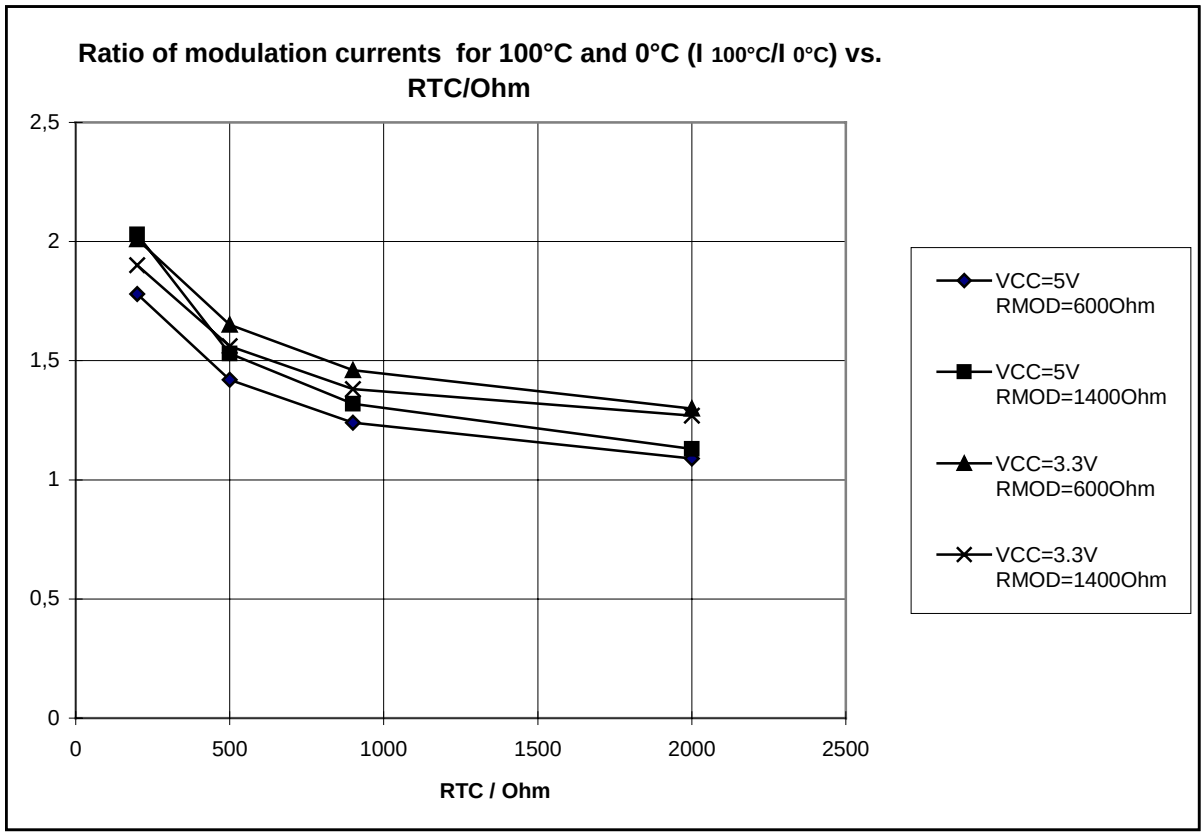
SP	Characteristic	Symbol	Unit	Min	Typ.	Max	Note
8	Modulation Temperature Coefficient Resistor Range	R_{TC}	kΩ	0.03		3	Note 5,6
	Serial Data Input						
9	Data Input Voltage High	V_{IH}	V	2		V_{CC} -0.2	
10	Data Input Voltage Swing	$\lvert V_D - V_{DN} \rvert$	mV	200		1000	
11	Data Input Current High	$I_{IHD/DN}$	µA			300	
12	Data Input Current Low	$I_{ILD/DN}$	µA	- 300			
13	V_{BB} Output Voltage at D/DN	V_{BB}	V	V_{CC} - 1.1		V_{CC} - 0.85	Note 7
14	Data Input Resistor	R_{IN}	kΩ	4	5	6	Note 7
15	Input Capacitance	C_{INPECL}	pF			0.6	
	Logic Inputs RSTN, LE, LEN						
16	Input Voltage High	$V_{IHLOGIC}$	V	2.0		V_{CC}	
17	Input Voltage Low	$V_{ILLOGIC}$	V	0		0.8	
18	Input Current High	$I_{IHLOGIC}$	µA			5	
19	Input Current Low	$I_{ILLOGIC}$	µA	-5			
	Logic Outputs LF						
20	Output Voltage Low	$V_{OLLOGIC}$	V			0.4	
21	Output Current High (Leakage Current)	$I_{OHLOGIC}$	µA			100	open collector
22	Output Current Low	$I_{OLLOGIC}$	mA			1	sink current
	Input Signal Monitor (ISM)						
23	ISM Delay Time vs. C_{ISM} Capacitor Range	$\frac{t_{ISMDEL}}{C_{ISM}}$	$\frac{\mu s}{nF}$		9		Note 8 Note 9
24	Duty Cycle for laser enable		%	25		75	
25	Duty Cycle for laser disable		%	0		5	Input low
26	Duty Cycle for laser disable		%	95		100	Input high
	Laser Power Regulation / Control						
27	max. Bias Current for Vcc≥3.15V and Tj≥50°C	$I_{BIASmax}$	mA	60			
28	min. Bias Current	$I_{BIASmin}$	µA			300	
29	Bias Current at Laser Shut Down	I_{BIASSD}	µA			300	
30	Bias Current vs. Bias Monitor Current	$\frac{I_{BIAS}}{I_{SBIAS}}$			110		Note 10

SP	Characteristic	Symbol	Unit	Min	Typ.	Max	Note
31	Output Voltage Range BIAS, S_{BIAS}	V_{BIAS} VS_{BIAS}	V	0.5		4	
	Laser Supervising Circuit						
32	MD Failure Voltage High			V_{MD} nom + 2.2dB	V_{MD} nom + 2dB		Note 11 optical: +1dB
33	MD Failure Voltage Low				V_{MD} nom - 2dB	V_{MD} nom - 2.2dB	Note 11 optical: -1dB
34	MD Range without Failure Recognition		V	V_{MD} nom - 1.2dB		V_{MD} nom + 1.2dB	Note 12
35	Failure Recognition Time vs. C_{FDEL} Capacitor	$\frac{t_{FDEL}}{C_{FDEL}}$	$\frac{\mu s}{nF}$		115		Note 9 Note 13 Note 18
36	Shut Off Time after Failure or Laser Disable	t_{LDdis}	µs			3	Note 14
37	RSTN Pulse Width vs. C_{FDEL}		$\frac{\mu s}{nF}$		25		
38	V_{CC} Reset Threshold for Laser Enable/Disable		V	2.2		2.99	Note 15
39	Power On Delay vs. C_{PDEL} Capacitor Range	$\frac{t_{PDEL}}{C_{PDEL}}$	$\frac{ms}{nF}$		0.22		Note 16 Note 9
40	LD_{OFF} Low Output Current		mA	1		3	sink current
41	LD_{OFF} High Output Current		µA			2	sink current
42	LD_{OFF} High Output Voltage		V	V_{CC} -0.1			
	Reference Voltage						
43	Voltage Range V_{REF}	V_{REF}	V	1.84	2.0	2.15	
44	V_{REF} Source Current	$I_{REFsource}$	mA			1	
45	V_{REF} Sink Current	$I_{REFsink}$	µA			100	
46	MD Reference Value	V_{MDR}	V	1.1		1.3	Note 17
47	V_{MDR} Drift over Temperature Range	$\lvert \Delta V_{MDR} / V_{MDR} \rvert$	%			10	
48	V_{MDR} Drift over Supply Voltage Range 3 V ... 5.5 V	$\lvert \Delta V_{MDR} / V_{MDR} \rvert$	%			10	

Notes:

1. The bias -, modulation-, the LF- and S_{BIAS} output currents are not included.
2. This describes the AC modulation current (the DC component is the overall offset current). AC modulation current is drawn by O at $V_D > V_{DN}$, it is drawn by ON at $V_D < V_{DN}$. $I_{mod_{high}}$ refers to drawn modulation current (AC + DC). $I_{mod_{low}}$ refers to an inactive current output (DC current only).
3. Inactive current output (see also note 2).
4. Modulation current when the laser diode is disabled.
5. Adjustment of programmable parameter by resistor value within this range.
6. Modulation current adaptation within junction temperature range. Low junction temperature represents a low additional modulation current. High junction temperature represents a high additional modulation current.
7. D/DN inputs are internally terminated to V_{BB} by resistor R_{IN} . See data input stage description.
8. If data input duty cycle falls below 5 % or exceeds 95 % the laser will be disabled after t_{ISMDEL}. On the other hand, the laser will be enabled within t_{ISMDEL} whenever the data input duty cycle goes back to 25 % ... 75 %. Data input duty cycle refers to the quotient given by number of ones divided by number of zeros within serial data stream. t_{ISMDEL} will be adjusted by external capacitor at C_{ISM}.
9. A capacitor within this range programs the time.
10. S_{BIAS} is an open collector output for pulling up a resistor R_{SBIAS} to monitor the bias current.
11. The supervisor circuit will detect a failure condition if MD voltage exceeds $V_{MDnom} \pm$ 2dB range. V_{MDnom} is given by nominal voltage level at MD which is set by V_{MDR}.
12. The supervisor circuit will detect no failure condition if MD input voltage ranges from V_{MDnom} -1.2dB to V_{MDnom} + 1.2dB. V_{MDnom} is given by nominal voltage level at MD which is set by V_{MDR}.
13. A failure condition will be reported by LF if this condition lasts for t_{FDEL}. This time can be adjusted by external capacitor at C_{FDEL}.
14. Time between LF high (or LE low) and LD_{OFF} high.
15. At supply voltages below V_{CC} threshold the laser diode bias and modulation current will be held disabled and LD_{OFF} will be held high. Above the laser diode will be enabled after the Power On Delay.
16. The Power On Delay is the reset time after V_{CC} voltage has risen above the V_{CC} reset threshold. During the Power On Delay the laser diode bias and modulation current will be held disabled and LDOFF will be held high. This time can be adjusted by external capacitor at C_{PDEL}.
17. Temperature and voltage drift are included.
18. Minimal capacitor on C_{FDEL} has to be chosen that the failure recognition time is longer than the settling time of the bias controller.
19. Adjusting the modulation current by R_{MOD} notice that the increasing of R_{MOD} will increase the modulation current. R_{MOD} has to be adjusted that the modulation current is smaller than 60mA.

TYPICAL CHARACTERISTIC OF TEMPERATURE COMPENSATION



DATA INPUT STAGE

Both data inputs D and DN are terminated to a V_{BB} reference of nominal V_{CC} - 1 V by resistors R_{IN}. This easily provides the data input reference voltage at AC coupling. A schematic of the input stage is shown below:

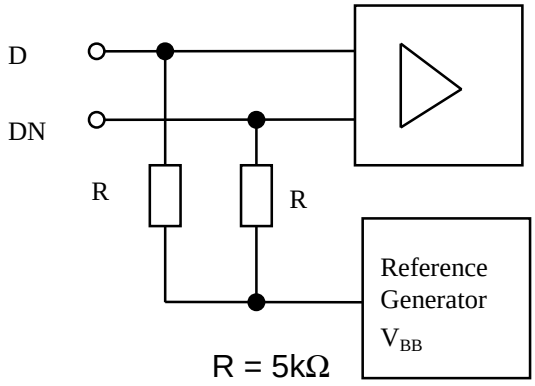


Figure 2: Data Input Stage

LASER AND V_{CC} SUPERVISING CIRCUIT

If there is a fault signal (Laser Fault), this signal is stored and indicated by LF. The fault indication (LF) can be reset with low level at RSTN or with power down (V_{CC} < V_{CC} Reset Threshold) only. After power up, LF will always be cleared. Together with resetting LF, the external capacitor at C_{FDEL} is charged to reset the fault delay time as well. This capacitor will also be charged whenever the laser is disabled by LE / LEN to accomplish equal fault delay times after laser enable, but this does not influence a previous fault indication by LF. The laser fault generation can be switched off by connecting C_{FDEL} to V_{EE}.

The Power On Delay is the reset time after V_{CC} voltage has risen above the V_{CC} reset threshold. This time can be adjusted by an external capacitor at C_{PDEL}. If C_{PDEL} is shorted to V_{CC}, there is no Power On Delay.

The laser control by LE and LEN is fully redundant. This means only an ’AND’ combination of LE = 1 / LEN = 0 can switch the laser on. The ’OR’ combination of LE = 0 / LEN = 1 switches the laser off. To guarantee this on any single fault condition too, LE and LEN paths are implemented completely separate and redundant (see table 1 for clarification).

LE	LEN	RSTN	in case of Laser Fault	Vcc<Reset Threshold Vcc	LDOFF	Modulation Enable***	Bias Enable***	LF
0	X	X	0	X	1	0	0	0
X	1	X	0	X	1	0	0	0
X	X	1	1	X	1	0	0	1
X	X	0	X	X	1	0	0	0
X	X	X	X	yes	1	0	0	0
1	0	1	0	no**	0*	1	1	0

Table 1: Laser Diode Currents Enable / Disable Signals

* : sink current enabled = Low
** : after Power On Delay.
*** : internal signal

The table shows the static states of these signals. Dynamic changes or delays due to external delay capacitors are not shown.
Bias current is disabled by setting Bias Enable low, modulation current is disabled by setting Modulation Enable low.
LE and LEN do not effect LF. This means LF can not be reset by any combination of these signals.

INPUT SIGNAL MONITORING

Data Level in t_{ISMDEL}	ISM Laser Enable***	LDOFF	Modulation Enable***	Bias Enable***	LF
constant High	0	1	0	0	0
constant Low	0	1	0	0	0

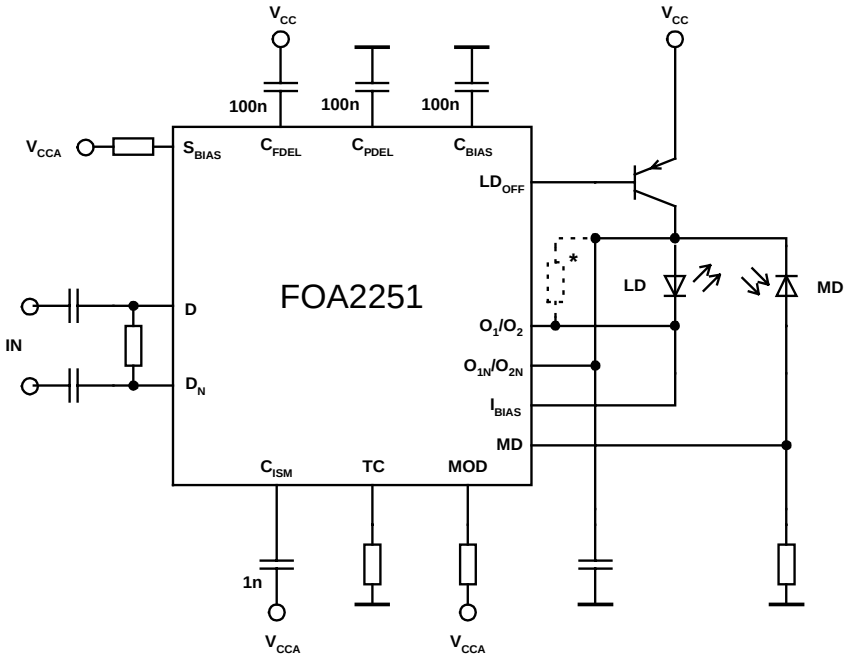
Table 2: Function of ISM Circuit

*** : internal signal

INPUT / OUTPUT SIGNAL DESCRIPTION

Signal Name	Function	Explanation
D / DN	Differential Input	Differential Data Input. D corresponds to O and DN to ON current output. With a high level at D and a low level at DN modulation current is drawn by O and ON is in high impedance state. With a low level at D and a high level at DN modulation current is drawn by ON and O is in high impedance state. Both inputs are prebiased to Vcc - 1 V, there input impedance is 5 kΩ.
C_{FDEL}	Control	With an external capacitor at C_{FDEL} the laser fault detection delay time can be adjusted. This means if a constant fault condition is present, a laser fault indication will be generated and the laser will be shut down after this delay time. The laser fault (LF) generation can be switched off if C_{FDEL} is connected to GND.
C_{PDE}L	Control	With an external capacitor at C_{PDEL} the Power On Delay time can be adjusted. There is no Power On Delay if C_{PDEL} is shorted to V_{CC}.
C_{ISM}	Control	With an external capacitor at C_{ISM} the delay time for detection of a low duty cycle input situation can be adjusted. If the input signal monitor is not used C_{ISM} has to be pulled down by 10 kΩ resistor
I_{BIAS}	Bias Output	A sink current drawn by IBIAS determines the laser diode bias current.
C_{BIAS}	Control	The controller characteristic can be set to an i-controller with an external capacitor at C_{BIAS} and the time constants are selectable.
S_{BIAS}	Monitor Output	S_{BIAS} is an open collector output for pulling up a resistor to monitor the bias current with a fixed relation.
V_{BIAS}	Bias Output	This output can be connected to the base of an external bias current NPN transistor. It can be left open if not used. It is dedicated for applications which can not use the internal bias transistor because of too high circuit power dissipation. The output is not activated if V_{EE1} is connected to V_{EE}.
LD_{OFF}	Laser Shut Down Output	Whenever the laser diode is disabled LD_{OFF} will deliver a high voltage level close to Vcc. This voltage is reduced by a minimum of 1.2 V if the laser diode is enabled. This output can be tied to the base of a pnp transistor to support a laser diode V_{CC} shut down. If not used, this output can be left open without laser driver performance restrictions.
LE	Logic Input	A high level at LE enables, a low level disables the laser diode. For constant enable this input can be tied to V_{CC}.
LEN	Logic Input	A low level at LEN enables, a high level disables the laser diode. For constant enable this input can be tied to GND.
LF	Logic Output	Fault Indicator. A high level is generated whenever a fault situation is detected by the supervisor circuit. Fault situations are laser power failures indicated by MD input voltage deviation from V_{MDnom}.
MD	Monitor Diode Input	This is the controller feedback input. The voltage at this input represents the monitor diode current and by this the laser output power. The bias current will be controlled to an equal level of MD and V_{MDR}.
MOD	Control	An external resistor at MOD sets the modulation current level.
O / ON	Differential Current Output	These output signals drive the modulation current switched by D / DN data inputs and leveled by MOD, TC and chip junction temperature.
RSTN	Logic Input	Low active reset input. This input resets the LF indication if present. Further the laser diode is held within shut down mode if this signal is at low level. For constant laser diode enable this signal can be tied to V_{CC}.
TC	Control	An external resistor at TC sets the modulation current temperature coefficient. The temperature information is derived from chip junction temperature.
V_{CCA}	Power Supply	Positive power supply for analog circuit part.
V_{CCD}	Power Supply	Positive power supply for digital circuit part.
V_{EE1}	Power Supply	Negative power supply, only connected to the output stage of bias generator, normally GND.
V_{EE2}	Power Supply	Negative power supply, only connected to the output stage and the stage before of modulator, normally GND.
V_{EE}	Power Supply	Negative power supply of the rest of circuit, normally GND.
V_{REF}	Reference Voltage	V_{REF} is a reference voltage output.

APPLICATION EXAMPLES



* if threshold current of laser is smaller than 2 mA

Figure 3: Positive Bias Regulation

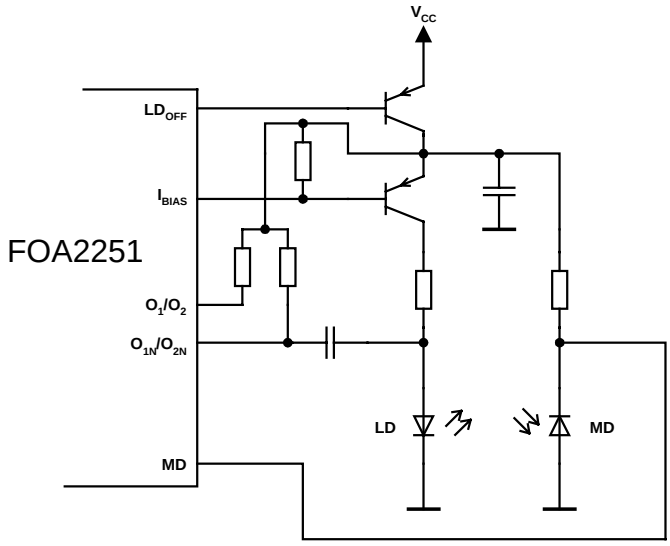


Figure 4: Negative Bias Regulation

PIN CONFIGURATION

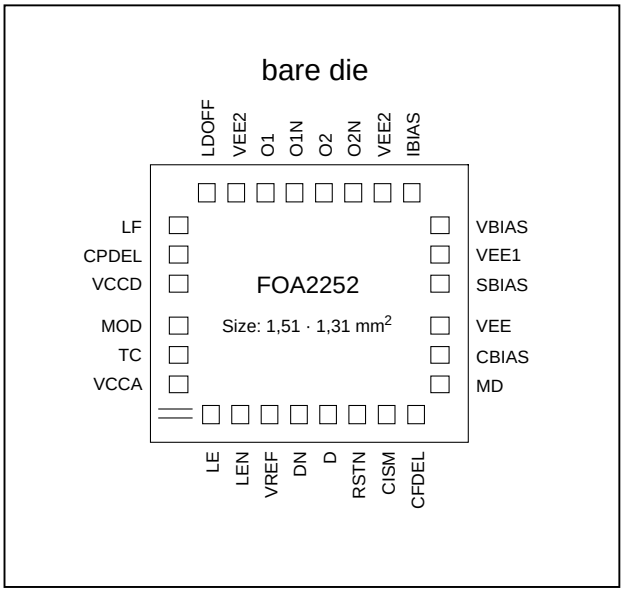


Figure 5: Pad assignment

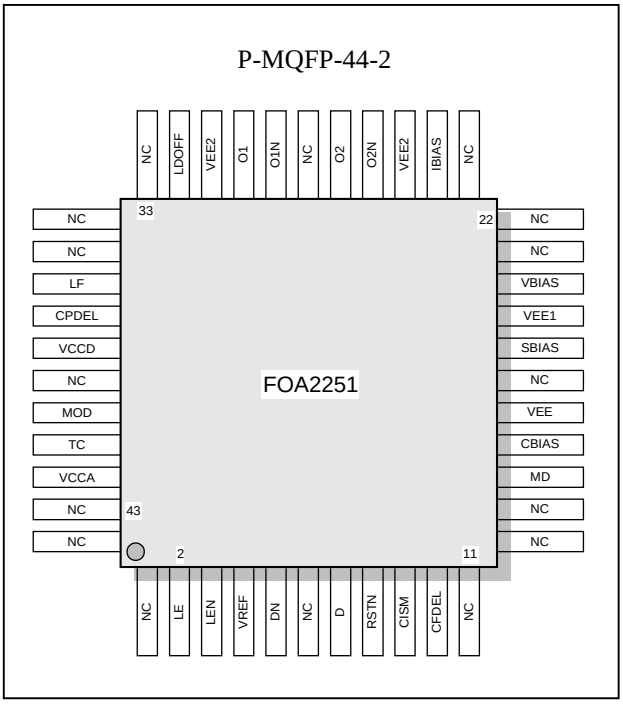
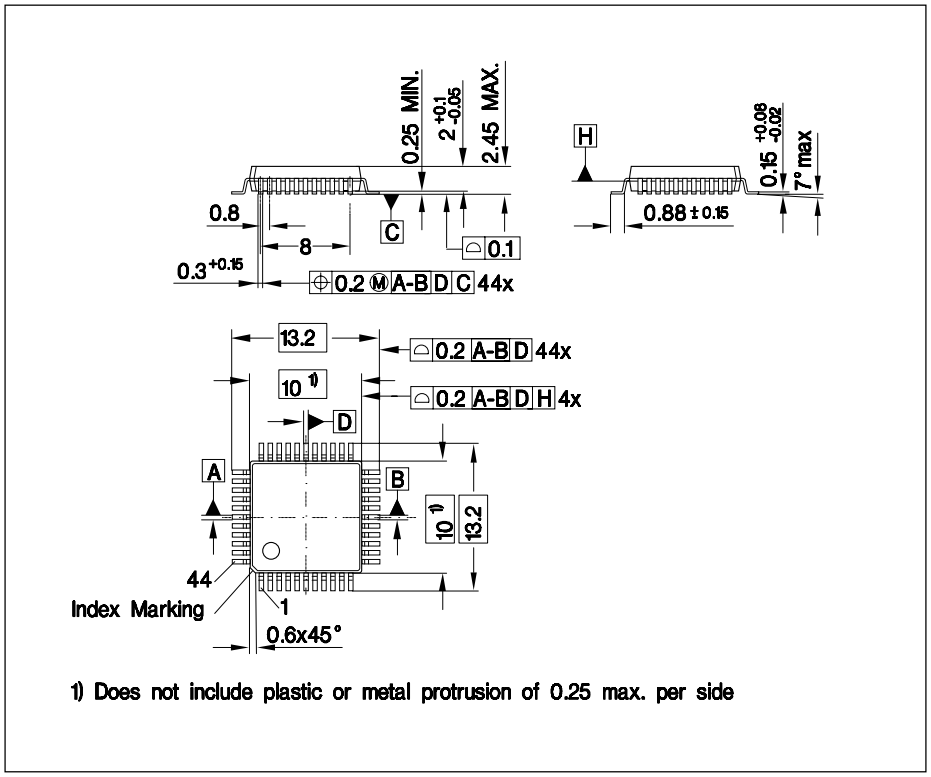


Figure 6: Package pinning

PACKAGE OUTLINE OF P-MQFP-44-2



1) Does not include plastic or metal protrusion of 0.25 max. per side