

# MC2042-3

**LED/Laser Driver for FDDI, Fast Ethernet, Fibre Channel, OC3/STM-1,  
IEEE1394  
Data Sheet**

Preliminary Information

LED/Laser Driver for FDDI, Fast Ethernet, Fibre Channel, OC3/STM-1, IEEE1394

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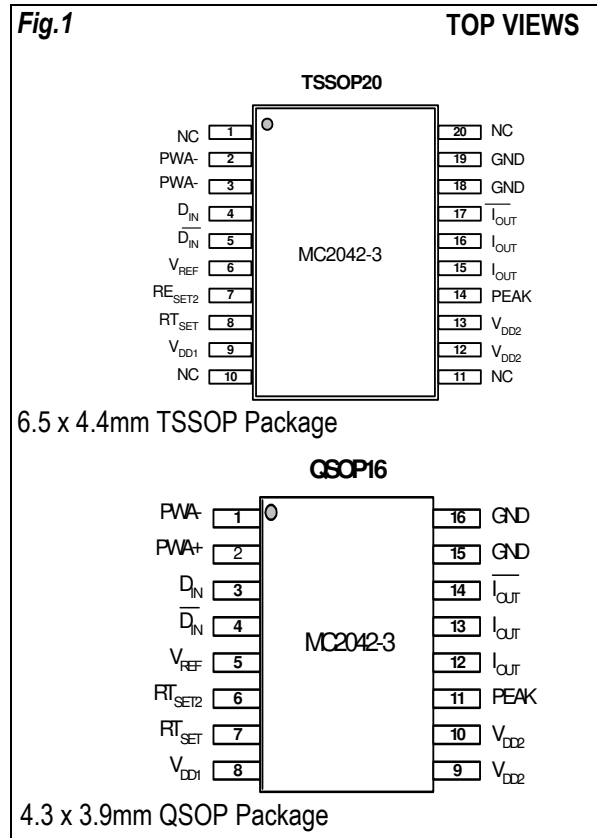
**FEATURES**

- ❑ Data rates to >500 Mbps, depending on LED
- ❑ Single chip solution, available as die or in TSSOP20, QSOP16 or Narrow body SO16 fabricated in deep sub-micron CMOS for lowest cost & power consumption and long term reliability
- ❑ Programmable output current from 30 mA to 120 mA
- ❑ RC programmable pre-emphasis or 'peaking' circuit giving drive current rise and fall times <500 ps
- ❑ Resistor programmable compensation for temperature dependence of LED output power
- ❑ PECL input with optional Pulse Width Adjust
- ❑ Single-ended CMOS input compatible at low speeds
- ❑ V<sub>REF</sub> voltage generator and output pin
- ❑ Supports most LED types (e.g. 660 to 1300 nm)
- ❑ Single +5 V to +3.3 V operation

**APPLICATIONS**

- ❑ FDDI, fiber Channel
- ❑ Fast Ethernet, IEEE1394
- ❑ OC3/STM1

**CONNECTIONS**



**GENERAL DESCRIPTION**

The MC2042-3 is a CMOS IC designed for high-speed LED drive in low-cost optical fiber based transmission systems. Depending on the LED used, data rates to >500Mbps can be achieved.

The LED drive current is set by a resistor. To improve LED 'on' time, a pre-emphasis circuit is included, which may be set via a simple RC network.

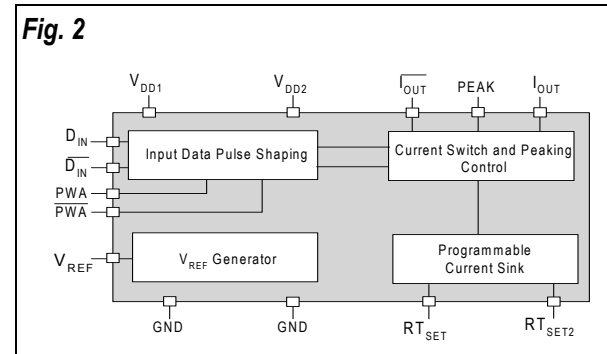
To minimize the effects of temperature on LED output power, LED drive temperature compensation can be set by resistor over a 0 - 10,000 ppm/°C range.

Differential positive-ECL (PECL) data on the input pins can be shaped, if desired, by the differential voltage on the Pulse Width Adjust (PWA) pins. This adjustment is continuous over a ±500 ps range. In addition, the V<sub>REF</sub> output pin allows single-ended input to the MC2042 and provides compatibility with industry-standard FO modules.

**TABLE 1 ORDERING INFORMATION**

Part	Pin-Package
MC2042-3DIE	Waffle Pack
MC2042-3DIEW	Expanded Whole Wafer on a Ring
MC2042-3Q16	QSOP16
MC2042-3T20	TSSOP20
MC2042-3S16	SOIC16
MC2042-3Q16TR	QSOP16 Tape and Reel
MC2042-3T20	TSSOP20 Tape and Reel

**TOP LEVEL DIAGRAM**



## LED/Laser Driver for FDDI, Fast Ethernet, Fibre Channel, OC3/STM-1, IEEE1394

TABLE 2 \_\_\_\_\_ PIN DESCRIPTIONS

TSSOP20 Pin	QSOP16 Pin	SOIC16	Die Pin	Name	Description
1	-	-	-	NC	Not connected, leave open
2	1	13	13	$\overline{PWA}$	Inverse pulse width adjust input
3	2	14	14	PWA	Differential pulse width adjust input. Allows continuous adjustment of input data pulse width
4	3	15	15	$D_{IN}$	Differential data input
5	4	16	16	$D_{\overline{IN}}$	Inverse differential data input
6	5	1	1	$V_{REF}$	Reference output. Can be used with single-ended data input
7	6	2	2	$RT_{SET2}$	Temperature compensation adjustment pin. Allows temperature dependence of LED light output to be reduced or removed
8	7	3	3	$RT_{SET}$	Sets nominal LED drive current
9	8	4	4	$V_{DD1}$	Power pin, connect to most positive supply
10	-	5	-	NC	Not connected
11	-	10	-	NC	Not connected
12	9	6	5	$V_{DD2}$	LED shorting pin, connect to most positive supply. Speeds LED switch off
13	10	-	6	$V_{DD2}$	LED shorting pin, connect to most positive supply. Speeds LED switch off
14	11	7	7	PEAK	Connection for pre-emphasis or peaking circuit
15	12	8	8	$I_{OUT}$	Driver output. Connect LED between this pin and $V_{DD}$
16	13	-	9	$I_{OUT}$	Driver output. Connect LED between this pin and $V_{DD}$
17	14	9	10	$\overline{I_{OUT}}$	Logical inverse of pin $I_{OUT}$ . Connect resistor of approximately the same value as LED (at the programmed drive current level) between this pin and $V_{DD}$
18	15	11	11	GND	Ground pin. Connect to the most negative supply
19	16	12	12	GND	Ground pin. Connect to the most negative supply
20	-	-	-	NC	Not connected, leave open

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**TABLE 3** \_\_\_\_\_ **ABSOLUTE MAXIMUM RATINGS**

Symbol	Parameter	Rating	Units
P <sub>TOT</sub>	Total power dissipation (TSSOP20)	255	mW
V <sub>CC</sub>	Power supply (V <sub>CC</sub> -GND)	7	V
T <sub>J</sub>	Junction temperature	150	°C
T <sub>A</sub>	Operating ambient	-40 to +85	°C
T <sub>STG</sub>	Storage temperature	-65 to +150	°C

These are the absolute maximum ratings at or beyond which the IC can be expected to fail or be damaged. Reliable operation at these extremes for any length of time is not implied.

**TABLE 4** \_\_\_\_\_ **DC ELECTRICAL CHARACTERISTICS**

Symbol	Parameter	Min	Typ	Max	Units
V <sub>CC</sub>	Supply Voltage	3.0	-	5.5	V
Din	Allowable voltage at data inputs	Gnd - 0.3	-	V <sub>CC</sub> +0.3	
I <sub>LED</sub> ON	LED drive current	30	-	120	mA
I <sub>LED</sub> OFF	LED off current	-	-	50	µA
I <sub>COMP</sub>	LED drive current temperature compensation range	0	-	1	%/°C
V <sub>LED_H</sub>	minimum allowable voltage at IOUT	V <sub>DD</sub> -2.0	-	-	V

**TABLE 5** \_\_\_\_\_ **AC ELECTRICAL CHARACTERISTICS**

Symbol	Parameter	Min	Typ	Max	Units
V <sub>in</sub> (Diff)	Differential Input Voltage, 2*(DinH - DinL)	300mV	-	2*V <sub>CC</sub>	V
	Common Mode Input Voltage	V <sub>CC</sub> /2	-	(V <sub>CC</sub> -(V <sub>in</sub> [Diff])/4)	V
f <sub>C</sub>	Maximum data rate	300	-	-	Mbps
T <sub>PWA</sub>	Input data pulse width adjust range	-500	-	500	ps
LED t <sub>r</sub>	LED drive rise time	-	-	1	ns
LED t <sub>f</sub>	LED drive fall time	-	-	1	ns
I <sub>PEAK</sub>	Peaking current (as % of LED drive current)	0	-	50	%
PEAK t <sub>r</sub>	Peaking current rise time	-	-	1	ns
PEAK t <sub>f</sub>	Peaking current fall time	-	-	1	ns
PEAK t <sub>d</sub>	Peaking current decay time	-	C1x(R4+5)	-	S
I <sub>DD</sub>	Supply current	-	-	I <sub>LED</sub> +20	mA

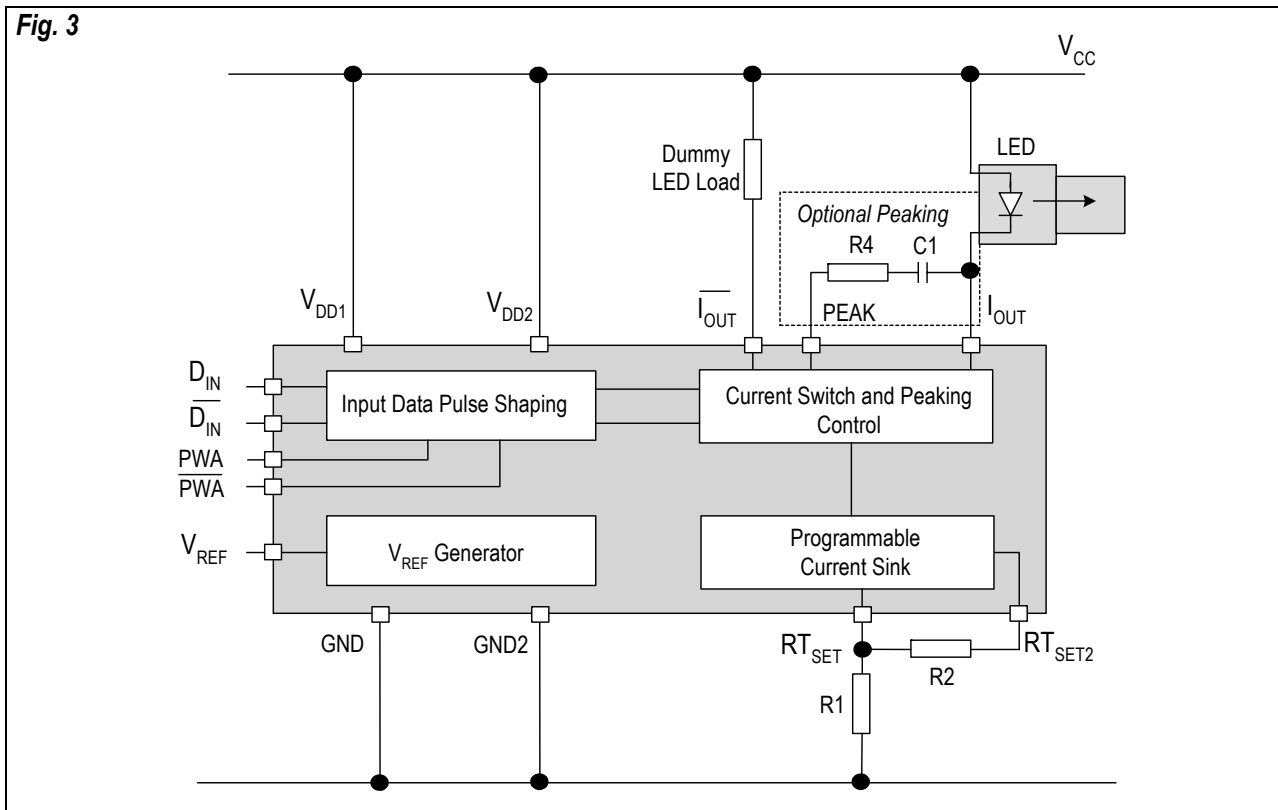
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TYPICAL APPLICATIONS CIRCUIT

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Fig. 3



FUNCTIONAL DESCRIPTION

**Signal Path Description**

Differential Positive-ECL (PECL) data on the data input pins controls the LED current switch. The LED current flows either through the LED or via the dummy load so that  $V_{DD}$  noise is minimized. To reduce LED 'turn-off' time, the LED is momentarily short-circuited, via  $V_{DD2}$ , before the current is switched to the dummy load.

**LED Drive and Temperature Compensation**

The LED drive current and temperature compensation is set by the two resistors R1 and R2. The simplified application diagram (Figure 3) shows R1 connected between RTSET and GND, and R2 between RTSET and the RTSET2 pin.

The current flowing out of the RTSET pin determines the LED drive current.

The temperature independent component of the LED drive current is set primarily by R1. The temperature dependent component by R2. However, R1 and R2 are not independent.

The RTSET2 pin connects to an internal diode on the IC which exhibits standard diode behaviour with temperature. As temperature rises, the voltage on the diode drops, the current flowing through R2 increases and the LED drive current increases.

Given the various interdependencies of the drive current, R1, R2, and temperature compensation, the relationships have been tabulated (see Temperature Compensation table). Please contact Mindspeed if other combinations are required.

The LED 'on' current is controlled to  $\pm 10\%$ .

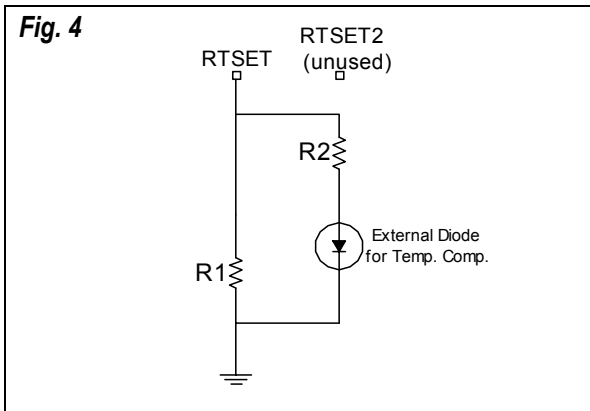
A Microsoft Excel file is available from Mindspeed which will calculate appropriate values for RTset resistors R1

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FUNCTIONAL DESCRIPTION

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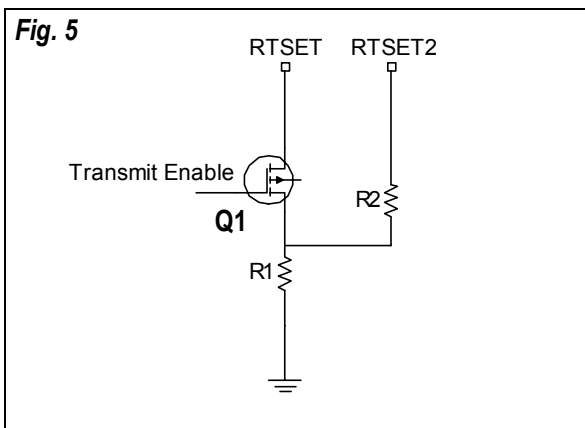
and R2 given your LED current, forward voltage, and LED temperature coefficient. The file may be obtained from a Mindspeed Field Applications Engineer and is named '**MC2042-3 resistor selection.xls**'. See section *Temperature Compensation Tables* if the spreadsheet is not available.



**Transmit Enable/Disable**

There is no dedicated pin on the MC2042 to disable the LED drive current. However, the LED drive current can be disabled by disabling the current out of pin RTSET. The LED current is approximately 100x the current out of pin RTSET, so if the current out of this pin is 0, the LED drive current is 0. However, if peaking is used the peaking current will not be disabled.

Figure 5 illustrates how the current out of RTSET can be disabled by adding a MOSFET (Q1) at the RTSET node of the R1/R2 temperature compensation network. The voltage on the gate of Q1 then controls transmit enable/disable. When selecting Q1, a MOSFET should be chosen with an Rds(on) which is negligible compared to R1 and R2.



**Pre-Emphasis Or 'Peaking'**

To improve LED 'turn on' time an optional pre-emphasis function is included on the MC2042-3. If this is not required, then the PEAK pin should be left floating.

Two external components (R4, C1) are required as shown in Fig. 3 to implement peaking.

When the LED is turned on, the voltage on PEAK is pulled LOW very rapidly. This voltage transient is coupled through R4 and C1 and exerts a transient current on the LED.

When the LED is turned off, the voltage on PEAK is pulled HIGH rapidly. This voltage transient is coupled through R4 and C1 and exerts a transient current in the opposite direction on the LED.

The transient current amplitude and RC decay are given approximately by:

Peak current (Amps):  $4/(R4 + 5)$

Decay (seconds):  $C1 \times (R4 + 5)$

The above approximations assume an ideal LED model with 0 Ohms resistance. Real LEDs will slightly alter the peaking effect. Typical values for R4 and C1 are:

$R4 = 50 \Omega$

$C1 = 20 \text{ pF}$

**LED Clamping, Laser Driving**

Since most LEDs exhibit a longer 'turn off' time than 'turn on' time, a clamping function is included on the MC2042 in order to reduce the 'turn off' time. Clamping is enabled via the two V<sub>DD2</sub> connections.

The disadvantage of clamping is that the LED's internal capacitance has to be fully charged again before the LED starts to emit light. This delayed 'turn on' effect becomes noticeable when the nominal LED drive current is low. Use of the peaking circuit helps solve this problem. Thus, the combination of peaking and clamping results in very fast 'turn on' and 'turn off' times for the LED.

When driving lasers, it will often be helpful to disable this clamping. This can be achieved by leaving the V<sub>DD2</sub> connections floating. V<sub>DD1</sub> must still be connected.

**LED Drive Pulse Width Adjust (PWA)**

The input pulse width can be adjusted prior to application to the LED switch. The differential voltage on the PWA (Pulse Width Adjust) pins shapes the input pulse linearly over a nominal -500 to +500 ps range, according to the formula:

$$\Delta PW (ps) = K \times V_{PWA}$$

Where:

$$K = 500 \pm 100$$

and

$$V_{PWA} = (V_{PWA+}) - (V_{PWA-})$$

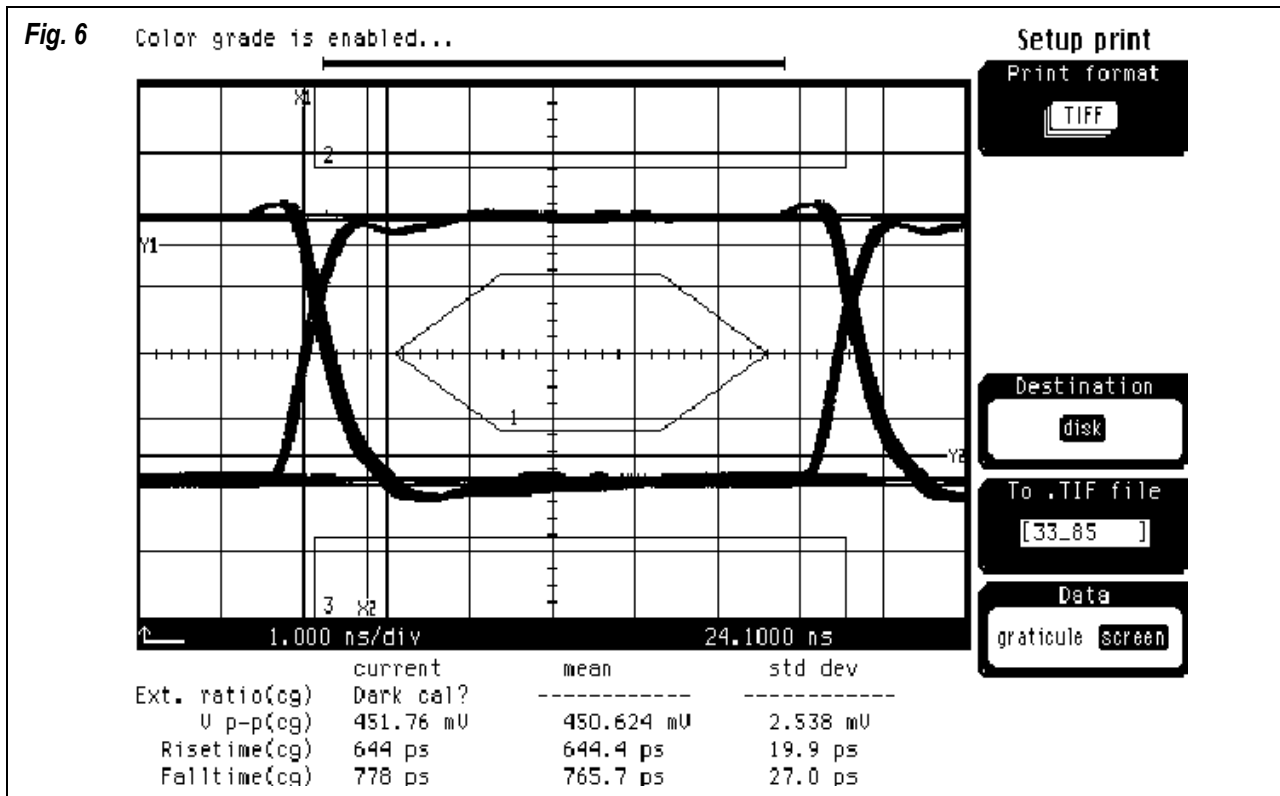
The maximum range for  $V_{PWA}$  is  $\pm 1V$ . The input impedance is  $3.6 k\Omega$ .  $V_{PWA+}$  and  $V_{PWA-}$  will settle at a nominal voltage equal to  $(0.6 * V_{DD})$  if left floating. It is recommended that adjustment be implemented by pull down resistors on PWA+ or PWA-. However, it is common for one or other pin to be tied to ground as a zero-cost, 'gross' adjustment.

If pulse width adjustment is not required PWA+ and PWA- should be tied to ground.

**Eye Diagram**

The eye diagram below is typical of the electrical output of the MC2042-3. The crossover point can be moved up and down using the PWA pin. The overshoot can be increased by using the PEAK pin.

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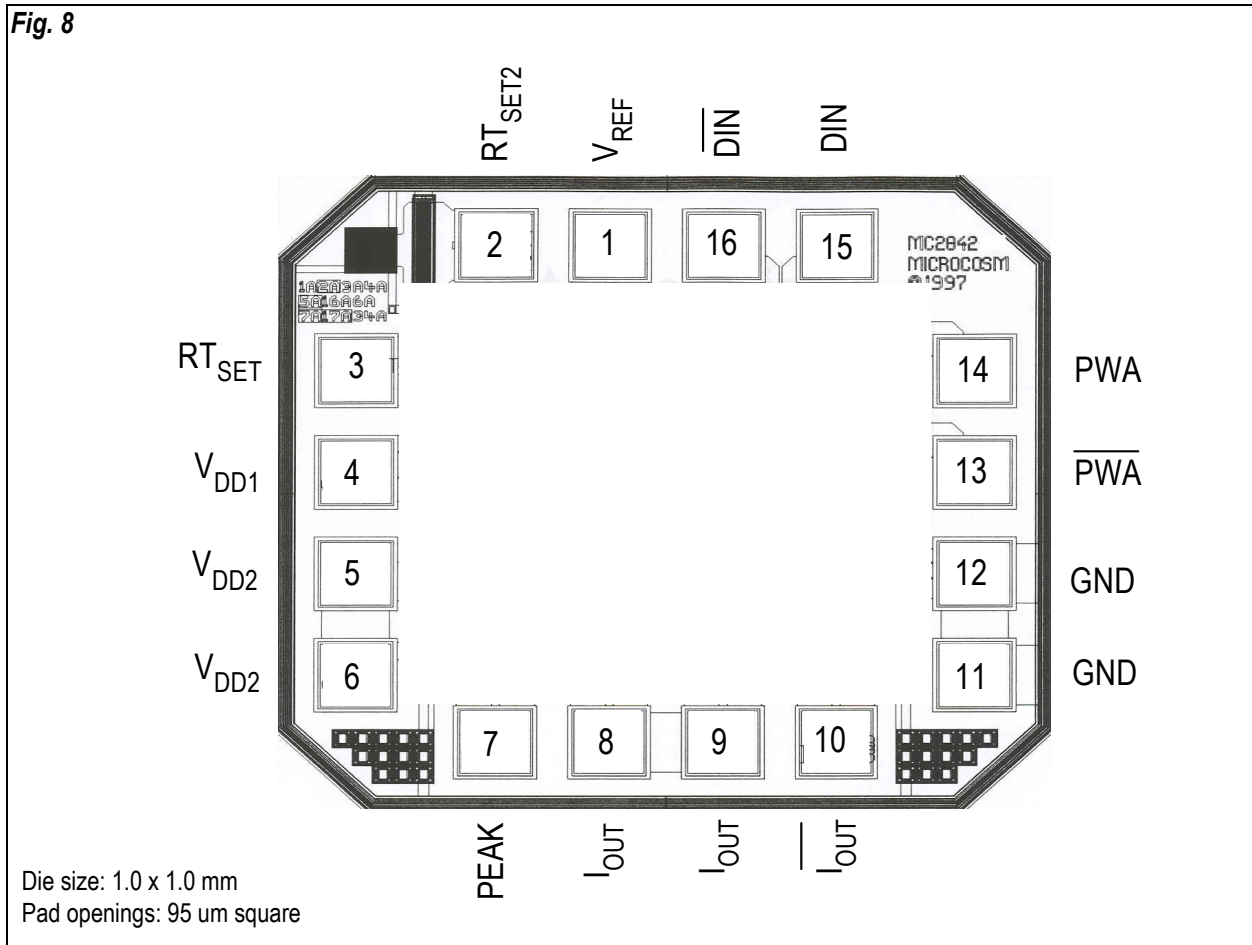




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BARE DIE

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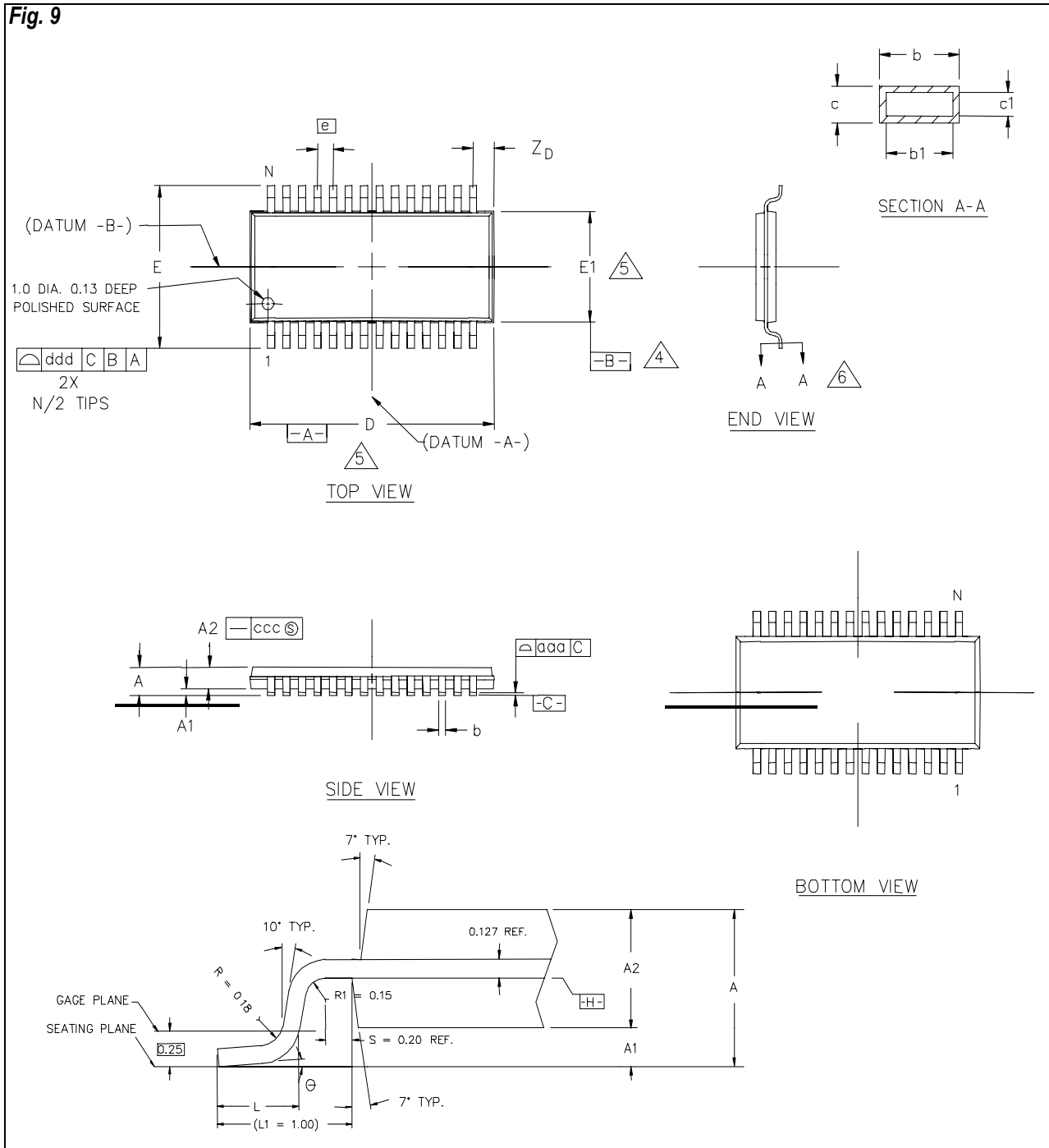
**TABLE 6** BARE DIE PAD COORDINATES

Pad	Description	X	Y	Pad	Description	X	Y
1	V <sub>REF</sub>	-73	394.5	9	I <sub>OUT</sub>	73	-394.5
2	RT <sub>SET2</sub>	-219	394.5	10	I <sub>OUT</sub>	219	-394.5
3	RT <sub>SET</sub>	-397	214.7	11	GND	397	-223.3
4	V <sub>DD1</sub>	-397	68.7	12	GND	397	-77.3
5	V <sub>DD2</sub>	-397	-77.3	13	PWA	397	68.7
6	V <sub>DD2</sub>	-397	-223.3	14	PWA	397	214.7
7	PEAK	-219	-394.5	15	D <sub>IN</sub>	219	394.5
8	I <sub>OUT</sub>	-73	-394.5	16	D <sub>IN</sub>	73	394.5

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TSSOP20 PACKAGE INFORMATION

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Note:

Package dimensions on page 12.

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QSOP16 PACKAGE INFORMATION

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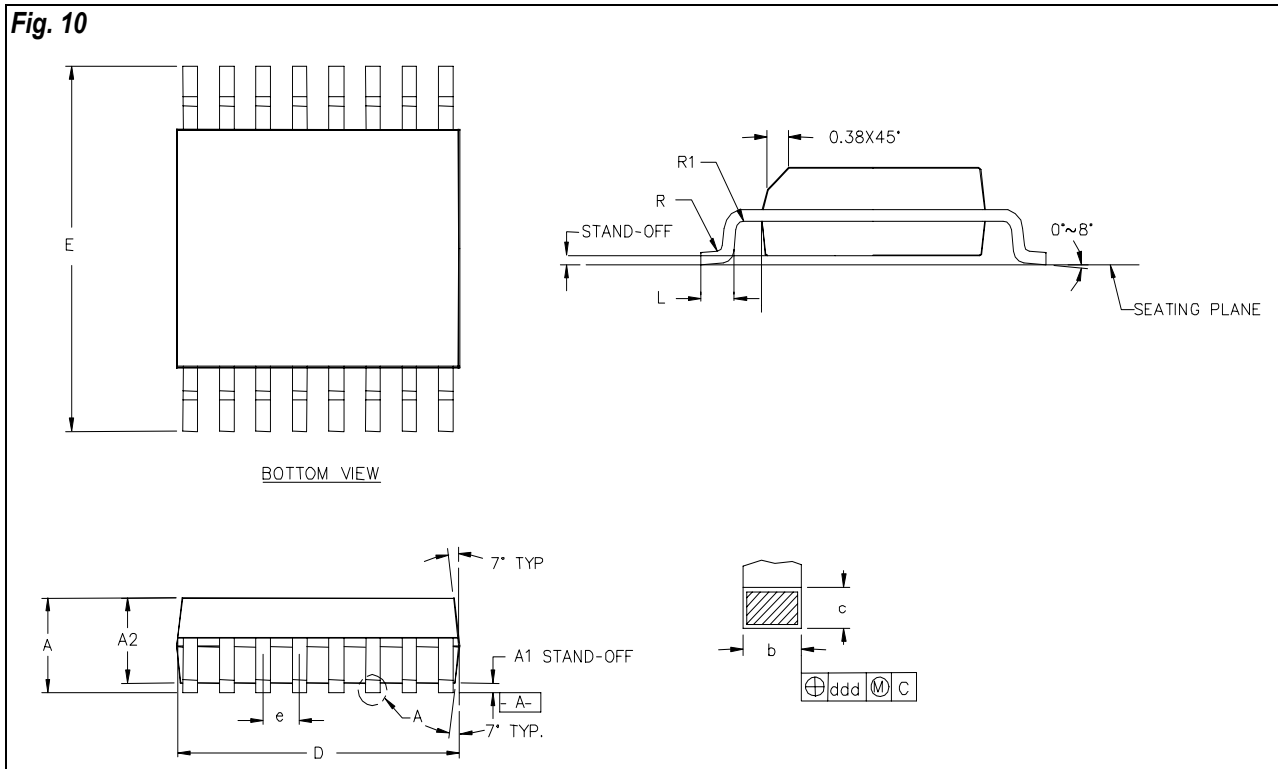


TABLE 7 TSSOP20 DIMENSIONS

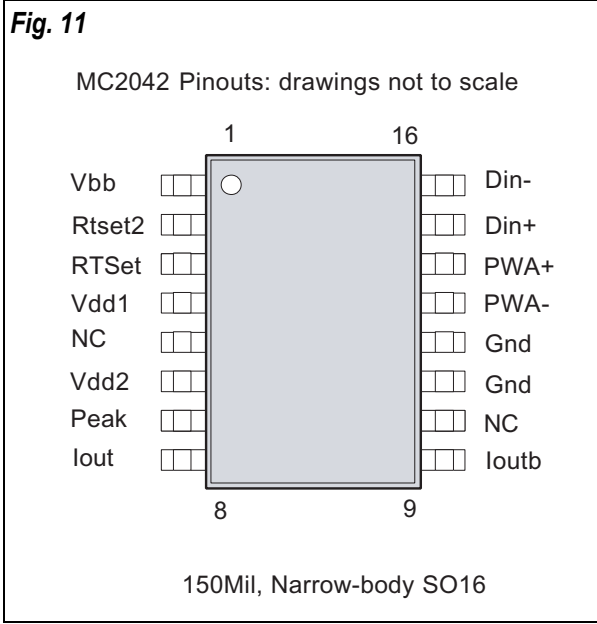
Dims.	Tols/leads	TSSOP20L
A	MAX	1.20
A1		0.5MIN/.10MAX.
A2	NOM	.90
D	±.05	6.50
E	±.10	6.40
E1	±.10	4.40
L	+ .15/- .10	.60
L1	REF.	1.00
Zp	REF.	.325
e	BASIC	.65
b	±.05	.22
c		.13MIN/.20MAX
e	±4°	4°
aaa	MAX.	.10
bbb	MAX.	.10
ccc	MAX	.05
ddd	MAX.	.20

TABLE 8 QSOP16 DIMENSIONS

Dims.	Tols/N	QSOP16
A	MAX.	1.60
A1	±.05	0.1
A2	±.10	1.40
D	±.10	4.9
E	±.20	6.00
E1	±.10	3.90
L	±.05	0.6
ccc	MAX.	0.10
ddd	MAX.	0.10
e	BASIC	0.65
b	±.05	0.25
c	±.05	.2 Min. .24 Max.
R	±.05	0.20
R1	Min.	0.20

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**Temperature Compensation Tables**

On following Page - Showing R1 from 1k8 to 47k ohms and R2 from 47 to 4k7 ohms.

Choose the desired ILED at 2 different die temperatures to select appropriate R1/R2 values. NOTE: the tables are based on MC2042-3 junction temperatures (Tj), at 50° and 125°C. The user must take into account the power dissipation and thermal resistance to arrive at the die temperature.

Example, at Vcc=5v:

Ambient	25	85	°C
Iled	70	100	mA
VLed	1.5	1.5	v
Pstatic	50	50	mW
Pdynamic	$(V_{cc}-V_{Led}) \cdot (70) = 245$	350	mW
Rt	100	100	°C/Watt
Tj	$T_a+24.5+5 = 54.5$	$85+35+5 = 125$	°C

Then R1=3300, R2= 270 ohms (shaded) is one possible solution.

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TABLE 9 TEMPERATURE COMPENSATION TABLE

Tj=50	1800	2200	2700	3300	3900	4700	5600	6800	8200	10000	12000	15000	18000	22000	27000	33000	39000	47000
47	135.9	131.4	127.7	124.7	122.7	120.8	119.3	117.9	116.9	115.9	115.2	114.5	114	113.6	113.2	112.9	112.7	112.5
56	130.8	126.1	122.3	119.2	117.1	115.1	113.5	112.1	111	110	109.2	108.5	108	107.5	107.1	106.8	106.6	106.4
68	125	120.1	116.1	112.9	110.6	108.6	106.9	105.4	104.3	103.2	102.4	101.6	101.1	100.6	100.2	99.92	99.7	99.49
82	119.4	114.3	110.1	106.7	104.4	102.2	100.5	98.92	97.67	96.58	95.76	94.93	94.39	93.89	93.47	93.14	92.91	92.7
100	113.4	108	103.6	100.1	97.68	95.4	93.62	91.98	90.68	89.54	88.68	87.81	87.24	86.72	86.28	85.93	85.69	85.47
120	107.9	102.4	97.81	94.14	91.61	89.24	87.39	85.68	84.32	83.14	82.24	81.34	80.74	80.2	79.75	79.38	79.13	78.9
150	101.4	95.68	90.87	87.04	84.38	81.9	79.96	78.17	76.75	75.51	74.56	73.62	73	72.42	71.95	71.57	71.31	71.06
180	96.38	90.41	85.44	81.47	78.72	76.14	74.13	72.28	70.8	69.51	68.53	67.56	66.91	66.31	65.82	65.43	65.15	64.9
220	91.09	84.92	79.76	75.64	72.79	70.12	68.03	66.1	64.57	63.23	62.21	61.2	60.52	59.91	59.39	58.98	58.7	58.44
270	86.06	79.68	74.35	70.08	67.12	64.36	62.19	60.19	58.6	57.21	56.16	55.11	54.4	53.77	53.23	52.81	52.51	52.24
330	81.51	74.94	69.44	65.04	61.99	59.13	56.89	54.82	53.18	51.74	50.65	49.56	48.83	48.17	47.62	47.18	46.88	46.59
390	78.03	71.3	65.68	61.17	58.04	55.11	52.81	50.69	49	47.52	46.4	45.28	44.54	43.86	43.29	42.84	42.53	42.23
470	74.46	67.58	61.82	57.19	53.98	50.97	48.61	46.43	44.69	43.18	42.02	40.87	40.1	39.41	38.82	38.36	38.04	37.74
560	71.43	64.41	58.52	53.79	50.51	47.43	45.01	42.78	41	39.45	38.26	37.08	36.29	35.58	34.98	34.5	34.17	33.86
680	68.4	61.24	55.23	50.4	47.04	43.88	41.4	39.12	37.29	35.7	34.48	33.27	32.46	31.73	31.11	30.62	30.28	29.97
820	65.8	58.52	52.4	47.47	44.04	40.82	38.29	35.95	34.08	32.45	31.21	29.97	29.14	28.38	27.76	27.25	26.91	26.58
1000	63.37	55.97	49.74	44.72	41.23	37.94	35.35	32.96	31.05	29.38	28.11	26.84	25.99	25.22	24.58	24.06	23.71	23.37
1200	61.41	53.91	47.59	42.5	38.94	35.6	32.96	30.53	28.59	26.88	25.58	24.29	23.42	22.63	21.98	21.45	21.09	20.75
1500	59.33	51.72	45.31	40.12	36.51	33.1	30.41	27.93	25.94	24.2	22.87	21.55	20.66	19.85	19.18	18.64	18.27	17.92
1800	57.86	50.18	43.69	38.45	34.78	31.33	28.6	26.08	24.06	22.29	20.94	19.59	18.69	17.87	17.18	16.63	16.25	15.9
2200	56.46	48.7	42.15	36.84	33.13	29.63	26.87	24.31	22.26	20.46	19.08	17.71	16.79	15.95	15.26	14.7	14.31	13.95
2700	55.23	47.42	40.8	35.44	31.69	28.15	25.35	22.75	20.67	18.84	17.45	16.05	15.11	14.26	13.55	12.98	12.59	12.22
3300	54.21	46.34	39.68	34.27	30.48	26.9	24.07	21.44	19.33	17.48	16.06	14.65	13.7	12.83	12.11	11.53	11.13	10.76
3900	53.48	45.57	38.87	33.42	29.61	26	23.15	20.5	18.37	16.5	15.07	13.63	12.67	11.79	11.06	10.48	10.07	9.692
4700	52.77	44.82	38.08	32.61	28.77	25.13	22.26	19.58	17.43	15.54	14.09	12.64	11.67	10.78	10.04	9.448	9.036	8.65

Tj=125	1800	2200	2700	3300	3900	4700	5600	6800	8200	10000	12000	15000	18000	22000	27000	33000	39000	47000
47	182.3	181.2	180.2	179.3	178.7	178.1	177.6	177.1	176.7	176.3	176.1	175.8	175.6	175.4	175.3	175.2	175.1	175
56	179.2	177.7	176.3	175.1	174.3	173.4	172.7	172	171.5	171	170.6	170.3	170	169.8	169.6	169.4	169.3	169.2
68	174.6	172.5	170.6	168.9	167.7	166.5	165.5	164.6	163.9	163.2	162.7	162.2	161.9	161.6	161.3	161.1	160.9	160.8
82	168.8	166	163.4	161.2	159.6	158.1	156.9	155.7	154.7	153.9	153.2	152.6	152.1	151.7	151.4	151.1	150.9	150.8
100	161.1	157.4	154.1	151.3	149.4	147.5	146.1	144.7	143.6	142.6	141.9	141.2	140.7	140.2	139.8	139.5	139.3	139.1
120	152.8	148.4	144.6	141.6	139.4	137.3	135.7	134.2	132.9	131.9	131.1	130.2	129.7	129.2	128.8	128.4	128.2	128
150	141.9	137	132.7	129.3	126.8	124.5	122.7	121	119.7	118.5	117.6	116.7	116.1	115.6	115.1	114.8	114.5	114.3
180	133	127.6	123.1	119.3	116.7	114.3	112.4	110.6	109.2	108	107.1	106.1	105.5	104.9	104.5	104.1	103.8	103.6
220	123.4	117.7	112.8	108.9	106.2	103.7	101.7	99.84	98.37	97.08	96.11	95.13	94.48	93.89	93.39	93	92.72	92.47
270	114.2	108.2	103.1	99.07	96.26	93.61	91.54	89.62	88.09	86.75	85.74	84.72	84.04	83.42	82.91	82.49	82.21	81.94
330	105.9	99.67	94.44	90.24	87.32	84.58	82.43	80.44	78.85	77.46	76.41	75.35	74.64	74	73.47	73.04	72.74	72.46
390	99.6	93.2	87.83	83.52	80.51	77.69	75.48	73.43	71.8	70.36	69.28	68.19	67.46	66.8	66.25	65.81	65.5	65.22
470	93.2	86.63	81.11	76.67	73.58	70.67	68.39	66.28	64.59	63.12	61.99	60.87	60.12	59.44	58.87	58.42	58.1	57.8
560	87.79	81.06	75.41	70.86	67.69	64.71	62.36	60.19	58.46	56.95	55.79	54.64	53.87	53.17	52.58	52.11	51.79	51.49
680	82.43	75.55	69.76	65.09	61.83	58.77	56.36	54.14	52.36	50.8	49.61	48.42	47.63	46.91	46.31	45.82	45.49	45.18
820	77.87	70.85	64.93	60.15	56.83	53.69	51.22	48.94	47.12	45.52	44.3	43.08	42.26	41.52	40.9	40.41	40.07	39.74
1000	73.63	66.47	60.43	55.55	52.15	48.94	46.41	44.07	42.2	40.56	39.31	38.06	37.22	36.46	35.83	35.32	34.97	34.64
1200	70.22	62.95	56.81	51.84	48.37	45.1	42.52	40.14	38.23	36.55	35.27	33.99	33.14	32.36	31.71	31.19	30.83	30.49
1500	66.63	59.23	52.97	47.91	44.37	41.03	38.39	35.95	33.99	32.27	30.97	29.65	28.77	27.97	27.31	26.77	26.4	26.05
1800	64.11	56.62	50.28	45.15	41.55	38.16	35.48	32.99	31	29.25	27.92	26.58	25.68	24.87	24.19	23.64	23.26	22.91
2200	61.72	54.15	47.73	42.52	38.87	35.42	32.7	30.17	28.14	26.36	25	23.63	22.72	21.89	21.19	20.63	20.25	19.88
2700	59.65	52	45.5	40.23	36.53	33.03	30.27	27.7	25.64	23.82	22.44	21.05	20.11	19.27	18.56	17.99	17.59	17.22
3300	57.93	50.21	43.65	38.32	34.58	31.04	28.24	25.63	23.54	21.7	20.29	18.87	17.93	17.06	16.34	15.76	15.36	14.98
3900	56.7	48.93	42.33	36.96	33.18	29.61	26.78	24.15	22.03	20.17	18.74	17.31	16.35	15.47	14.74	14.15	13.74	13.36
4700	55.52	47.7	41.05	35.64	31.84	28.23	25.37	22.71	20.57	18.68	17.24	15.79	14.81	13.93	13.18	12.59	12.17	11.78

Preliminary Information

## LED/Laser Driver for FDDI, Fast Ethernet, Fibre Channel OC3/STM-1

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Preliminary Information

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