FAIRCHILD
SEMICONDUCTOR®

# OPTICALLY ISOLATED
ERROR AMPLIFIER

FOD2712

DESCRIPTION

The FOD2712 Optically Isolated Amplifier consists of the popular RC431A precision programmable shunt reference and an optocoupler. The optocoupler is a gallium arsenide (GaAs) light emitting diode optically coupled to a silicon phototransistor. The reference voltage tolerance is 1%. The current transfer ratio (CTR) ranges from 100% to 200%.
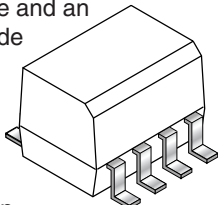
It is primarily intended for use as the error amplifier/reference voltage/optocoupler function in isolated ac to dc power supplies and dc/dc converters.

When using the FOD2712, power supply designers can reduce the component count and save space in tightly packaged designs. The tight tolerance reference eliminates the need for adjustments in many applications.

The device comes in a compact 8-pin small outline package.
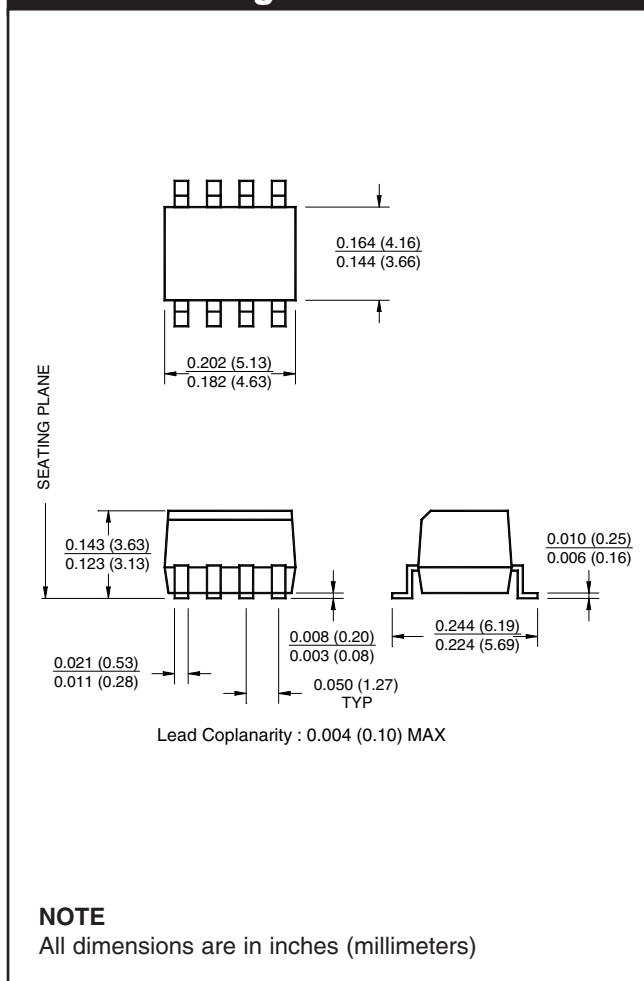
FEATURES
• Optocoupler, precision reference and error amplifier in single package
• 1.240V ± 1% reference
• CTR 100% to 200%
• 2,500V RMS isolation
• VDE approval 136616
• BSI approval 8661 and 8662
• UL approval E90700
• CSA approval 1113643
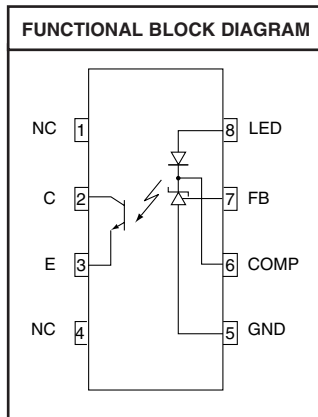
APPLICATIONS
• Power system for workstations
• Telecom central office supply
• Telecom bricks

Package Dimensions

0.164 (4.16)
0.144 (3.66)

0.202 (5.13)
0.182 (4.63)

SEATING PLANE

0.143 (3.63)
0.123 (3.13)

0.010 (0.25)
0.006 (0.16)

0.021 (0.53)
0.011 (0.28)

0.008 (0.20)
0.003 (0.08)

0.244 (6.19)
0.224 (5.69)

0.050 (1.27)
TYP

Lead Coplanarity : 0.004 (0.10) MAX

NOTE
All dimensions are in inches (millimeters)

FUNCTIONAL BLOCK DIAGRAM

NC	1		8	LED
C	2		7	FB
E	3		6	COMP
NC	4		5	GND

PIN DEFINITIONS

Pin Number	Pin Name	Pin function description
1	NC	Not connected
2	C	Phototransistor Collector
3	E	Phototransistor Emitter
4	NC	Not connected
5	GND	Ground
6	COMP	Error Amplifier Compensation. This pin is the output of the error amplifier. *
7	FB	Voltage Feedback. This pin is the inverting input to the error amplifier
8	LED	Anode LED. This pin is the input to the light emitting diode.

* The compensation network must be attached between pins 6 and 7.

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TYPICAL APPLICATION
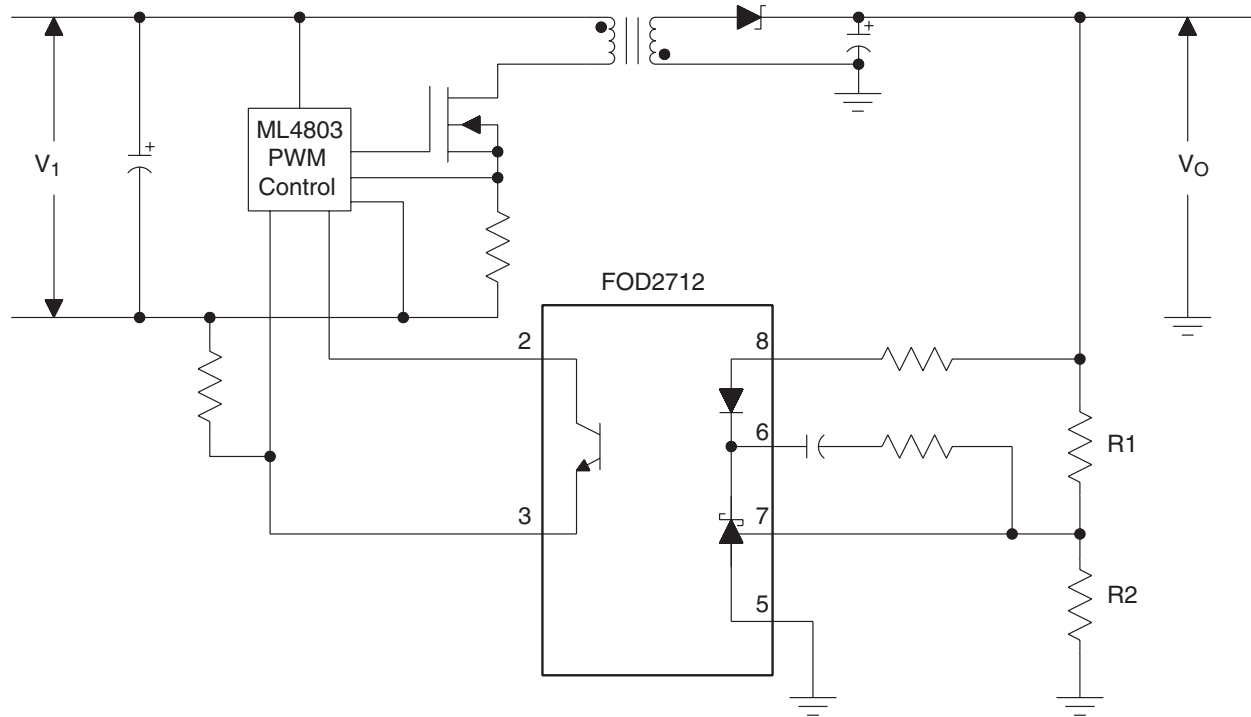
ABSOLUTE MAXIMUM RATINGS (T_A = 25°C Unless otherwise specified.)

Parameter	Symbol	Value	Units
Storage Temperature	T_{STG}	-55 to +125	°C
Operating Temperature	T_{OPR}	-40 to +85	°C
Reflow Temperature Profile (refer to fig 21)			
Input Voltage	V_{LED}	13.2	V
Input DC Current	I_{LED}	20	mA
Collector-Emitter Voltage	V_{CEO}	30	V
Emitter-Collector Voltage	V_{ECO}	7	V
Collector Current	I_C	50	mA
Input Power Dissipation (note 1)	PD1	145	mW
Transistor Power Dissipation (note 2)	PD2	85	mW
Total Power Dissipation (note 3)	PD3	145	mW

Notes
1. Derate linearly from 25°C at a rate of 2.42 mW/ °C
2. Derate linearly from 25°C at a rate of 1.42 mW/ °C.
3. Derate linearly from 25°C at a rate of 2.42 mW/ °C.
4. Functional operation under these conditions is not implied. Permanent damage may occur if the device is subjected to conditions outside these ratings.

ELECTRICAL CHARACTERISTICS (V_{CC} = 12 V, T_A = 25°C Unless otherwise specified.)

INPUT CHARACTERISTICS

Parameter	Test Conditions	Symbol	Min	Typ**	Max	Unit
LED forward voltage	(I_{LED} = 10 mA, V_{COMP} = V_{FB}) (Fig.1)	V_F			1.5	V
Reference voltage		V_{REF}				V
(-40 to +85°C)	(V_{COMP} = V_{FB}, I_{LED} = 10 mA (Fig.1)		1.221		1.259	
(25°C)			1.228	1.240	1.252	
Deviation of V_{REF} over temperature - See Note 1 (T_A = -40 to +85°C)		$V_{REF (DEV)}$		4	12	mV
Ratio of Vref variation	(I_{LED} = 10 mA,	$\Delta V_{REF}/$		-1.5	-2.7	mV/V
to the output of the error amplifier	V_{COMP} = V_{REF} to 12 V) (Fig.2)	ΔV_{COMP}				
Feedback input current	(I_{LED} = 10 mA, R1 = 10 kΩ) (Fig.3)	I_{REF}		0.15	0.5	µA
Deviation of I_{REF} over temperature - See Note 1 (T_A = -40 to +85°C)		$I_{REF (DEV)}$		0.15	0.3	µA
Minimum drive current	(V_{COMP} = V_{FB}) (Fig.1)	$I_{LED (MIN)}$		55	80	µA
Off-state error amplifier current	(V_{LED} = 13.2 V, V_{FB} = 0) (Fig.4)	$I_{(OFF)}$		0.001	0.1	µA
Error amplifier	(V_{COMP} = V_{FB}, I_{LED} = 0.1 mA to 15 mA,	$|Z_{OUT}|$		0.25		Ohm
output impedance - See Note 2	f<1 kHZ)					

1. The deviation parameters $V_{REF(DEV)}$ and $I_{REF(DEV)}$ are defined as the differences between the maximum and minimum values obtained over the rated temperature range. The average full-range temperature coefficient of the reference input voltage, $\Delta V_{REF,}$ is defined as:

$$|\Delta V_{REF}|(ppm/°C) = \frac{\{V_{REF(DEV)} / V_{REF} (T_A = 25°C)\} \times 10^6}{\Delta T_A}$$

where ΔT_A is the rated operating free-air temperature range of the device.

2. The dynamic impedance is defined as $|Z_{OUT}| = \Delta V_{KA}/\Delta I_{K.}$ When the device is operating with two external resistors (see Figure 2), the total dynamic impedance of the circuit is given by:

$$|Z_{KA,TOT}| = \frac{\Delta V}{\Delta I} \approx |Z_{KA}| \times [1 + \frac{R1}{R2}]$$

OUTPUT CHARACTERISTICS (T$_A$ = 25°C Unless otherwise specified.)

Parameter	Test Conditions	Symbol	Min	Typ	Max	Unit
Collector dark current	(V$_{CE}$ = 10 V) (Fig. 5)	I$_{CEO}$			50	nA
Collector-emitter voltage breakdown	(I$_C$ = 1.0 mA)	BV$_{CEO}$	70			V
Emitter-collector voltage breakdown	(I$_E$ = 100 µA)	BV$_{ECO}$	7			V

TRANSFER CHARACTERISTICS (T$_A$ = 25°C Unless otherwise specified.)

Parameter	Test Conditions	Symbol	Min	Typ	Max	Unit
Current transfer ratio	(I$_{LED}$ = 10 mA, V$_{COMP}$ = V$_{FB}$, V$_{CE}$ = 5 V) (Fig. 6)	CTR	100		200	%
Collector-emitter saturation voltage	(I$_{LED}$ = 10 mA, V$_{COMP}$ = V$_{FB}$, I$_C$ = 2.5 mA) (Fig. 6)	V$_{CE (SAT)}$			0.4	V

ISOLATION CHARACTERISTICS (T$_A$ = 25°C Unless otherwise specified.)

Parameter	Test Conditions	Symbol	Min	Typ	Max	Unit
Input-output insulation leakage current	(RH = 45%, T$_A$ = 25°C, t = 5s, V$_{I-O}$ = 3000 VDC) (note. 1)	I$_{I-O}$			1.0	µA
Withstand insulation voltage	(RH <= 50%, T$_A$ = 25°C, t = 1 min) (notes. 1,2)	V$_{ISO}$	2500			Vrms
Resistance (input to output)	V$_{I-O}$ = 500 VDC (note. 1)	R$_{I-O}$		10^{12}		Ohm

SWITCHING CHARACTERISTICS (T$_A$ = 25°C Unless otherwise specified.)

Parameter	Test Conditions	Symbol	Min	Typ	Max	Unit
Bandwidth	(Fig. 7)	B$_W$		10		kHZ
Common mode transient immunity at output high	(I$_{LED}$ = 0 mA, |V$_{cm}$| = 10 V$_{PP}$ RL = 2.2 kΩ (Fig. 8) (note. 3)	|CMH|		1.0		kV/µs
Common mode transient immunity at output low	(I$_{LED}$ = 10 mA, |V$_{cm}$| = 10 V$_{PP}$ RL = 2.2 kΩ (Fig. 8) (note. 3)	|CML|		1.0		kV/µs

Notes
1. Device is considered as a two terminal device: Pins 1,2 3 and 4 are shorted together and Pins 5,6,7 and 8 are shorted together.
2. 2500 VAC RMS for 1 minute duration is equivalent to 3000 VAC RMS for 1 second duration.
3. Common mode transient immunity at output high is the maximum tolerable (positive) dVcm/dt on the leading edge of the common mode impulse signal, Vcm, to assure that the output will remain high. Common mode transient immunity at output low is the maximum tolerable (negative) dVcm/dt on the trailing edge of the common pulse signal,Vcm, to assure that the output will remain low.
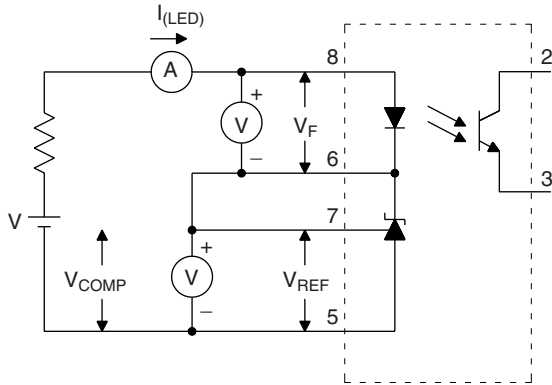
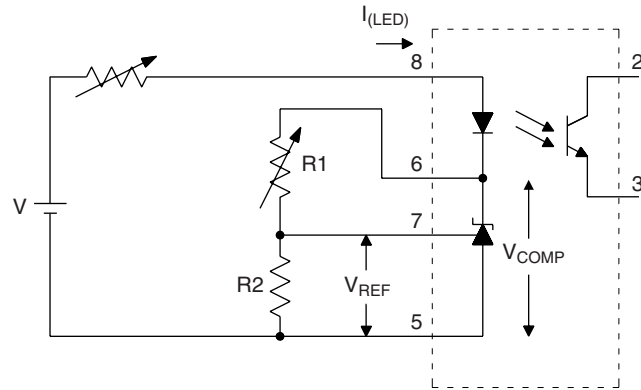FIG. 1. V_{REF}, V_F, I_{LED} (min) TEST CIRCUIT

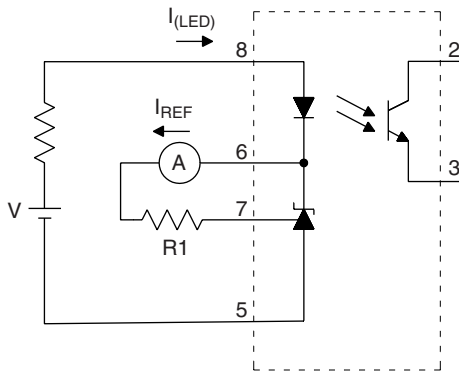

FIG. 2. $\Delta V_{REF}/\Delta V_{COMP}$ TEST CIRCUIT

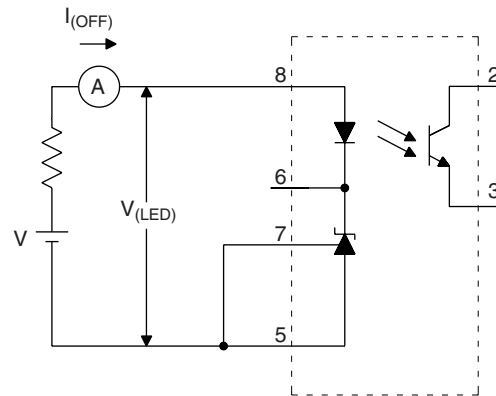FIG. 3. I_{REF} TEST CIRCUIT
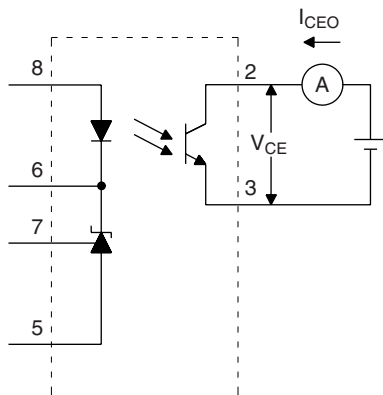

FIG. 4. $I_{(OFF)}$ TEST CIRCUIT

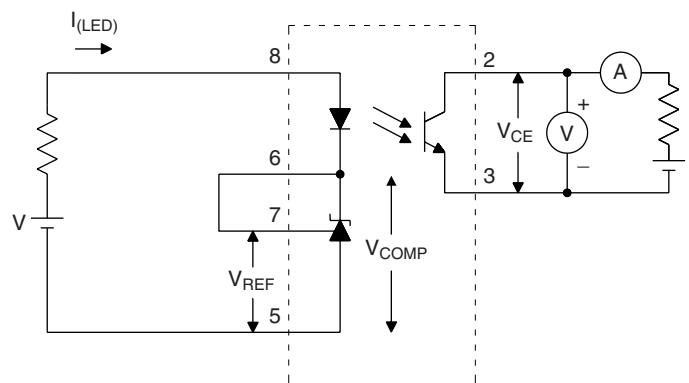

FIG. 5. I_{CEO} TEST CIRCUIT

FIG. 6. CTR, $V_{CE(sat)}$ TEST CIRCUIT
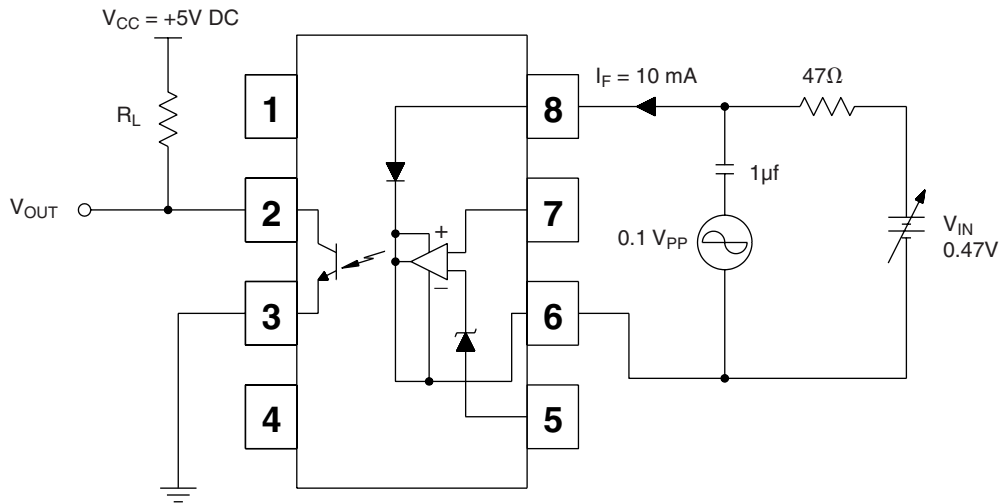
Fig. 7 Frequency Response Test Circuit
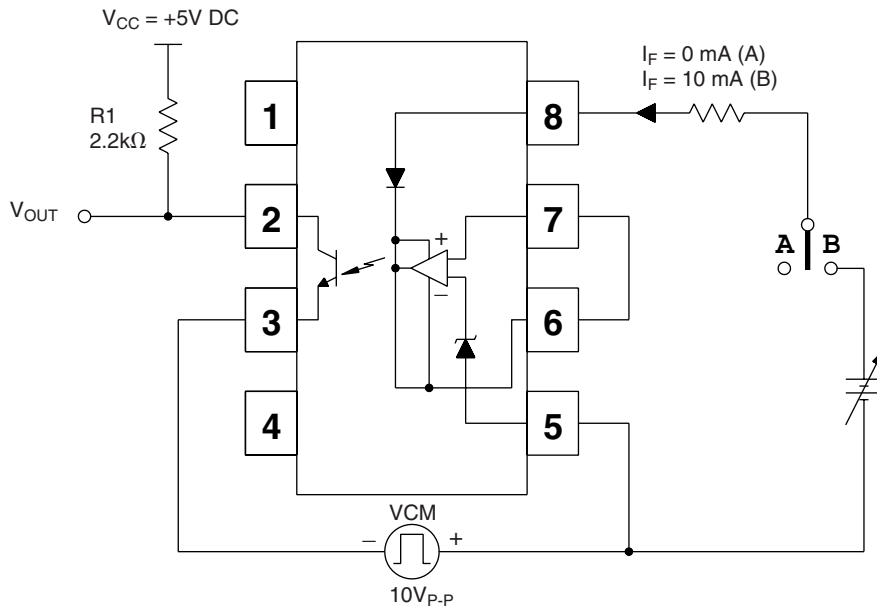
Fig. 8 CMH and CML Test Circuit

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TYPICAL PERFORMANCE CURVES

Fig. 9a LED Current vs Cathode Voltage

$T_A = 25°C$
$V_{COMP} = V_{FB}$

X-axis: V_{COMP} - CATHODE VOLTAGE (V)
Y-axis: I_{LED} - SUPPLY CURRENT (mA)

Fig. 9b LED Current vs Cathode Voltage

$T_A = 25°C$
$V_{COMP} = V_{FB}$

X-axis: V_{COMP} - CATHODE VOLTAGE (V)
Y-axis: I_{LED} - SUPPLY CURRENT (µA)
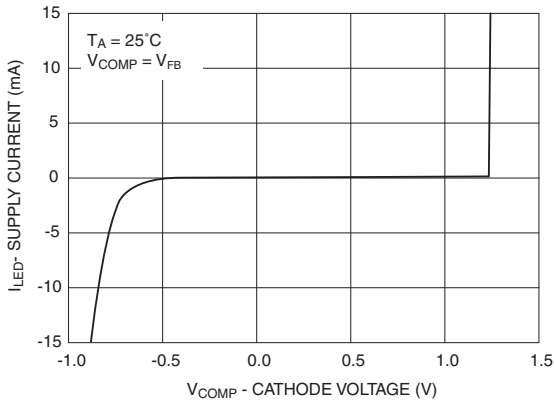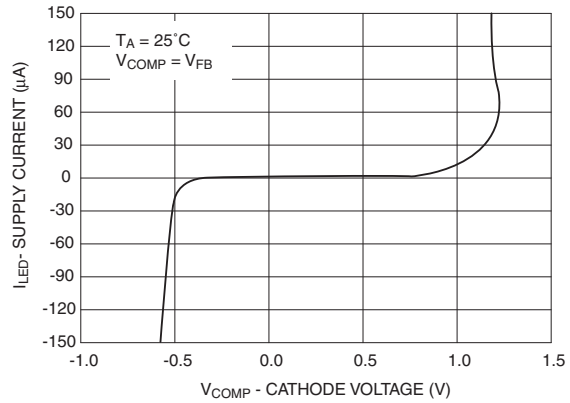
Fig. 10 Reference Voltage vs Ambient Temperature

$I_{LED} = 10$ mA

X-axis: T_A - AMBIENT TEMPERATURE (°C)
Y-axis: V_{REF} - REFERENCE VOLTAGE (V)
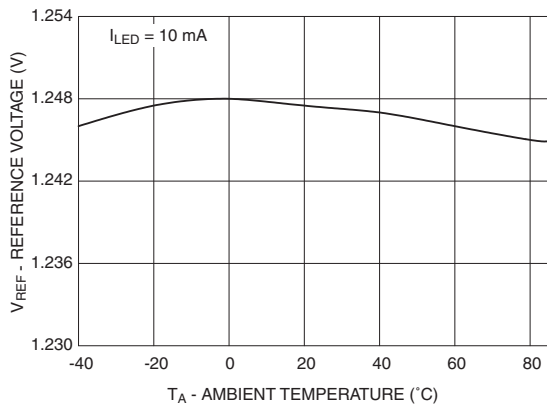
Fig. 11 Reference Current vs Ambient Temperature

$I_{LED} = 10$ mA
$R_1 = 10$ kΩ

X-axis: T_A - AMBIENT TEMPERATURE (°C)
Y-axis: I_{REF} - REFERENCE CURRENT (nA)
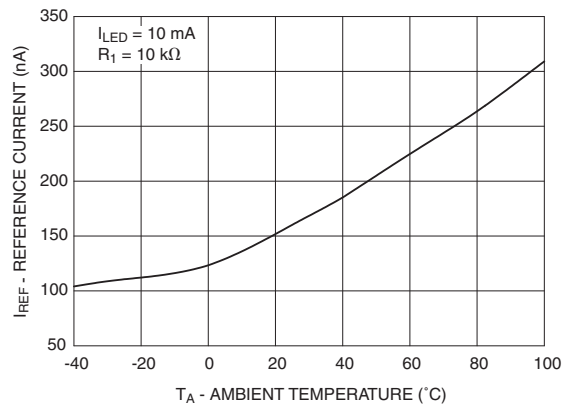
Fig. 12 Off Current vs Ambient Temperature

$V_{LED} = 13.2$ V
$V_{FB} = 0$

X-axis: T_A - AMBIENT TEMPERATURE (°C)
Y-axis: $I_{(OFF)}$ - OFF CURRENT (nA)
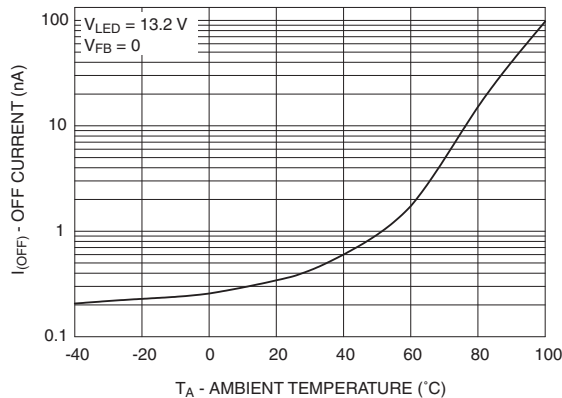
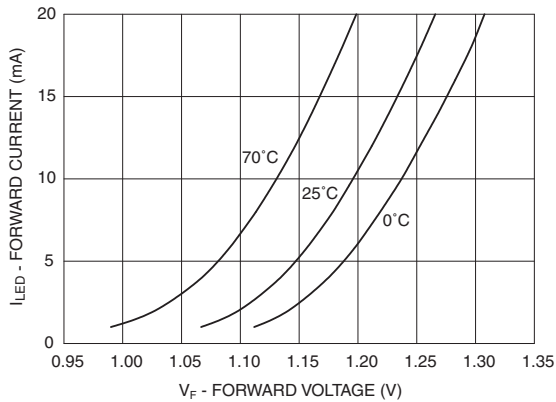**Fig.13 LED Forward Current vs Forward Voltage**

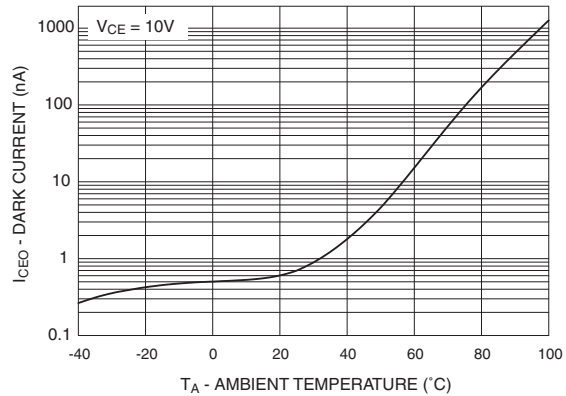**Fig.14 Dark Current vs Temperature**

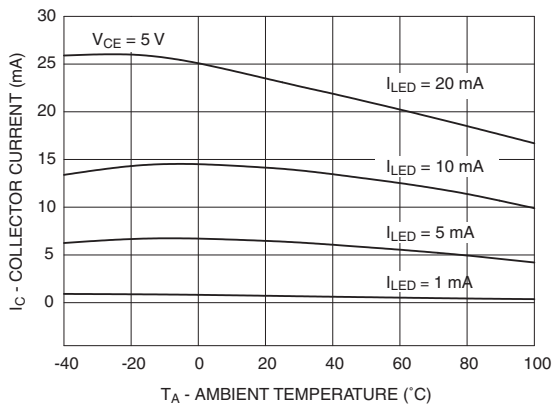**Fig. 15 Collector Current vs Ambient Temperature**

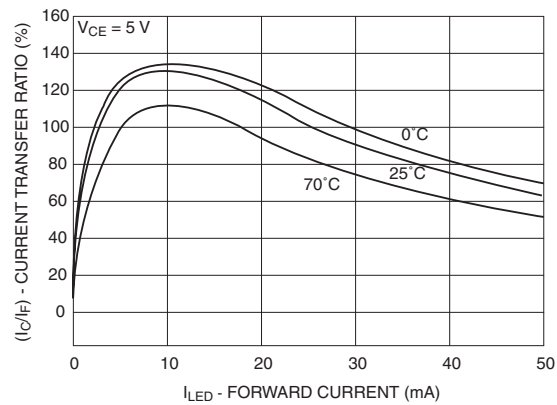**Fig. 16 Current Transfer Ratio vs LED Current**

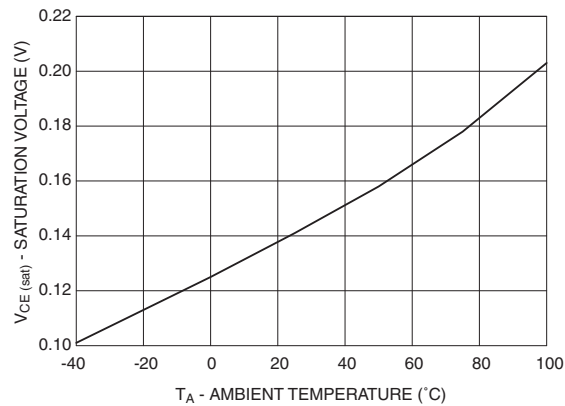**Fig. 17 Saturation Voltage vs Ambient Temperature**

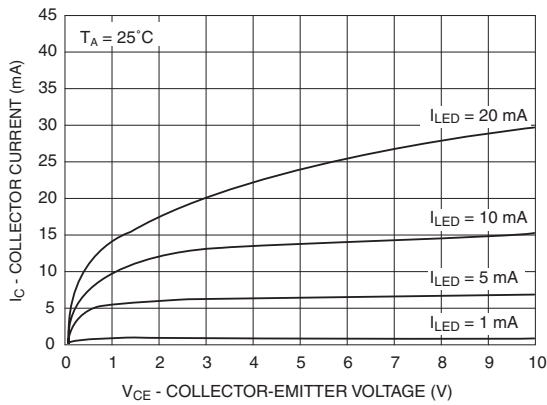**Fig. 18 Collector Current vs Collector Voltage**

Fig. 19 Delta V_{REF}/Delta V_{COMP} vs Ambient Temperature
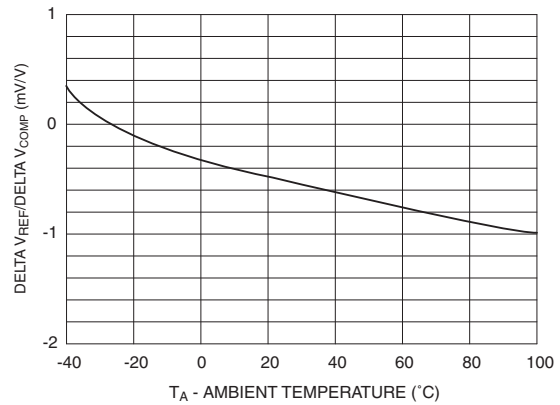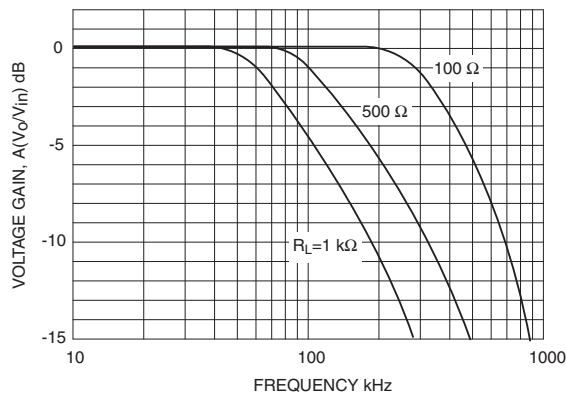

Fig. 20 Voltage Gain Vs Frequency

The FOD2712

The FOD2712 is an optically isolated error amplifier. It incorporates three of the most common elements necessary to make an isolated power supply, a reference voltage, an error amplifier, and an optocoupler. It is functionally equivalent to the popular RC431A shunt voltage regulator plus the CNY17F-3 optocoupler.

Powering the Secondary Side

The LED pin in the FOD2712 powers the secondary side, and in particular provides the current to run the LED. The actual structure of the FOD2712 dictates the minimum voltage that can be applied to the LED pin: The error amplifier output has a minimum of the reference voltage, and the LED is in series with that. Minimum voltage applied to the LED pin is thus 1.25V + 1.5V = 2.75V. This voltage can be generated either directly from the output of the converter, or else from a slaved secondary winding. The secondary winding will not affect regulation, as the input to the FB pin may still be taken from the output winding.

The LED pin needs to be fed through a current limiting resistor. The value of the resistor sets the amount of current through the LED, and thus must be carefully selected in conjunction with the selection of the primary side resistor.

Feedback

Output voltage of a converter is determined by selecting a resistor divider from the regulated output to the FB pin. The FOD2712 attempts to regulate its FB pin to the reference voltage, 1.24V. The ratio of the two resistors should thus be:

$$\frac{R_{TOP}}{R_{BOTTOM}} = \frac{V_{OUT}}{V_{REF}} - 1$$

The absolute value of the top resistor is set by the input offset current of 0.8µA. To achieve 1% accuracy, the resistance of R_{TOP} should be:

$$\frac{V_{OUT} - 1.24}{R_{TOP}} > 80 \text{ µA}$$

Compensation

The compensation pin of the FOD2712 provides the opportunity for the designer to design the frequency response of the converter. A compensation network may be placed between the COMP pin and the FB pin. In typical low-bandwidth systems, a 0.1µF capacitor may be used. For converters with more stringent requirements, a network should be designed based on measurements of the system's loop. An excellent reference for this process may be found in "Practical Design of Power Supplies" by Ron Lenk, IEEE Press, 1998.

Secondary Ground

The GND pin should be connected to the secondary ground of the converter.

No Connect Pins

The NC pins have no internal connection. They should not have any connection to the secondary side, as this may compromise the isolation structure.

Photo-Transistor

The Photo-transistor is the output of the FOD2712. In a normal configuration the collector will be attached to a pull-up resistor and the emitter grounded. There is no base connection necessary.

The value of the pull-up resistor, and the current limiting resistor feeding the LED, must be carefully selected to account for voltage range accepted by the PWM IC, and for the variation in current transfer ratio (CTR) of the opto-isolator itself.

Example: The voltage feeding the LED pins is +12V, the voltage feeding the collector pull-up is +10V, and the PWM IC is the Fairchild KA1H0680, which has a 5V reference. If we select a 10KΩ resistor for the LED, the maximum current the LED can see is (12V-2.75V)/10KΩ = 925µA. The CTR of the opto-isolator is a minimum of 100%, and so the minimum collector current of the photo-transistor when the diode is full on is also 925µA. The collector resistor must thus be such that:

$$\frac{12V - 5V}{R_{COLLECTOR}} < 925 \text{ µA or } R_{COLLECTOR} > 7.5K\Omega;$$

select 15KΩ to allow some margin.

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ORDERING INFORMATION
Example: FOD2712   X   Y

X	Y
Packaging Option	
R1: Tape and Reel (500 per reel)	V:VDE tested
R2: Tape and Reel (2,500 per reel)	

QT Carrier Tape Specifications

3.5 ± 0.2

0.3 MAX

8.3 ± 0.1

0.1 MAX

8.0 ± 0.1

2 ± 0.05

4.0 ± 0.1

Ø1.5 MIN

1.75 ± 0.10

5.5 ± 0.05

12.0 ± 0.3

5.2 ± 0.2

Ø1.5 + 0.1/-0

6.4 ± 0.2

User Direction of Feed →

225˚C

220˚C:10 sec to 40 sec

Time>183˚C:120 sec to 180 sec

250
200
150
100
50
0

0   1   2   3   4   5   Time (Min)

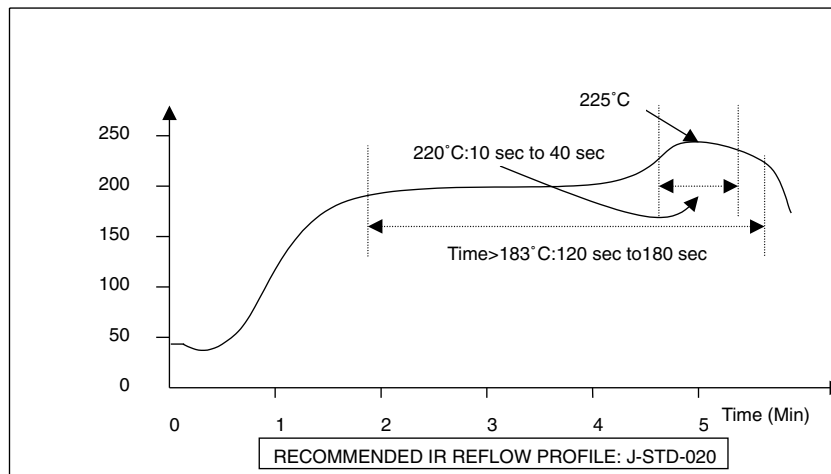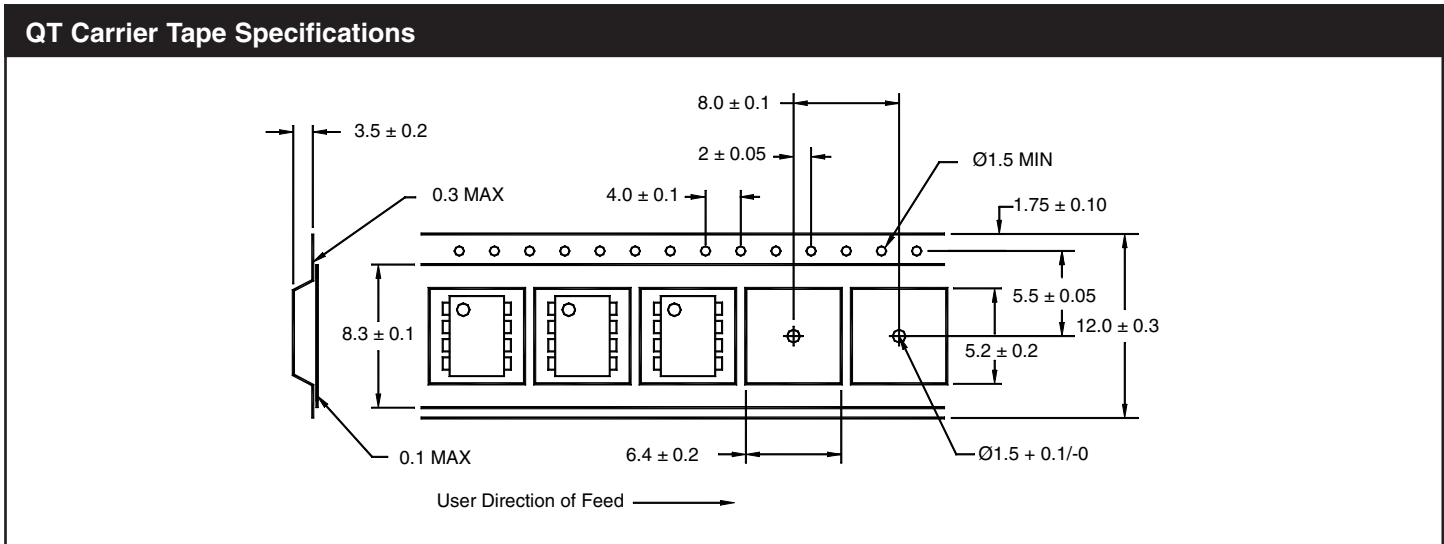RECOMMENDED IR REFLOW PROFILE: J-STD-020

Fig. 21 JEDEC Reflow Profile

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2. A critical component in any component of a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.