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FAIRCHILD SEMICONDUCTOR®

December 2010

# FOD2712A
# Optically Isolated Error Amplifier

## Features

- Optocoupler, precision reference and error amplifier in single package
- 1.240V ± 1% reference
- CTR 100% to 200%
- 2,500V RMS isolation
- UL approval E90700

## Applications

- Power system for workstations
- Telecom central office supply
- Telecom bricks

## Description

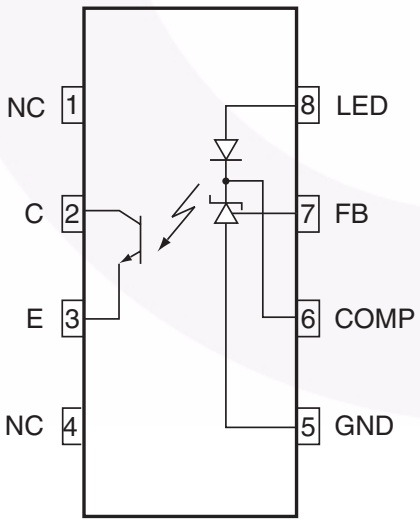
The FOD2712A Optically Isolated Amplifier consists of the popular AZ431L precision programmable shunt reference and an optocoupler. The optocoupler is a gallium arsenide (GaAs) light emitting diode optically coupled to a silicon phototransistor. The reference voltage tolerance is 1%. The current transfer 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.

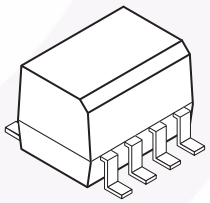
When using the FOD2712A, power supply designers can reduce the component count and save space in tightly packaged designs. The tight tolerance reference eliminates the need for adjustments in many applications.

The device comes in a compact 8-pin small outline package.

## Schematic




## Package Outline



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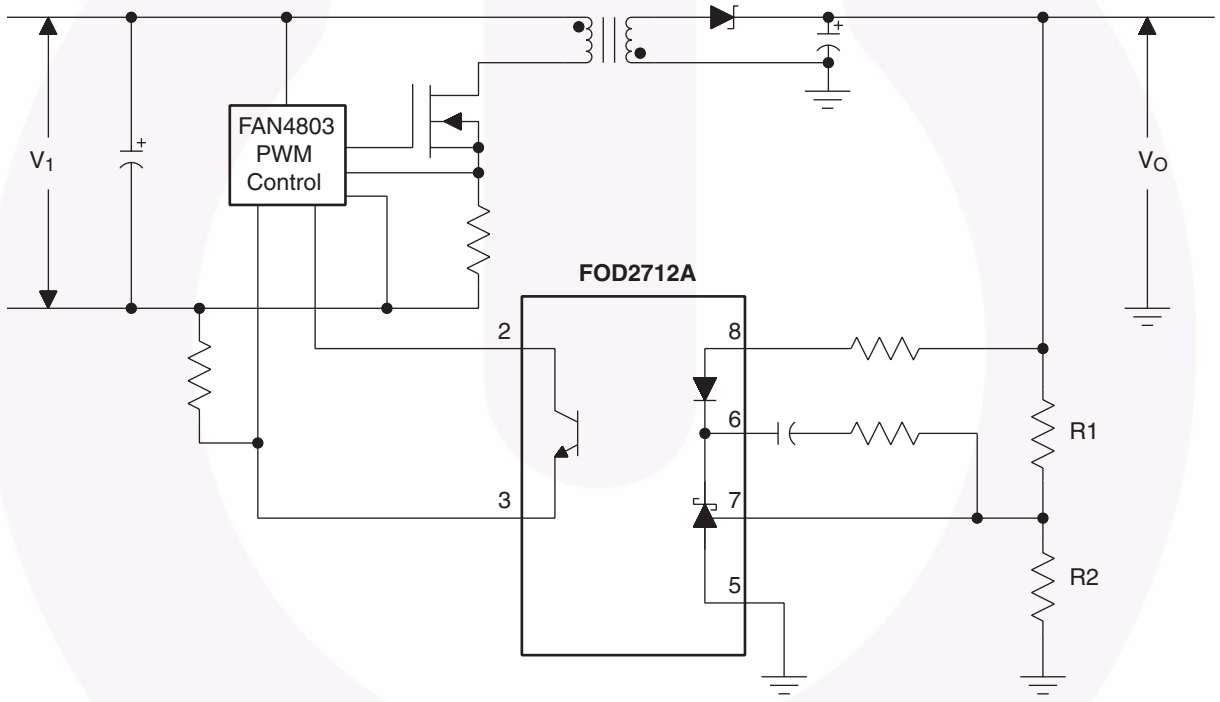

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## Pin Definitions

| Pin Number | Pin Name | Functional 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.

## Typical Application






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## Absolute Maximum Ratings ($T_A$ = 25°C unless otherwise specified)

Stresses exceeding the absolute maximum ratings may damage the device. The device may not function or be operable above the recommended operating conditions and stressing the parts to these levels is not recommended. In addition, extended exposure to stresses above the recommended operating conditions may affect device reliability. The absolute maximum ratings are stress ratings only.

| Symbol | Parameter | Value | Units |
|---|---|---|---|
| $T_{STG}$ | Storage Temperature | -40 to +125 | °C |
| $T_{OPR}$ | Operating Temperature | -40 to +85 | °C |
| | Reflow Temperature Profile (refer to 15) | | |
| $V_{LED}$ | Input Voltage | 13.2 | V |
| $I_{LED}$ | Input DC Current | 20 | mA |
| $V_{CEO}$ | Collector-Emitter Voltage | 30 | V |
| $V_{ECO}$ | Emitter-Collector Voltage | 7 | V |
| $I_C$ | Collector Current | 50 | mA |
| PD1 | Input Power Dissipation(1) | 145 | mW |
| PD2 | Transistor Power Dissipation(2) | 85 | mW |
| PD3 | Total Power Dissipation(3) | 145 | mW |

**Notes:**

1. Derate linearly from 25°C at a rate of 2.42mW/°C
2. Derate linearly from 25°C at a rate of 1.42mW/°C.
3. Derate linearly from 25°C at a rate of 2.42mW/°C.



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## Electrical Characteristics ($V_{CC}$ = 12V, $T_A$ = 25°C unless otherwise specified)

### Input Characteristics

| Symbol | Parameter | Test Conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| $V_F$ | LED Forward Voltage | $I_{LED}$ = 10mA, $V_{COMP} = V_{FB}$ (Fig.1) | | | 1.5 | V |
| $V_{REF}$ | Reference Voltage | $V_{COMP} = V_{FB}$, $I_{LED}$ = 10mA (Fig.1) | | | | |
| | -40°C to +85°C | | 1.221 | | 1.259 | V |
| | 25°C | | 1.228 | 1.240 | 1.252 | |
| $V_{REF\ (DEV)}$ | Deviation of $V_{REF}$ over temperature See Note 1 | $T_A$ = -40 to +85°C | | 4 | 12 | mV |
| $\frac{\Delta V_{REF}}{\Delta V_{COMP}}$ | Ratio of Vref Variation to the Output of the Error Amplifier | $I_{LED}$ = 10 mA, $V_{COMP} = V_{REF}$ to 12V (Fig. 2) | | -1.5 | -2.7 | mV/V |
| $I_{REF}$ | Feedback Input Current | $I_{LED}$ = 10mA, R1 = 10kΩ (Fig. 3) | | 0.15 | 0.5 | µA |
| $I_{REF\ (DEV)}$ | Deviation of $I_{REF}$ Over Temperature See Note 1 | $T_A$ = -40 to +85°C | | 0.15 | 0.3 | µA |
| $I_{LED\ (MIN)}$ | Minimum Drive Current | $V_{COMP} = V_{FB}$ (Fig.1) | | 55 | 80 | µA |
| $I_{(OFF)}$ | Off-state Error Amplifier Current | $V_{LED}$ = 6V, $V_{FB}$ = 0 (Fig.4) | | 0.001 | 0.1 | µA |
| $\lvert Z_{OUT}\rvert$ | Error Amplifier Output Impedance See Note 2 | $V_{COMP} = V_{FB}$, $I_{LED}$ = 0.1mA to 15mA, f < 1kHZ | | 0.25 | | Ω |

**Notes:**

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 $\Delta T_A$ is the rated operating free-air temperature range of the device.

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

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



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## Electrical Characteristics ($V_{CC}$ = 12V, $T_A$ = 25°C unless otherwise specified) (Continued)

### Output Characteristics

| Symbol | Parameter | Test Conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| $I_{CEO}$ | Collector Dark Current | $V_{CE}$ = 10V (Fig. 5) | | | 50 | nA |
| $BV_{CEO}$ | Collector-Emitter Voltage Breakdown | $I_C$ = 1.0mA | 70 | | | V |
| $BV_{ECO}$ | Emitter-Collector Voltage Breakdown | $I_E$ = 100µA | 7 | | | V |

### Transfer Characteristics

| Symbol | Parameter | Test Conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| CTR | Current Transfer Ratio | $I_{LED}$ = 10mA, $V_{COMP} = V_{FB}$, $V_{CE}$ = 5V (Fig. 6) | 100 | | 200 | % |
| $V_{CE\ (SAT)}$ | Collector-Emitter Saturation Voltage | $I_{LED}$ = 10mA, $V_{COMP} = V_{FB}$, $I_C$ = 2.5mA (Fig. 6) | | | 0.4 | V |

### Isolation Characteristics

| Symbol | Parameter | Test Conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| $I_{I-O}$ | Input-Output Insulation Leakage Current | RH = 45%, $T_A$ = 25°C, t = 5s, $V_{I-O}$ = 3000 VDC (Note 1) | | | 1.0 | µA |
| $V_{ISO}$ | Withstand Insulation Voltage | RH ≤ 50%, $T_A$ = 25°C, t = 1 min. (Note 1) | 2500 | | | Vrms |
| $R_{I-O}$ | Resistance (Input to Output) | $V_{I-O}$ = 500 VDC (Note 1) | | $10^{12}$ | | Ω |

### Switching Characteristics

| Symbol | Parameter | Test Conditions | Min. | Typ. | Max. | Unit |
|---|---|---|---|---|---|---|
| $B_W$ | Bandwidth | Fig. 7 | | 10 | | kHz |
| $\lvert CMH \rvert$ | Common Mode Transient Immunity at Output HIGH | $I_{LED}$ = 0mA, $\lvert V_{cm} \rvert$ = 10 $V_{PP}$ RL = 2.2kΩ (Fig. 8) (Note 2) | | 1.0 | | kV/µs |
| $\lvert CML \rvert$ | Common Mode Transient Immunity at Output LOW | $I_{LED}$ = 10mA, $\lvert V_{cm} \rvert$ = 10 $V_{PP}$ RL = 2.2kΩ (Fig. 8) (Note 2) | | 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. 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.

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## Test Circuits

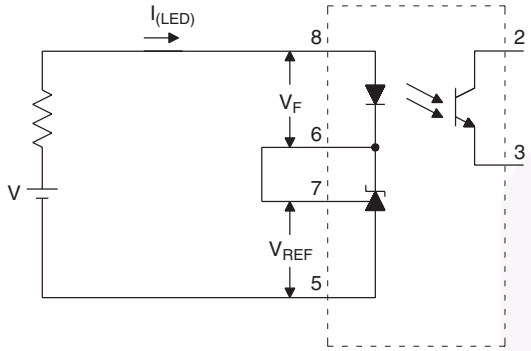



**Figure 1. $V_{REF}$, $V_F$, $I_{LED}$ (min) Test Circuit**

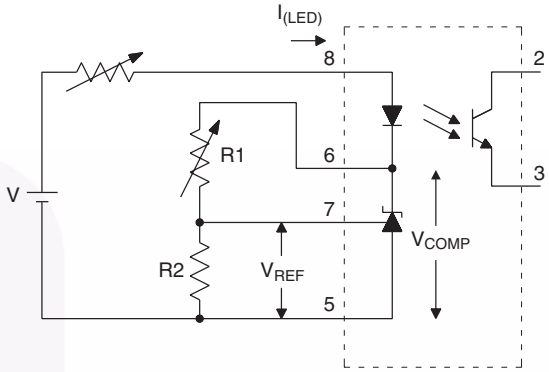



**Figure 2. $\Delta V_{REF}/\Delta V_{COMP}$ Test Circuit**

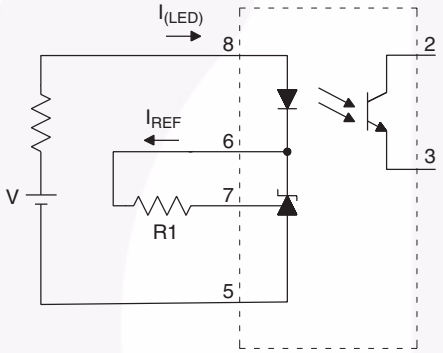



**Figure 3. $I_{REF}$ Test Circuit**

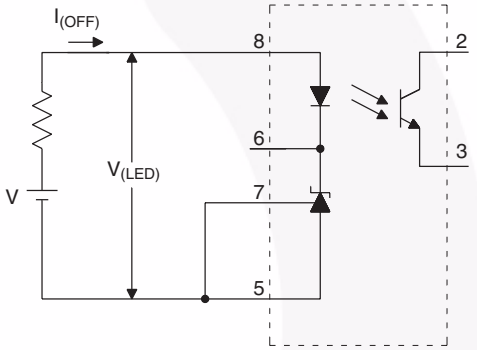



**Figure 4. $I_{(OFF)}$ Test Circuit**

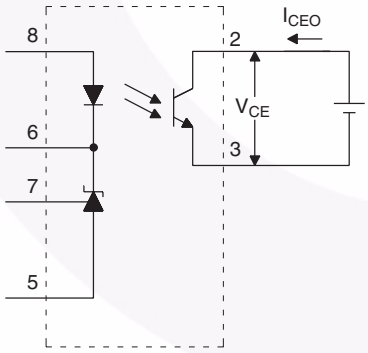



**Figure 5. $I_{CEO}$ Test Circuit**

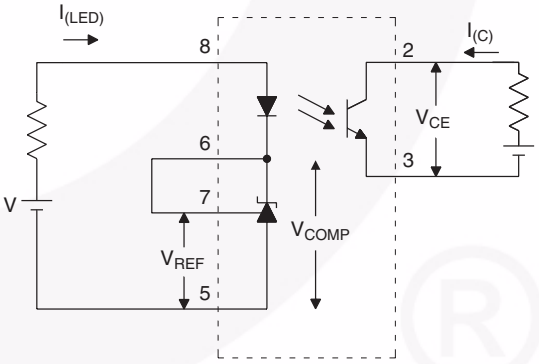



**Figure 6. CTR, $V_{CE(sat)}$ Test Circuit**



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## Test Circuits (Continued)

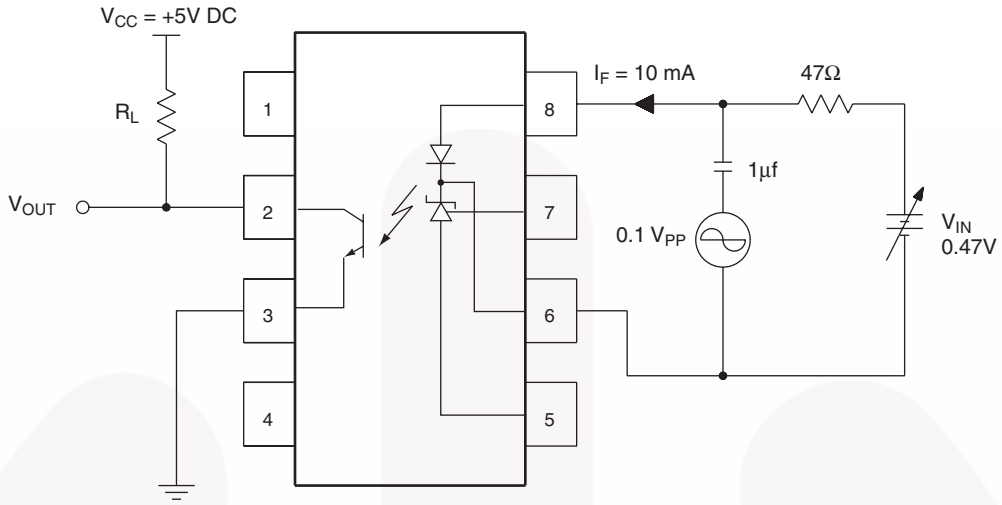



**Figure 7. Frequency Response Test Circuit**

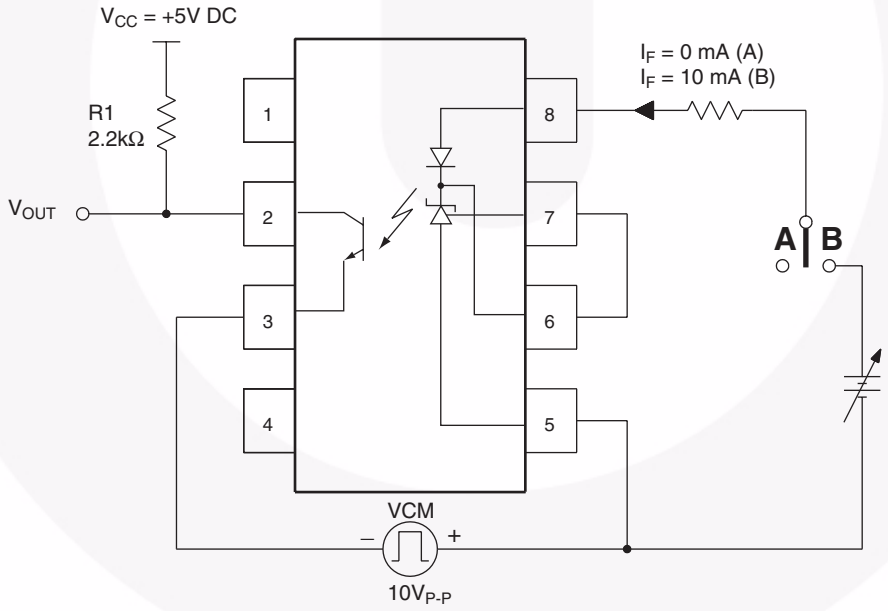



**Figure 8. CMH and CML Test Circuit**



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## Typical Performance Curves

Fig. 9a LED Current vs. Cathode Voltage

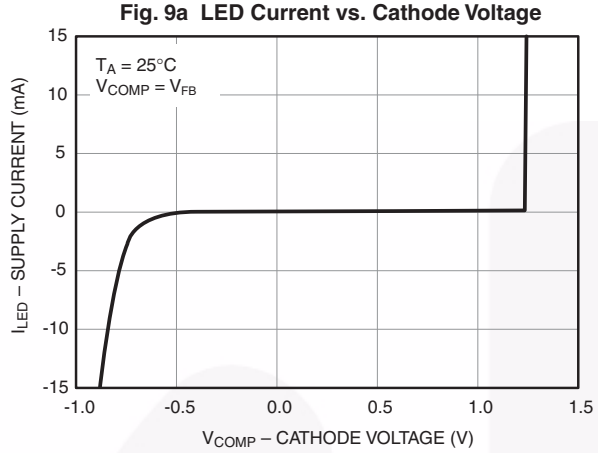



Fig. 9b LED Current vs. Cathode Voltage

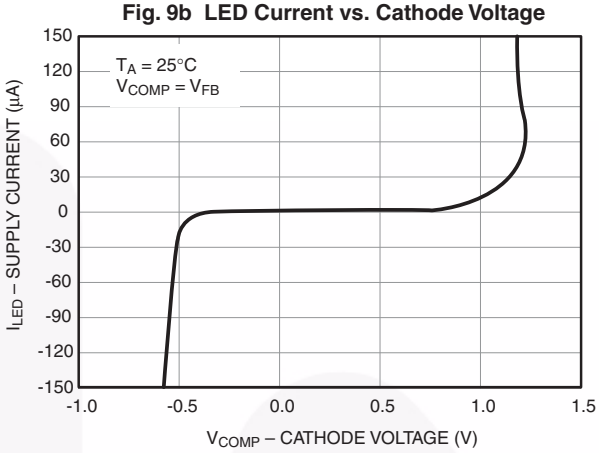



Fig. 10 Reference Voltage vs. Ambient Temperature

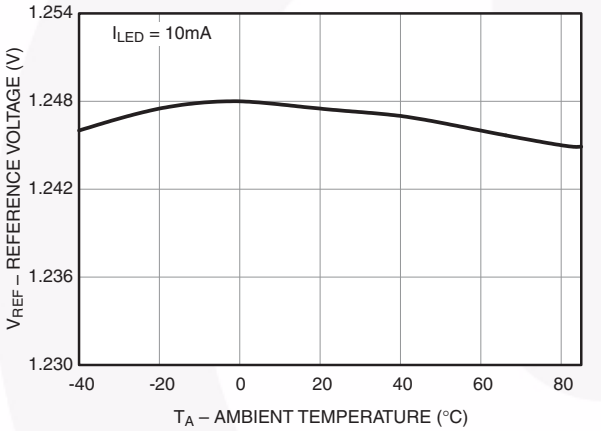



Fig. 11 Reference Current vs. Ambient Temperature

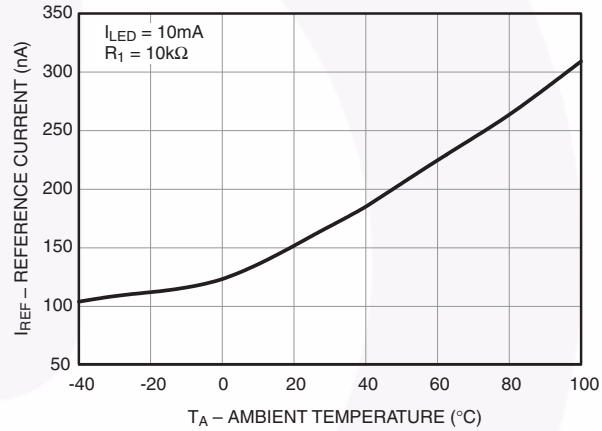
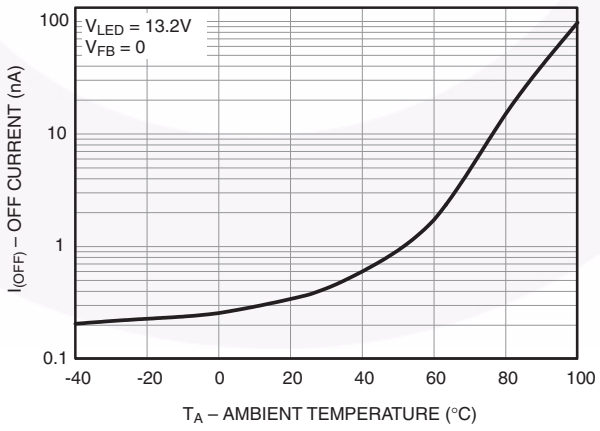



Fig. 12 Off Current vs. Ambient Temperature






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## Typical Performance Curves (Continued)

**Fig.13 LED Forward Current vs. Forward Voltage**

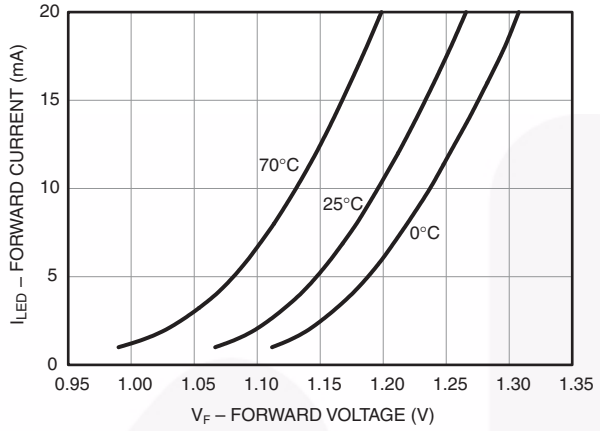



**Fig.14 Dark Current vs. Temperature**

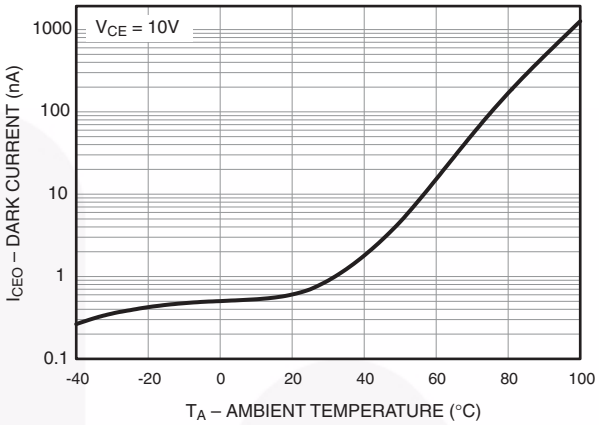



**Fig. 15 Collector Current vs. Ambient Temperature**

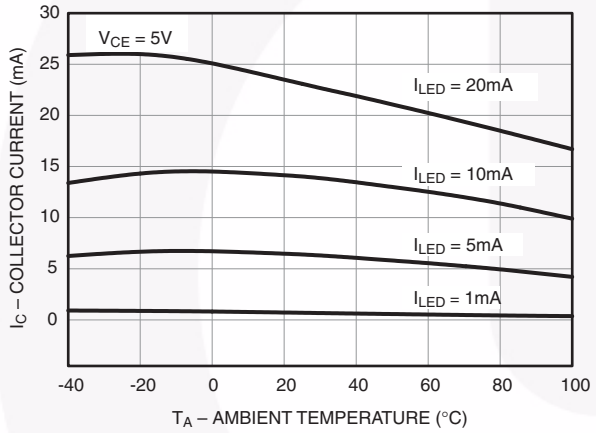



**Fig. 16 Current Transfer Ratio vs. LED Current**

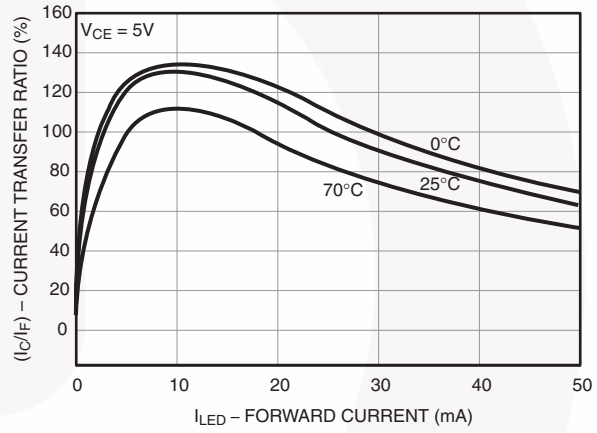
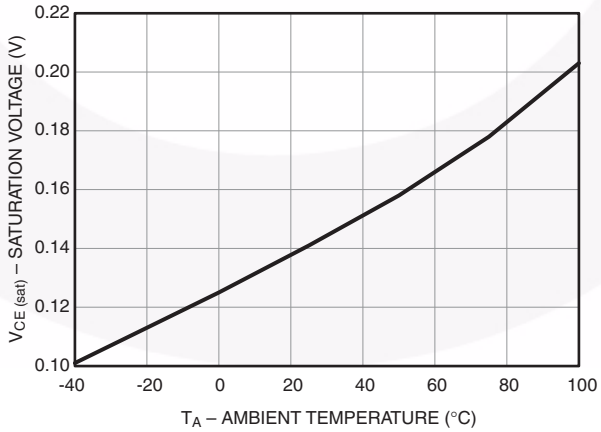



**Fig. 17 Saturation Voltage vs. Ambient Temperature**






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## Typical Performance Curves (Continued)

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

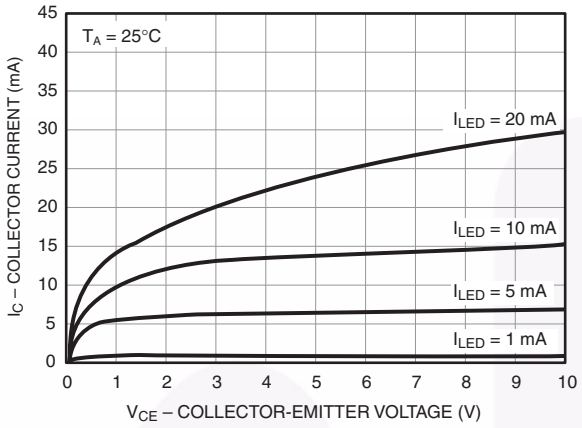



**Fig. 19 Delta $V_{REF}$/Delta $V_{COMP}$ vs. Ambient Temperature**

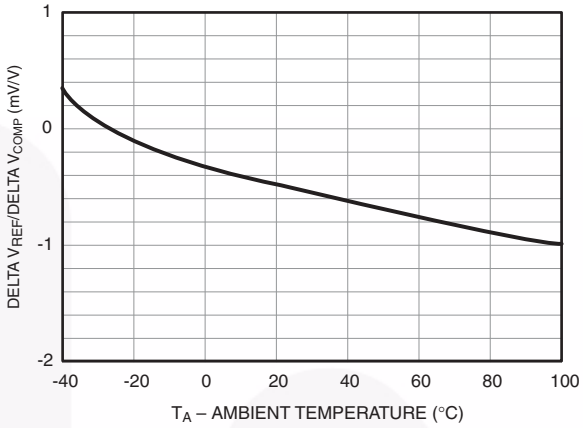
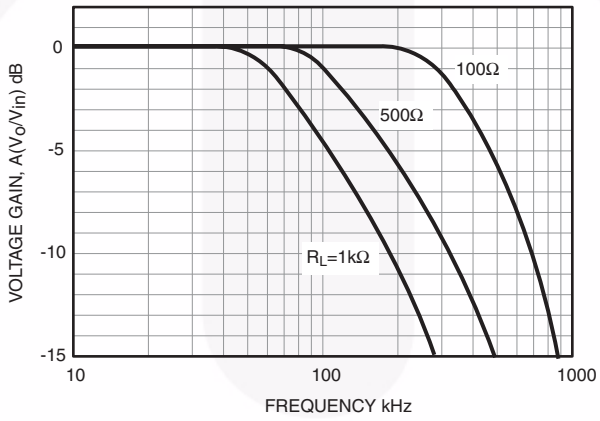



**Fig. 20 Voltage Gain vs. Frequency**






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## The FOD2712A

The FOD2712A 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 AZ431L shunt voltage regulator plus the CNY17F-3 optocoupler.

## Powering the Secondary Side

The LED pin in the FOD2712A powers the secondary side, and in particular provides the current to run the LED. The actual structure of the FOD2712A 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 1.24V + 1.5V = 2.74V. 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 FOD2712A 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:

$$\frac{V_{OUT} - 1.24}{R_{TOP}} > 80\mu A$$

## Compensation

The compensation pin of the FOD2712A 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 FOD2712A. 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–2.74V) /10KΩ = 926µA.

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 926µA. The collector resistor must thus be such that:

$$\frac{10V - 5V}{R_{COLLECTOR}} < 926\mu A \text{ or } R_{COLLECTOR} > 5.4K\Omega;$$

select 10KΩ to allow some margin.

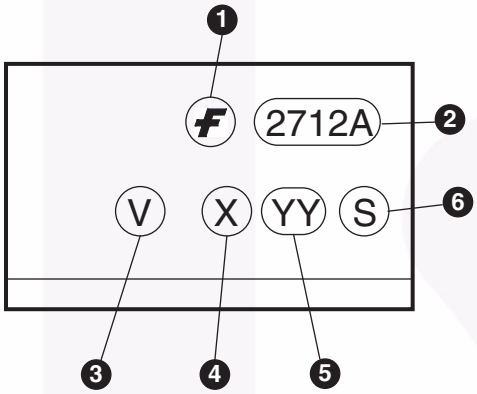


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## Ordering Information

| Option | Example Part Number | Description |
|---|---|---|
| V | FOD2712AV | VDE 0884 |
| R2 | FOD2712AR2 | Tape and reel (2500 units per reel) |
| R2V | FOD2712AR2V | VDE 0884, Tape and reel (2500 units per reel) |

## Marking Information

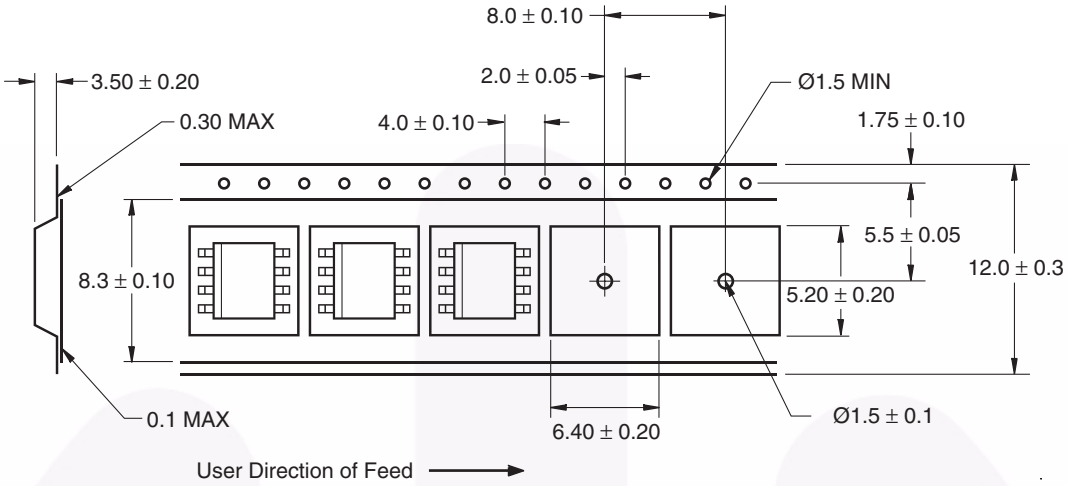



| Definitions | |
|---|---|
| 1 | Fairchild logo |
| 2 | Device number |
| 3 | VDE mark (Note: Only appears on parts ordered with VDE option – See order entry table) |
| 4 | One digit year code, e.g., ‘3’ |
| 5 | Two digit work week ranging from ‘01’ to ‘53’ |
| 6 | Assembly package code |



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## Carrier Tape Specifications

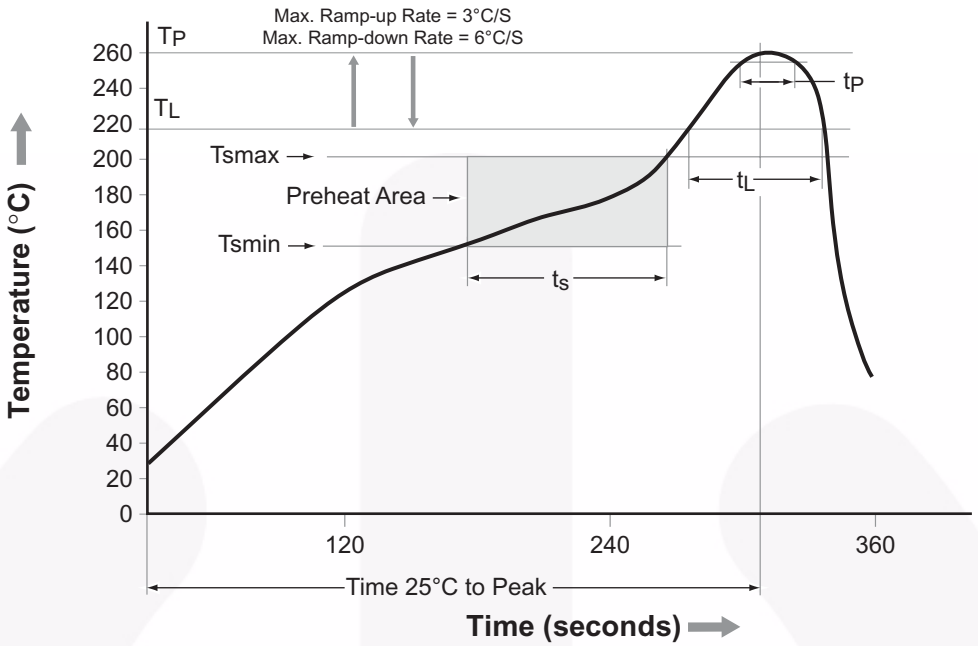



Dimensions in mm



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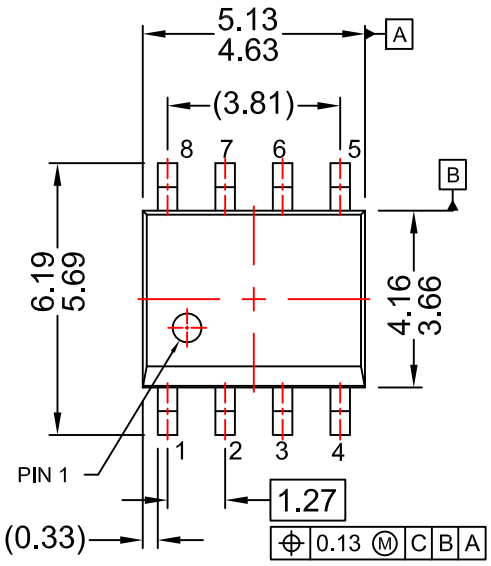
## Reflow Profile

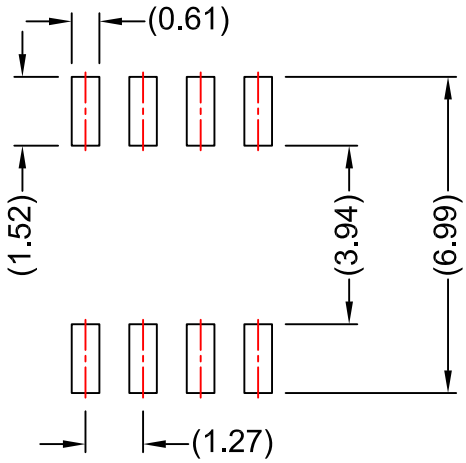



| Profile Feature | Pb-Free Assembly Profile |
|---|---|
| Temperature Min. (Tsmin) | 150°C |
| Temperature Max. (Tsmax) | 200°C |
| Time ($t_S$) from (Tsmin to Tsmax) | 60–120 seconds |
| Ramp-up Rate ($t_L$ to $t_P$) | 3°C/second max. |
| Liquidous Temperature ($T_L$) | 217°C |
| Time ($t_L$) Maintained Above ($T_L$) | 60–150 seconds |
| Peak Body Package Temperature | 260°C +0°C / –5°C |
| Time ($t_P$) within 5°C of 260°C | 30 seconds |
| Ramp-down Rate ($T_P$ to $T_L$) | 6°C/second max. |
| Time 25°C to Peak Temperature | 8 minutes max. |

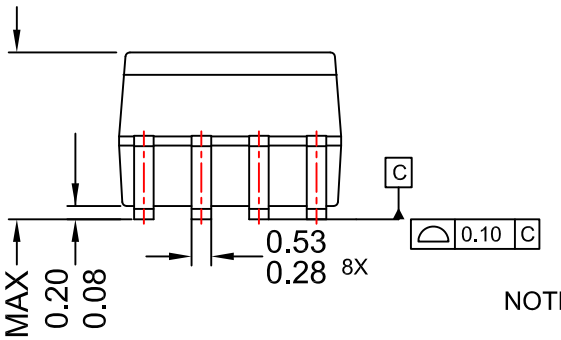


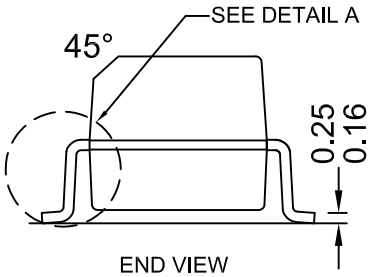
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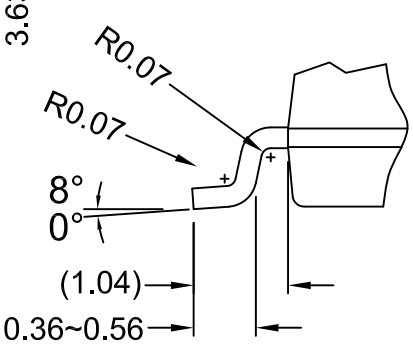




LAND PATTERN RECOMMENDATION




END VIEW




DETAIL A
SCALE: 2:1

NOTES:

A) NO STANDARD APPLIES TO THIS PACKAGE
B) ALL DIMENSIONS ARE IN MILLIMETERS.
C) DIMENSIONS DO NOT INCLUDE MOLD FLASH OR BURRS.
D) LANDPATTERN STANDARD: SOIC127P600X175-8M.
E) DRAWING FILENAME: MKT-M08Erev5

FAIRCHILD

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