LINFINITY MICROELECTRONICS

THE INFINITE POWER OF INNOVATION

# LXM1597-01

## 5V CCFL INVERTER MODULES

Not recommended for New Designs

## DESCRIPTION

LXM1597-01 CCFL (cold cathode florescent lamp) Inverter Modules are specifically designed for driving LCD back light lamps in applications where dimmability, ultra-high efficiency, high light output, low noise emissions, reliable fail safe design, and small form factors are critical parameters. Both monochrome and color displays are supported.

The modules convert unregulated DC voltage from the system battery or AC adapter directly to high-frequency, high-voltage sine waves required to ignite and operate CCFL lamps. The module design is based on a proprietary Linfinity IC that provides important new performance advances.

Remarkable improvements in efficiency and RF emissions result from its *single* stage resonant inverter featuring a patent pending Current Synchronous, Zero Voltage Switching (CS-ZVS) topology. CS-ZVS produces nearly pure sine wave currents in the lamp enabling maximum light delivery while reducing both conducted and radiated noise. This topology simultaneously performs three tasks consisting of line voltage regulation, lamp current regulation, and lamp dimming in a single power stage made up of two pairs of low loss FET's. The FET's drive an LC resonant circuit that feeds the primary of a high voltage transformer with a sinusoidal voltage.

Required L and C values in the resonant circuit are such that very low loss components can be used to obtain higher electrical efficiency than is possible with previous topologies.

The full bridge LXM1597-01 is optimized to efficiently operate with up to 4 watt lamps at input voltages of 5 volts. This module will operate over the full 4.5V to 7V input voltage range.

The modules are equipped with a dimming input that permits full range brightness control from an external potentiometer, and a sleep input that reduces module power to a few microwatts in shut down mode.

All modules feature output open and short circuit protection.

**IMPORTANT:** For the most current data, consult LinFinity's web site: **http://www.linfinity.com**.

## KEY FEATURES

- 15 to 30% More Light Output
- Closed Loop, Fully Regulating Design
- 4.5V To 7V Input Voltage Range
- Versatile Brightness Control Input
- 3 MicroAMP Sleep Current
- Output Short Circuit Protection And Automatic Over-Voltage Limiting
- 8mm Max. Height, Narrow Footprints
- Single Sided PCB Is Self Insulating

## APPLICATIONS

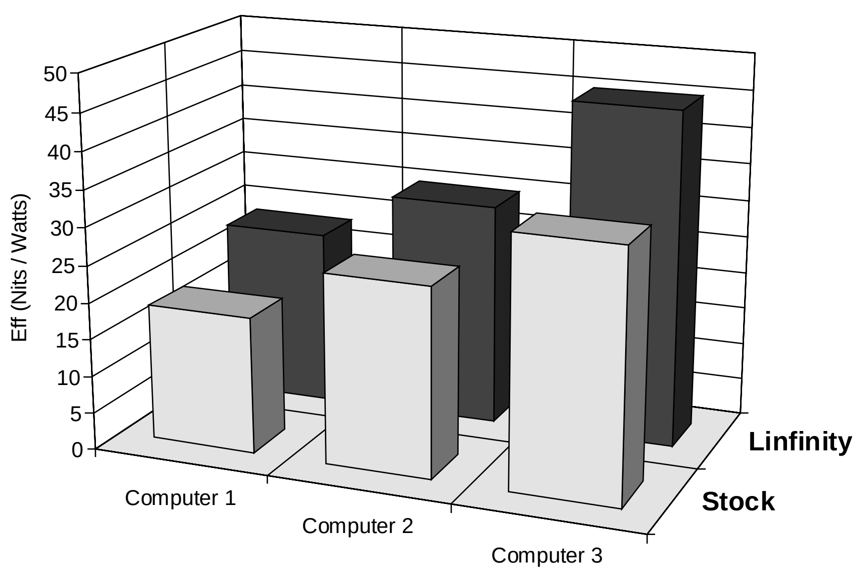
- Notebook And Sub-Notebook Computers
- Personal Digital Assistants
- Portable Instrumentation
- Automotive Displays
- Desktop Displays
- Airline Entertainment Centers

## BENEFITS

- Ultra-High Efficiency, Line Voltage Regulation And Sleep Mode Extend Computer Battery Life
- Cool Operation PermitS Close Proximity To LCD Panel Without Display Distortion
- Smooth, Full-Range Brightness Control Gives Your Product A High Quality Image
- Low EMI / RFI Design Minimizes Shielding Requirements
- Narrow, Low-Profile Standard Modules Fit Into Most LCD Enclosures
- Single Sided PCB Saves Expensive High Voltage Insulating Tapes

## PRODUCT HIGHLIGHT

BACKLIGHT INVERTER LIGHT OUTPUT EFFICIENCY COMPARISON




## MODULE ORDER INFO

| 5V INPUT |
|---|
| **LXM1597-01** |

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## ABSOLUTE MAXIMUM RATINGS (Note 1)

Input Supply Voltage ($V_{IN}$) ............ -0.3V to 7.0V
Output Voltage, no load ............ Internally Limited to $1900V_{RMS}$
Output Current ............ $8.0mA_{RMS}$ (Internally Limited)
Output Power ............ 4.2W
Input Signal Voltage, (SLEEP and BRITE Inputs) ............ -0.3V to 6.5V
Ambient Operating Temperature, zero airflow ............ 0°C to 60°C
Storage Temperature Range ............ -40°C to 85°C

Note 1. Exceeding these ratings could cause damage to the device. All voltages are with respect to Ground. Currents are positive into, negative out of the specified terminal.

## RECOMMENDED OPERATING CONDITIONS (R.C.)

*This module has been designed to operate over a wide range of input and output conditions. However, best efficiency and performance will be obtained if the module is operated under the condition listed in the '**R.C.**' column. Min. and Max. columns indicate values beyond which the inverter, although operational, will not function optimally.*

| Parameter | Symbol | Recommended Operating Conditions | | | Units |
|---|---|---|---|---|---|
| | | Min. | R.C. | Max. | |
| Input Supply Voltage | $V_{IN}$ | 4.5 | 5 | 7 | V |
| Output Power | $P_O$ | | 2.5 | 4.0 | W |
| Brightness Control Input Voltage Range | $V_{BRITE}$ | 0.8 | | 2.5 | V |
| Lamp Operating Voltage | $V_{LAMP}$ | 240 | 500 | 650 | $V_{RMS}$ |
| Lamp Current - Full Brightness | $I_{OLAMP}$ | | 5 | 7 | $mA_{RMS}$ |
| Operating Ambient Temperature Range | $T_A$ | 0 | | 60 | °C |

## ELECTRICAL CHARACTERISTICS

Unless otherwise specified, these specifications apply over the recommended operating conditions and 25°C ambient temperature for the LXM1597.

| Parameter | Symbol | Test Conditions | LXM1597 | | | Units |
|---|---|---|---|---|---|---|
| | | | Min. | Typ. | Max. | |
| **Output Pin Characteristics** | | | | | | |
| Full Bright Lamp Current | $I_{L (MAX)}$ | $V_{BRITE}$ = 2.5 $V_{DC}$, $\overline{SLEEP}$ = Logic High | 6.2 | 6.6 | 7.0 | mA |
| Minimum Lamp Current | $I_{L (MIN)}$ | $V_{BRITE}$ = 0.8 $V_{DC}$, $\overline{SLEEP}$ = Logic High | | 2.6 | | $mA_{RMS}$ |
| Lamp Start Voltage | $V_{LS}$ | 0°C < $T_A$ < 60°C | 1300 | | | $V_{RMS}$ |
| Operating Frequency | $f_O$ | $V_{BRITE}$ = 2.5$V_{DC}$, $\overline{SLEEP}$ = Logic High, $V_{IN}$ = 5V | | 50 | | KHz |
| **Brightness Control** | | | | | | |
| Input Current | $I_{BRITE}$ | $V_{BRITE}$ = 0$V_{DC}$ | | -200 | -1000 | $nA_{DC}$ |
| Input Voltage for Max. Lamp Current | $V_C$ | $I_{O (LAMP)}$ = 100% | 2.4 | 2.5 | 2.6 | $V_{DC}$ |
| Input Voltage for 50% Lamp Current | $V_C$ | $I_{O (LAMP)}$ = 50% | | 1.25 | | $V_{DC}$ |
| **$\overline{SLEEP}$ Input** | | | | | | |
| Input Logic 1 | $V_{IH}$ | | 2.2 | | 5.5 | $V_{DC}$ |
| Input Logc 0 | $V_{IL}$ | | 0 | | 0.8 | $V_{DC}$ |
| Input Current | $I_{IN}$ | $V_{\overline{SLEEP}}$ = 0 - 5$V_{DC}$ | | 50 | 100 | $\mu A_{DC}$ |
| **Voltage Reference** | | | | | | |
| Output Voltage | $V_{REF}$ | 0 < $I_{REF}$ < 500µA | 2.40 | 2.50 | 2.60 | $V_{DC}$ |
| Output Current | $I_{REF}$ | | 500 | | | $\mu A_{DC}$ |
| **Power Characteristics** | | | | | | |
| Sleep Current | $I_{IN (MIN)}$ | $V_{IN}$ = 5$V_{DC}$ , $\overline{SLEEP}$ = Logic 0 | | 3 | 10 | $\mu A_{DC}$ |
| Electrical Efficiency (calculated values) | η | LXM1597, $V_{IN}$ = 5$V_{DC}$, $I_{O (LAMP)}$ = 5$mA_{RMS}$ | | 90 | | % |



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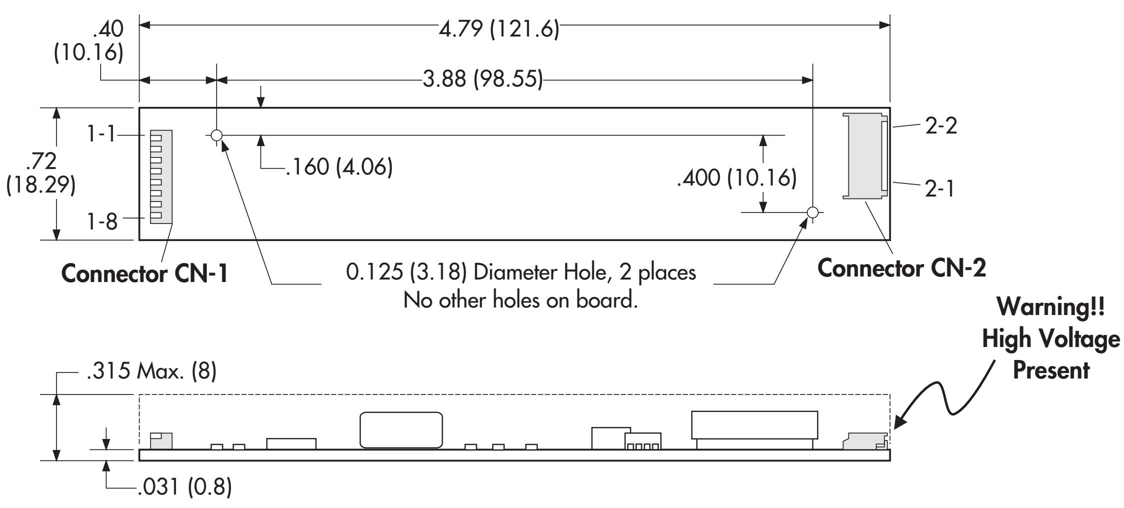
## FUNCTIONAL PIN DESCRIPTION

| Conn. | Pin | Description |
|---|---|---|
| **CN1** | | |
| CN1-1<br>CN1-2 | $V_{IN}$ | Input voltage. (+4.5 to +7$V_{DC}$) |
| CN1-3<br>CN1-4 | GND | Power supply return. |
| CN1-5 | $\overline{SLEEP}$ | Logical high on this pin enables inverter operation. Logical low removes power from the module and the lamp. A floating input is sensed as a logical low and will disable inverter operation. If not used, connect $\overline{SLEEP}$ through a 33kΩ resistor to $V_{IN}$ or directly to any voltage between 2.5 and 5.5V. |
| CN1-6 | BRITE | Brightness control input. Apply 0.8 to 2.5 volts DC to control lamp brightness. Lamp current varies linearly with input voltage. 2.5V gives maximum brightness. |
| CN1-7 | AGND | Brightness control signal return. For best results do not run 5V power supply current return through this pin. |
| CN1-8 | $V_{REF}$ | Reference Voltage Output. 2.5V @ 500µA max. For use with external dimming circuit. |
| **CN2** | | |
| CN2-1 | LAMP LO | High voltage connection to low side of lamp. Connect to lamp terminal with longer lead length. Do not connect to ground. |
| CN2-2 | LAMP HI | High voltage connection to high side of lamp. Connect to lamp terminal with shortest lead length. Do not connect to ground. |

## MECHANICAL OUTLINE




All dimensions in inches (mm)

| **Connectors:** | **Recommended Mate:** |
|---|---|
| **CN-1** = MOLEX 53261-0890 | Pins: 50079-8100*, Housing: 51021-0800<br>* Loose (-8000, Chain) Recommended #26 AWG wiring |
| **CN-2** = JST SM02(8.0) B-BHS-TB | Pins: 5BH-001T-P0.5, Housing: BHR-03VS-1 |

Note: All samples are equipped with connector mates and cable.

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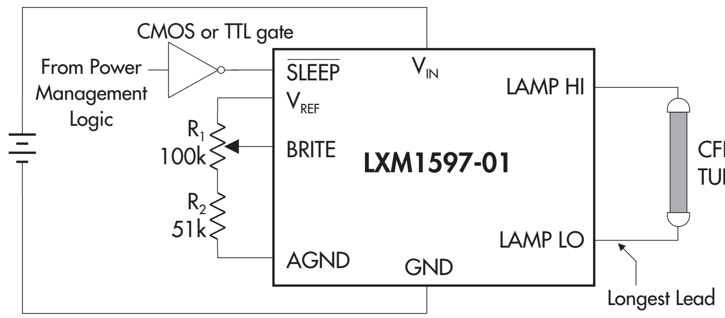
## CONNECTION DIAGRAM




Lamp Current (%) = $\frac{V_{BRITE}}{V_{REF}}$ x 100

$R_1$ = 100k typical, 5k minimum
$R_2$ = Value optional to determine lowest brightness setting
$R_2$ = 0.5 $R_1$ minimum

**FIGURE 1** — Recommended Connection Diagram

## EFFICIENCY MEASUREMENT SETUP

### INTRODUCTION

The best method for evaluating high voltage, high frequency inverters is by directly measuring light output versus power input. This method is highly recommended when evaluating inverter modules.

The following sections outline the recommended method for testing these modules.

### EQUIPMENT REQUIRED

1) Two DVM's with 0.1% or better accuracy.
2) A lab power supply. (0 - 20V, 0 - 2A)
3) The target notebook or LCD panel.
4) A Tektronix J1803 Luminance Head.
5) A Tektronix J17 Luminance Color Photometer.
6) A non-contact infrared temperature sensor (i.e. Fluke 80T-IR) with a mV meter.

### MEASUREMENT SETUP

Figure 2 shows the connection diagram for light output measurements. The photometer luminance head (J1803) is positioned directly in the center of the LCD screen. For best results open an application such as the Paintbrush program and choose the maximized view so that the entire screen is "white".

After application of the power to the CCFL wait at least 30 minutes to allow for the lamp and light output to stabilize. At the end of the 30 minute period read the light output in cd/m$^2$ (1 cd/m$^2$ = 1 Nit), as well as input voltage and current. Typical applications require about 70 to 100 Nits out of the screen. With the temperature probe record the temperature rises of critical components such as the high voltage transformer and the inductor.

The light output efficiency of the module can be calculated by the following equation:

$$\text{Eff} = \frac{\text{Light Output (in Nits)}}{V_{IN\,(DC)} * I_{IN\,(DC)}} = \frac{\text{Nits}}{\text{Watt}}$$

For competitive evaluation with another module from Linfinity or another manufacturer repeat the above steps for the second module.

After taking the data on the second module, compare the temperature rises on the transformer and inductors. The main figure of merit comparison is done between the two Eff numbers as follows:

$$\text{Percent More Efficient} = \frac{\text{Eff}_1 - \text{Eff}_2}{\text{Eff}_2} * 100$$

The result of the above shows how much more efficient module #1 is than module #2.

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## EFFICIENCY MEASUREMENT SETUP (continued)

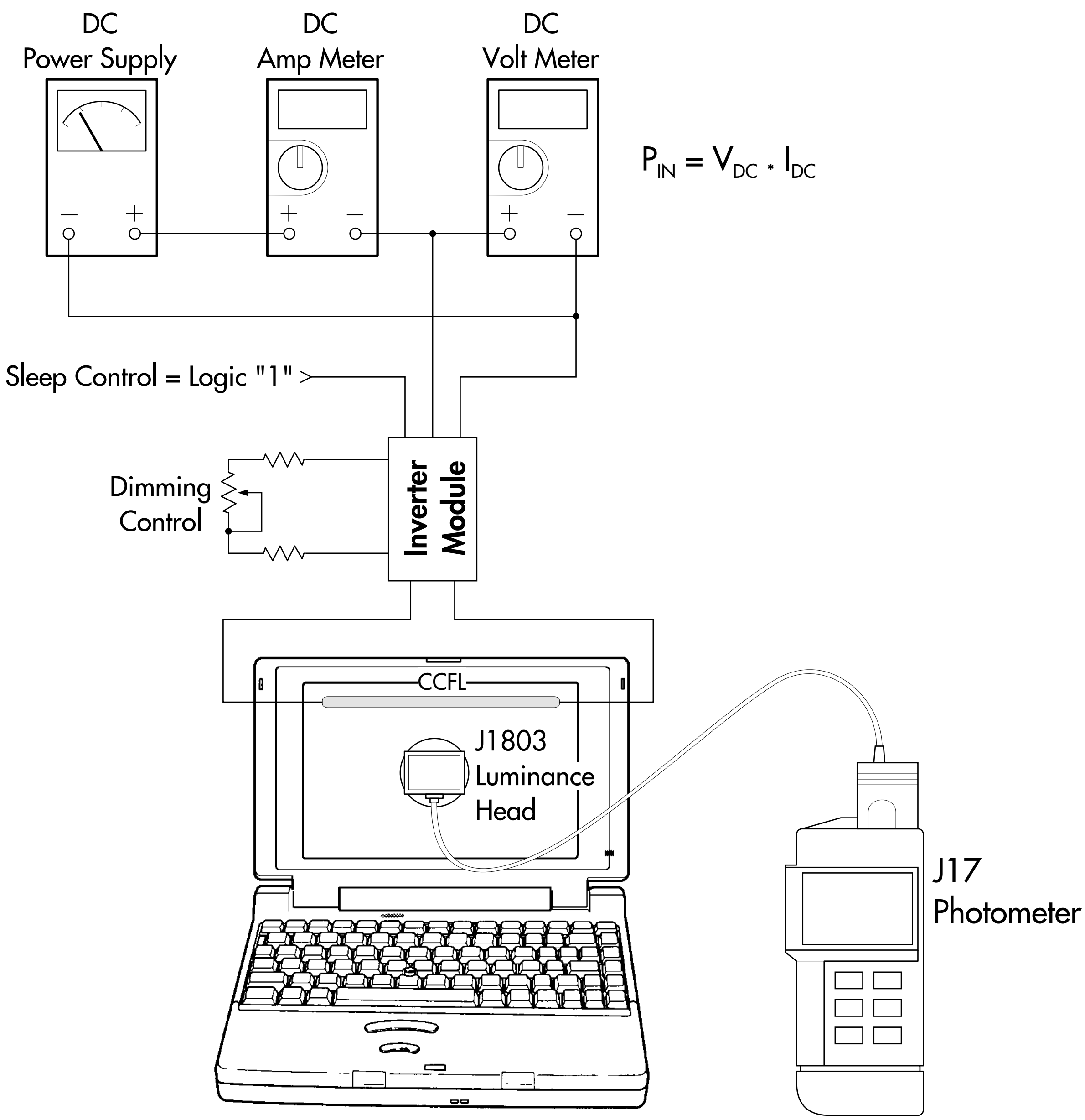


**FIGURE 2** — Light Output Measurement Setup