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MICROELECTRONICS

THE INFINITE POWER OF INNOVATION

## RangeMAX™ LXM1621-xx

### DIGITAL DIMMING DUAL LAMP CCFL INVERTER MODULE

### PRELIMINARY DATA SHEET

## DESCRIPTION

**RangeMAX Wide Range Dimming, Dual Output Inverter.** The LXM1621 Direct Drive™ CCFL (Cold Cathode Fluorescent Lamp) Inverter Modules are specifically designed for driving LCD backlight lamps.

Similar to the LXM1620, the LXM1621 excels in applications where critical parameters include very wide range dimmability, high efficiency and reliable fail-safe design in a small form factor. These 12 volt input modules are specifically designed with desktop and industrial applications in mind.

Unlike the LXM1620 or any traditional dimming CCFL inverters, the LXM1621 provides the designer a vastly superior display brightness range. 1000:1+ brightness range is achievable with a standard LCD display (see Product Highlight). Our wide range dimming provides exceptional display readability at less than 1% of full brightness, allowing both power savings and low ambient light operating capability (i.e. "night readable").

**RangeMAX Digital Dimming Technique.** Digital dimming provides flicker-free brightness control in any wide-range dimming application. Dimming ratios as great as 1000:1 can be achieved. Incorporation of a video synchronization feature allows wide ratio dimming without the display disturbances and interference seen with competitive products.

The modules are equipped with a dimming input that permits brightness control from an external potentiometer or DC voltage source. The resultant "burst drive" that energizes the lamp was designed specifically to ensure that no premature lamp degradation occurs (see "How RangeMAX Works" Section).

**Fail-safe Feature For Multiple Lamp Applications.** Our multi-output inverters are designed to keep your application operating at near normal brightness in the event that a lamp fails. This allows the display to remain "on-line" until lamp replacement is convenient.

**Direct Drive Technology.** The module design is based on a new Direct Drive topology, which provides a number of cost and performance advantages. The LXM1621-xx Direct Drive inverters eliminate the classic resonant inductor and capacitors, thus reducing cost and allowing a substantial reduction in module size.

**Universal Connector Configuration.** Linfinity's multiple lamp inverters include a built in connector array for the most common LCD lamp configurations.

**Additional Features.** Other benefits of this new topology are fixed-frequency operation and secondary-side strike-voltage regulation.

Strike-voltage regulation minimizes corona discharge in the output transformer and related circuitry, providing longer life and higher reliability. All LXM1621 modules feature both open and shorted lamp protection.

The LXM1621 is fully customizable (electronically and mechanically) to specific customer requirements.

## KEY FEATURES

- RangeMAX Wide Range Dimming
- 8V To 18V Input Voltage Range
- Small Form Factor
- Easy To Use Brightness Control
- MicroAmp SLEEP Mode
- Output Short-Circuit Protection And Automatic Strike-Voltage Regulation
- Fixed Frequency Operation
- Universal Connector Configuration

## APPLICATIONS

- Hi-Brite Displays
- Desktop Displays
- Low Ambient Light Conditions (i.e. Aircraft Cabins, Automobile)
- Industrial Applications

## BENEFITS

- High Efficiency Reduces Heating Problems
- Smooth, Flicker Free 0-100% Full-Range Brightness Control Gives Your Product A High Quality Image
- Output Open Circuit Voltage Regulation Minimizes Corona Discharge For Long Life And High Reliability
- Power Efficient, "Low Brightness" Capability Allows For Advanced Power Management

**NOTE:** For current data & package dimensions, visit our web site: **http://www.linfinity.com.**

## MODULE ORDER INFORMATION

| Part Number | Lamp Run Voltage | Lamp Current |
|---|---|---|
| LXM1621-01 | 500 - 750$V_{RMS}$ | 7mA |
| LXM1621-02 | 350 - 500$V_{RMS}$ | 6mA |
| LXM1621-03 | 350 - 500$V_{RMS}$ | 6.5mA |

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## ABSOLUTE MAXIMUM RATINGS (Note 1)

Input Supply Voltage ($V_{IN}$) ................................................................................................................ -0.3V to 18V
Output Voltage, no load ................................................................................................. Internally Limited to 1800$V_{RMS}$
Output Current ................................................................................................................ 10.0mA$_{RMS}$ (Internally Limited)
Output Power (per Lamp) ............................................................................................................................................... 6.0W
Input Signal Voltage (BRITE Input) ........................................................................................................... -0.3V to 6.5V
Input Signal Voltage ($\overline{SLEEP}$, $V_{SYNC}$ Inputs) ...................................................................................... -0.3V to $V_{IN}$
Ambient Operating Temperature ........................................................................................................................ 0°C to 70°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 Range (Functional) | | $V_{IN}$ | 8 | 12 | 18 | V |
| Input Supply Voltage (Fully Regulated Lamp Current) | | | 10.2 | 12 | 13.8 | V |
| Output Power (per Lamp) | **LXM1621-01** | $P_O$ | | 4 | 5 | W |
| | **LXM1621-02/-03** | | | 2.5 | 3 | W |
| Brightness Control Input Voltage Range | | $V_{BRT\ ADJ}$ | 0.0 | | 2.5 | V |
| Lamp Operating Voltage | **LXM1621-01** | $V_{LAMP}$ | 500 | 625 | 750 | $V_{RMS}$ |
| | **LXM1621-02/-03** | | 350 | 425 | 500 | $V_{RMS}$ |
| Lamp Current (Full Brightness - per Lamp) | **LXM1621-01** | $I_{OLAMP}$ | | 7.0 | | mA$_{RMS}$ |
| | **LXM1621-02** | | | 6.0 | | mA$_{RMS}$ |
| | **LXM1621-03** | | | 6.5 | | mA$_{RMS}$ |
| Operating Ambient Temperature Range | | $T_A$ | 0 | | 70 | °C |

## ELECTRICAL CHARACTERISTICS

Unless otherwise specified, these specifications apply over the recommended operating conditions and 25°C ambient temperature for the LXM1621-xx.

| Parameter | | Symbol | Test Conditions | LXM1621-xx | | | Units |
|---|---|---|---|---|---|---|---|
| | | | | Min. | Typ. | Max. | |
| **Output Pin Characteristics** | | | | | | | |
| Full Bright Lamp Current (per Lamp) | **1621-01** | $I_{L\,(MAX)}$ | $V_{BRT\ ADJ}$ = 2.5$V_{DC}$, $\overline{SLEEP}$ = HIGH, Burst Duty = 100%, $V_{IN}$ = 12$V_{DC}$ | 6.3 | 7.0 | 7.7 | mA$_{RMS}$ |
| | **1621-02** | | $V_{BRT\ ADJ}$ = 2.5$V_{DC}$, $\overline{SLEEP}$ = HIGH, Burst Duty = 100%, $V_{IN}$ = 12$V_{DC}$ | 5.5 | 6.0 | 6.5 | mA$_{RMS}$ |
| | **1621-03** | | $V_{BRT\ ADJ}$ = 2.5$V_{DC}$, $\overline{SLEEP}$ = HIGH, Burst Duty = 100%, $V_{IN}$ = 12$V_{DC}$ | 5.7 | 6.5 | 7.1 | mA$_{RMS}$ |
| Minimum Lamp Current (per Lamp) | | $I_{L\,(MIN)}$ | $V_{BRT\ ADJ}$ = 0$V_{DC}$, $\overline{SLEEP}$ = HIGH, Burst Duty = 2%, $V_{IN}$ = 9$V_{DC}$ | | 0.14 | | mA$_{RMS}$ |
| (Notes 2 & 3) | | | $V_{BRT\ ADJ}$ = -50mV$_{DC}$, $\overline{SLEEP}$ = HIGH, Burst Duty = 0.5%, $V_{IN}$ = 9$V_{DC}$ | | 0.035 | | mA$_{RMS}$ |
| Lamp Start Voltage | | $V_{LS}$ | 0°C < $T_A$ < 40°C, $V_{IN}$ ≥ 10.8$V_{DC}$ | 1500 | | 1800 | $V_{RMS}$ |
| Operating Frequency | | $f_O$ | $V_{BRT\ ADJ}$ = 2.5$V_{DC}$, $\overline{SLEEP}$ = HIGH, $V_{IN}$ = 12$V_{DC}$ | 52 | 57 | 62 | KHz |
| **BRITE Input** | | | | | | | |
| Input Current | | $I_{BRT}$ | $V_{BRT\ ADJ}$ = 0$V_{DC}$ | -6 | -8 | -10 | µA$_{DC}$ |
| Input Voltage for Max. Lamp Current | | $V_C$ | $I_{O\,(LAMP)}$ = 100% Duty Cycle | | 2.5 | 2.6 | $V_{DC}$ |
| Input Voltage for Min. Lamp Current | | $V_C$ | $I_{O\,(LAMP)}$ = 2% Duty Cycle | | 0 | 0 | $V_{DC}$ |
| (Note 3) | | | $I_{O\,(LAMP)}$ = 0.5% Duty Cycle | | -50 | | mV$_{DC}$ |
| **$\overline{SLEEP}$ Input** | | | | | | | |
| RUN Mode | | $V_{\overline{SLEEP}\,(HI)}$ | | 2.2 | | $V_{IN}$ | $V_{DC}$ |
| SLEEP Mode | | $V_{\overline{SLEEP}\,(LO)}$ | | -0.3 | | 0.8 | $V_{DC}$ |
| Input Current | | $I_{\overline{SLEEP}}$ | $\overline{SLEEP}$ = 5.0V | 70 | 75 | 100 | µA$_{DC}$ |

Note 2. Minimum lamp current required to maintain even light output may vary with display panel.
3. See 1000:1 Dimming Application section for details.

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## ELECTRICAL CHARACTERISTICS (Continued)

| Parameter | Symbol | Test Conditions | LXM1621-xx | | | Units |
|---|---|---|---|---|---|---|
| | | | Min. | Typ. | Max. | |
| **$V_{SYNC}$ Characteristics** | | | | | | |
| Logic High Level | $V_{SYNC (HI)}$ | | 4.0 | | 6.5 | $V_{DC}$ |
| Logic Low Level | $V_{SYNC (LO)}$ | | -0.3 | | 1.0 | $V_{DC}$ |
| Input Impedance | $Z_{IN}$ | | 60 | 66 | 75 | kΩ |
| Pulse Width (Note 4) | $t_{PW}$ | | 25 | | 250 | µs |
| Input Frequency | $f_{SYNC}$ | | 49 | | 150 | Hz |
| **Power Characteristics** | | | | | | |
| Sleep Current | $I_{IN (MIN)}$ | $V_{IN} = 12V_{DC}$ , $\overline{SLEEP} \leq 0.8V$ | | 5 | 50 | $µA_{DC}$ |

Note 4.  The module will be functional with pulse widths much larger than 250µs.

## FUNCTIONAL PIN DESCRIPTION

| Conn. | Pin | Description |
|---|---|---|
| **CN1** | | |
| CN1-1 CN1-2 | $V_{IN}$ | Input Power Supply. ($8V \leq V_{IN} \leq 18V$) |
| CN1-3 CN1-4 | GND | Power Supply Return. |
| CN1-5 | $\overline{SLEEP}$ | ON/OFF Control.  ($2.2V < \overline{SLEEP} < V_{IN}$ = ON, $-0.3V < \overline{SLEEP} < 0.8V$ = OFF) |
| CN1-6 | BRITE | Brightness Control ($-0.3V$ to $2.5V_{DC}$).   $2.5V_{DC}$ gives maximum lamp current. |
| CN1-7, 8 | $V_{SYNC}$ | Vertical syncronization input.  $49Hz < f_{SYNC} < 150Hz$ |

**CN2 thru CN5:**  Refer to Figure 2

## PHYSICAL DIMENSIONS

### LXM1621-xx
All dimensions are in inches (mm)



CN3 (Bottom Side)

4.88 (124)

CN2 (Bottom Side)

CN1

CN4

CN5

1.26 (32)

0.24 (6)

1.50 (38)

1.89 (48)

Ø 0.12 (3.0)
Grounded Mounting Hole - 2 plcs

0.338 (8.6) Max.

**Warning!!**
**High Voltage Present**
**At All Output**
**Connectors**

0.060 (1.52) max.

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# LXM1621-xx

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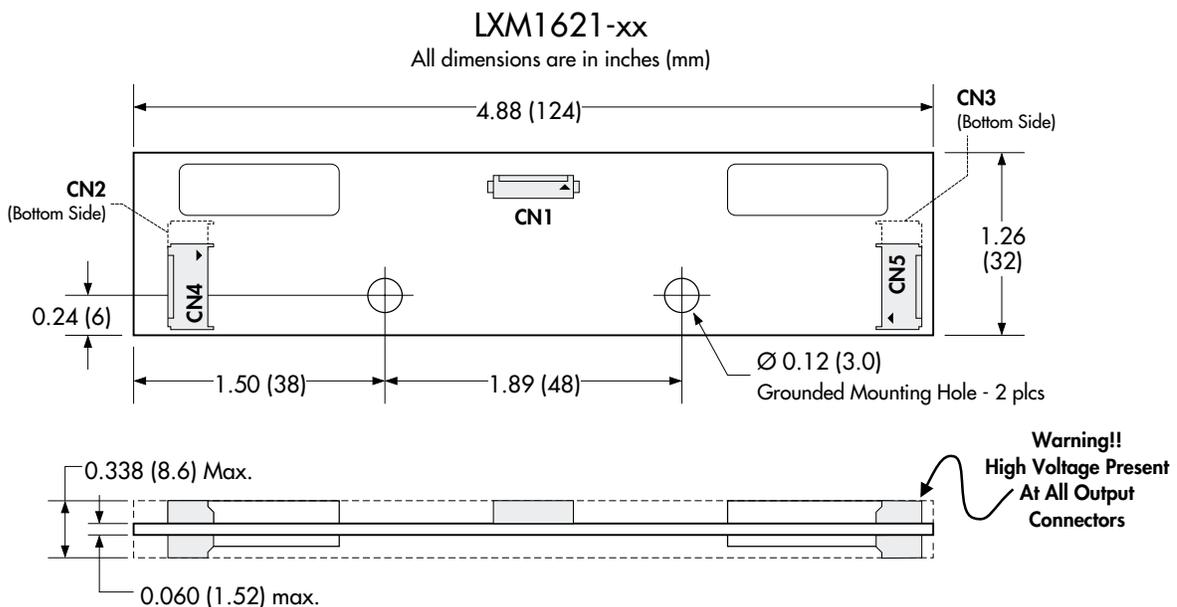
## D IGITAL  D IMMING  D UAL  L AMP  **CCFL** I NVERTER  M ODULE

### P RELIMINARY  D ATA  S HEET

### TYPICAL CONNECTION CONFIGURATIONS
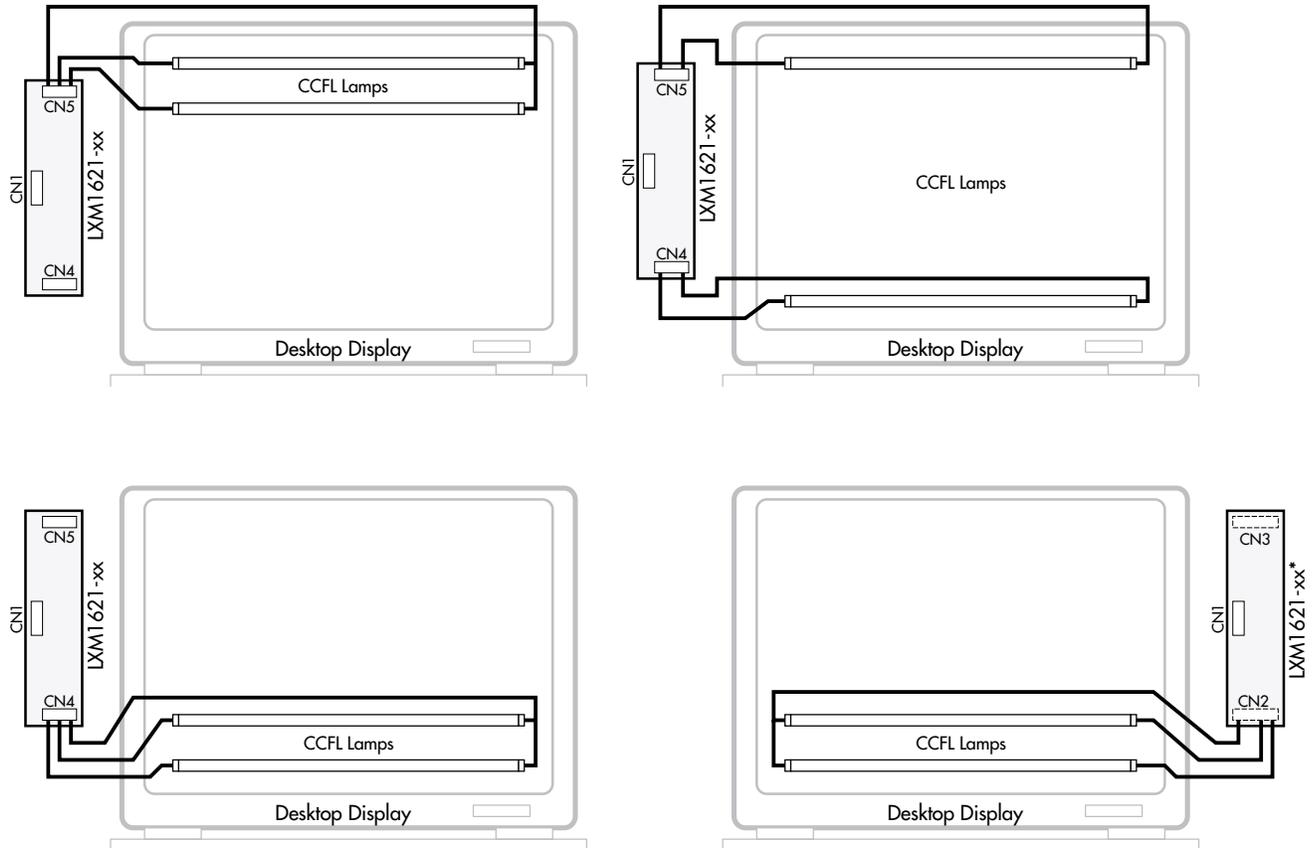


\* Connectors CN2 and CN3 are on the bottom side of the inverter. View shown is looking through the board.

**FIGURE 1**  —  Connectivity Configuration Examples

These examples illustrate four typical LCD wiring configurations that are accomodated by Linfinity's unique connector array. Linfinity inverters have multiple lamp connector styles that are common to the industry, which are duplicated at both ends of the module.  This permits over 12 variations of module mounting and interconnectivity configurations.

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### P R E L I M I N A R Y   D A T A   S H E E T

## CONNECTOR SCHEMATIC
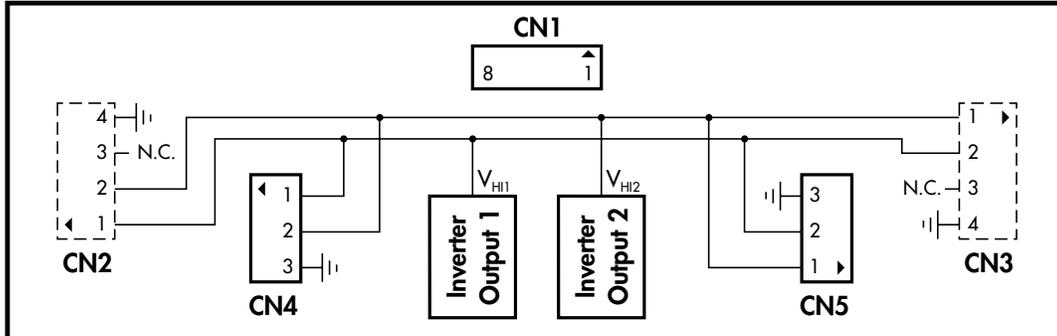


**FIGURE 2** — LXM1621-xx Connector Schematic

Note: CN2 and CN3 (shown with dashed lines) are located on the opposite side of the PCB from CN1, CN4 and CN5. Their pin numbers are shown as viewed looking through the printed circuit board.

**Connectors:**
**CN1** = MOLEX 53261-0890

**Mates With:**
Pins: 50079-8100*,   Housing: 51021-0800
* Loose (-8000, Chain) Recommended #26 AWG wiring

**CN2, CN3** = JST SM04(4.0)B-BHS-1-TB      JST BHR-04VS-1

**CN4, CN5** = JST SM03(4.0)B-BHS-1-TB      JST BHR-03VS-1

**Connection Rules**

1. Always install two (2) lamps. Operating with only one lamp may overdrive lamp current at maximum brightness settings.

2. Verify lamp wiring before connecting lamps to the inverter module. Connecting both lamps to one of the two inverter output circuits will result in reduced brightness. The LXM1621-xx module connectors are wired per industry standard. The lamp **hot** wires (high voltage wires) are always on pin 1 or 2, and the **cold** wire (low voltage wire) is always on pin 3 or 4.

## FAILSAFE FEATURE FOR MULTIPLE LAMP OPERATIONS

Our multi-output inverters are designed to keep your application operating at near normal brightness in the event that a lamp fails. This allows the display to remain "on-line" until lamp replacement is convenient.

Linfinity "pairs" the lamps so that if one lamp in the pair breaks, most of its current is added to the good lamp. CCFLs will respond with more brightness for a period of time. Operating time in this mode will be a function of the lamps age but should be typically in the order of hundreds of hours.

This operating characteristic can provide adequate display performance for a limited, but useful period of time. Shortening of the lamp life in this mode is typically not a concern as it is recommended that <u>all</u> <u>lamps</u> in a display be replaced at the same time.
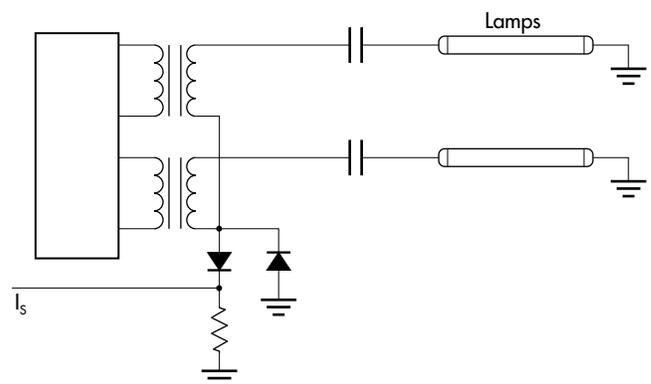


**FIGURE 3** — Dual Output Stage

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## HOW RANGEMAX WORKS

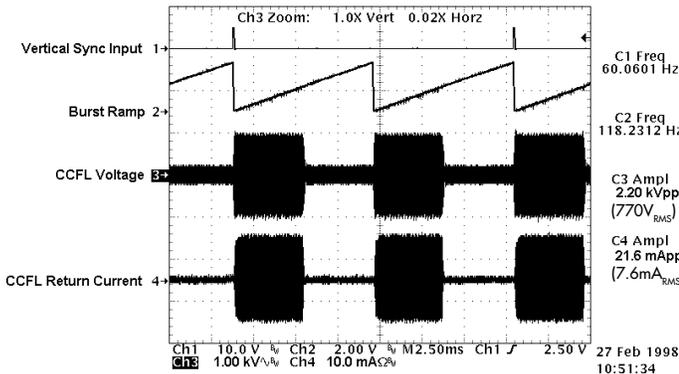### LAMP VOLTAGE & LAMP CURRENT — Burst Mode Operation
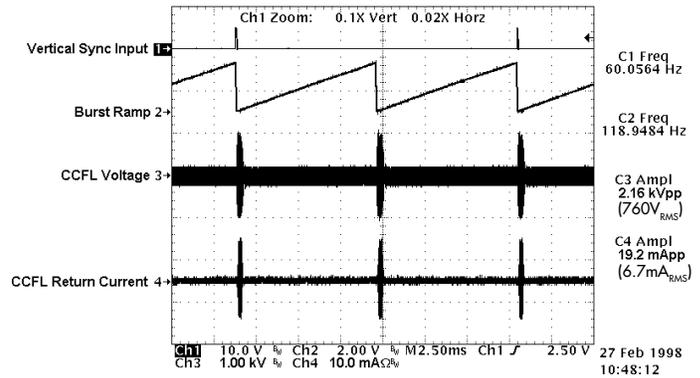


**FIGURE 4** — 50% Burst Duty Cycle



**FIGURE 5** — 2% Burst Duty Cycle

Rather than using the traditional dimming technique of varying lamp current magnitude to adjust light output, RangeMAX inverters use a fixed lamp current value with a duty cycle control method.

The lamp current burst width can be modulated from 100% (continuous lamp current) down to a 2% duty cycle, allowing the lamp to be dimmed to less than 1% of its full brightness.

As can be seen in Trace 4 of Figure 6, careful design consideration was given to controlling lamp start voltage to softly start current flow. This eliminates current over-shoot that can result in premature cathode wear and re-duce lamp life.
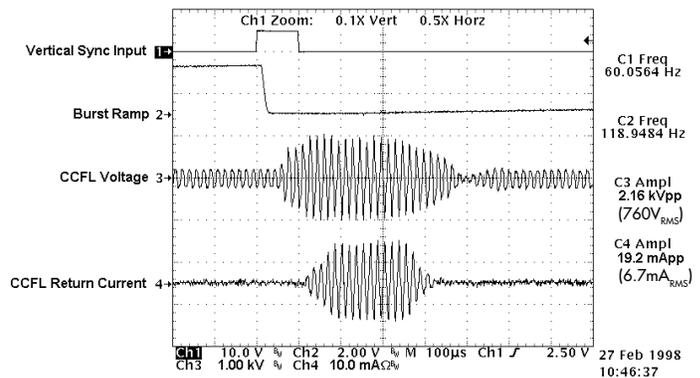


**FIGURE 6** — 2% Burst Duty Cycle (Expanded Time Base)
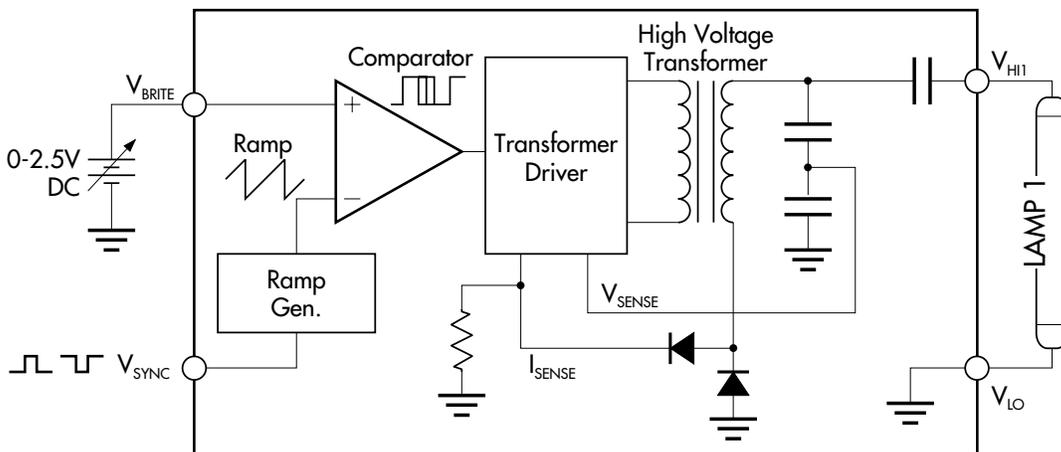


**FIGURE 7** — RangeMAX Block Diagram

## HOW RANGEMAX WORKS (continued)

### HIGHLIGHTS

■ On-board brightness control circuit includes a DC voltage to pulse width converter that minimizes system design work and system noise susceptibility. This provides a familiar and convenient interface while reducing the potential for externally induced noise which can cause lamp flicker.

■ An on-board oscillator operates the inverter BURST rate above 95Hz, well beyond standard 50/60Hz video refresh rates where the eye can perceive pulsing light.

■ RangeMAX inverter modules are designed to operate with the burst frequency synchronized to the video frame rate. This provides operation with no visible display disturbances caused by beat frequencies between the lamps and video frame rates.

■ In applications with no access to a vertical sync, the inverter burst frequency can be allowed to "free run" at 95Hz. In this non-synchronous mode, minor display disturbances may be found under certain video conditions. This performance is acceptable for many applications, but synchronization must be used when no disturbance can be tolerated.

■ Separate feedback loops for lamp current and open circuit voltage regulation insure reliable strike under all operating conditions, automatic over-voltage prevention with broken or failed lamps, and accurate lamp current regulation.
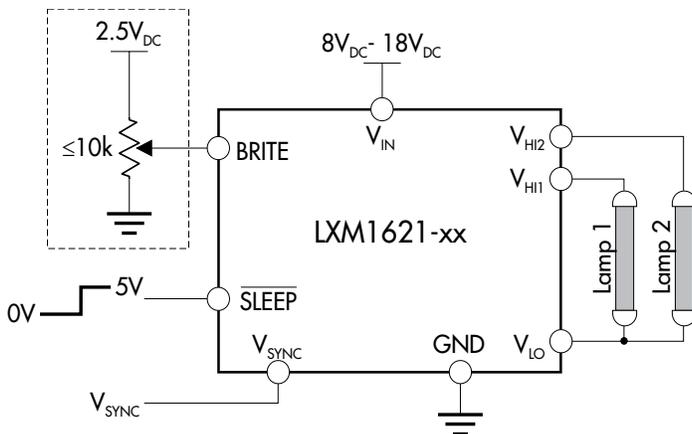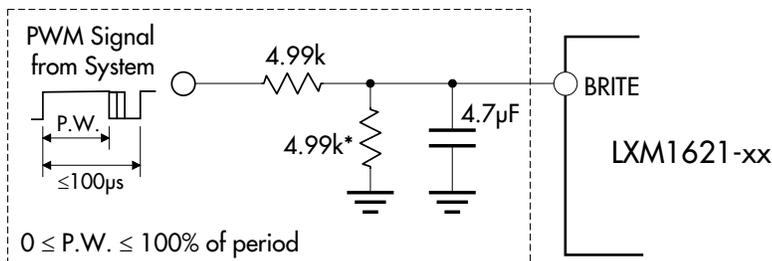
## TYPICAL 100:1 DIMMING APPLICATION



**FIGURE 8** — Potentiometer Brightness Control



* use 4.99k for 5V PWM amplitude, 15k for 3.3V PWM amplitude, and omit for 2.5V PWM amplitude.

**FIGURE 8A** — PWM Brightness Control

■ The brightness control may be a simple 10k potentiometer or a voltage output DAC. A PWM signal from a micro-controller may also be used with a suitable filter such as shown in Figure 8A.

■ If synchronization to the video framerate is desired, connect the vertical sync pulse from the system video controller to the appropriate $V_{SYNC}$ input. If no video synchronization is desired, connect $V_{SYNC}$ to ground.

■ If you need to turn the inverter ON/OFF remotely, connect a 3V or 5V logic signal to the $\overline{SLEEP}$ input. If remote ON/OFF is not needed, connect the $\overline{SLEEP}$ input to $V_{IN}$ or any other voltage greater than $2.2V_{DC}$.

■ Connect $V_{HI}$ to high voltage wire from the lamp. Connect $V_{LO}$ to the low voltage wire (wire with thinner insulation). If both lamp wires have heavy high voltage insulation, connect the longest wire to $V_{LO}$. $V_{LO}$ is connected directly to ground (GND pin) on the inverter PCB. Always insure a good lamp return by using a wire. Do not rely on a chassis ground connection.

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## 1000:1 DIMMING APPLICATION

The following application defines techniques capable of delivering dimming ranges in the 250:1 and 1000:1 range. As is widely understood, these techniques will provide general capabilities and actual system performance will vary with panel design, CCFTs, ambient temperature and a number of other variables outside the control of the inverter. These methods can be used in conjunction with other techniques such as lamp heating and matching.

Wide ratio (1000:1) dimming can be accomplished using the Linfinity inverter in two ways:

1) By varying the input voltage on the brightness pin as indicated in Figure 9. Caution must be exercised when applying negative voltage to the brightness control input. Applying more than -300mV to any inverter input will cause inverter malfunction (see Absolute Maximum Ratings).

2) By making a resistor value change on the module. If this option is preferrable, please contact the factory for application assistance.

Both methods discussed will provide a lower duty cycle operation than is necessary in a 100:1 dimming application.

Careful consideration should be made with regards to display quality at these dimming levels. At very low brightness levels, even very small amounts of noise on the $V_{BRITE}$ line can cause flicker on the display, so special care must be given to grounding, filtering and shielding the inverter from the digital logic and clock.
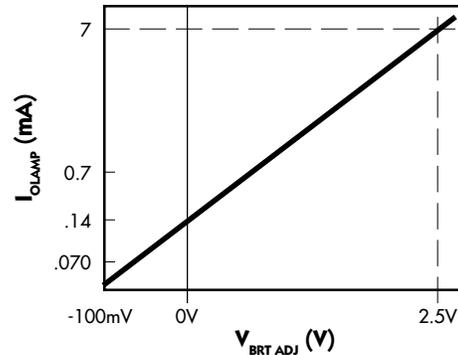


**FIGURE 9** — Average Lamp Current vs. $V_{BRITE}$ Voltage (per Lamp)

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### RangeMAX INVERTERS

Also available in Single Output **LXM1611-01**, **LXM1612-xx** or Quad Output **LXM1641-01** versions for multiple lamp applications.

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