

16-String High Efficiency LED Drivers for LCD TVs with Advanced Dimming Modes

Datasheet Brief



Features:

- · 12-Bit PWM String Dimming
- Forward, Center, Reverse and Inverse PWM Modes
- Fast 20MHz SPI Supports Up to 8 Devices per Bus
- 8-Bit Adaptive Power Correction Maximizes Efficiency for Up to 3 String Power Supplies
- External Current Regulation MOSFETs for High Voltage and/or Current
- Drives Up to 16 Parallel LED Strings Per Device, Cascade Additional Devices for More Strings
- Supports Adaptive, Real-Time Area Dimming for Highest Dynamic Range in LCD TVs and Monitors
- Easily Implements Scrolling, 3D, and Local Dimming Algorithms
- Programmable String Phase Reduces Motion Blur and Improves Efficiency
- Global Intensity Control via SPI Serial Interface
- 0.8% String to String Matching
- PWM Dimming Synchronized to VSYNC and HSYNC Including Frequency Multipliers and Dividers
- Second Set of PWM Registers Select Alternate Brightness and Timing
- Configurable Power-up Defaults Through Internal EEPROM
- LED Open Circuit and Short Circuit Fault Detection
- · Individual Fault Detection Enabled for Each String
- Over-Temperature Shutdown Protection
- Broadcast Write Simplifies Configuration
- -40°C To +85°C Operating Temperature Range

Atmel LED Drivers MSL2164 / MSL2166

16-String High-Efficiency LED Drivers for LCD TVs with Advanced Dimming Modes

The MSL2164/MSL2166 compact, high-power LED string drivers use external current control MOSFETs to sink up to 350mA per string, with matching better than $\pm 0.8\%$. The MSL2164/MSL2166 drive 16 parallel strings of LEDs and offer fault detection and management of open-circuit and short-circuit LEDs.

The MSL2164/MSL2166 feature a 20MHz SPI serial interface. Both devices support video frame-by-frame LED string intensity control for up to eight interconnected devices, allowing active area dimming and phase-shifted PWM outputs. They also include an advanced PWM engine that synchronizes PWM dimming to the video signal supporting forward, center, reverse and inverse PWM modes for reduced motion blur and waterfall noise.

The MSL2164/MSL2166 adaptively control any topology DC-DC or AC/DC converter that power the LED strings. The patent-pending "Efficiency Optimizers" minimize power use while maintaining LED current accuracy.

A unique combination of LED current control and pulse width dimming management offers simple full-screen brightness control, versatile area dimming and a consistent white point. Full-scale LED regulation current is set for each string using current sense resistors and a 10-bit register that controls global string current. The 12-bit global intensity register controls PWM dimming of all strings, and each string uses a 12-bit register to control individual string PWM dimming.

The MSL2164/MSL2166 monitor the LED strings for open-circuit, short-circuit, loss-of-sync and over-temperature faults, and provide a hardware fault output (FLTB) to notify the microcontroller. Detailed fault status and control are available through the serial interface. Additionally, the MSL2164/MSL2166 include on-chip EEPROMs that allow customizing of the register power-up states via the serial interface.

The MSL2164/MSL2166 are offered in a 9 x 9 x 0.85mm, 64-pin TQFN package and operate over the -40 $^{\circ}$ C to 85 $^{\circ}$ C temperature range.

Applications:

Long-Life, Efficient LED Backlighting for:

- · Televisions and Desktop Monitors
- · Medical and Industrial Instrumentation
- · Automotive Audio-visual Displays

Channel Signs

Architectural Lighting

Ordering Information:

16-CHANNEL LED STRING DRIVERS							
PART	INTERFACE	PACKAGE					
MSL2164	3 FB0	64 pin, 9 x 9 x 0.85mm TQFN					
MSL2166	2 FBO + 1 FBI	64 pin, 9 x 9 x 0.85mm TQFN					

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Application Circuit

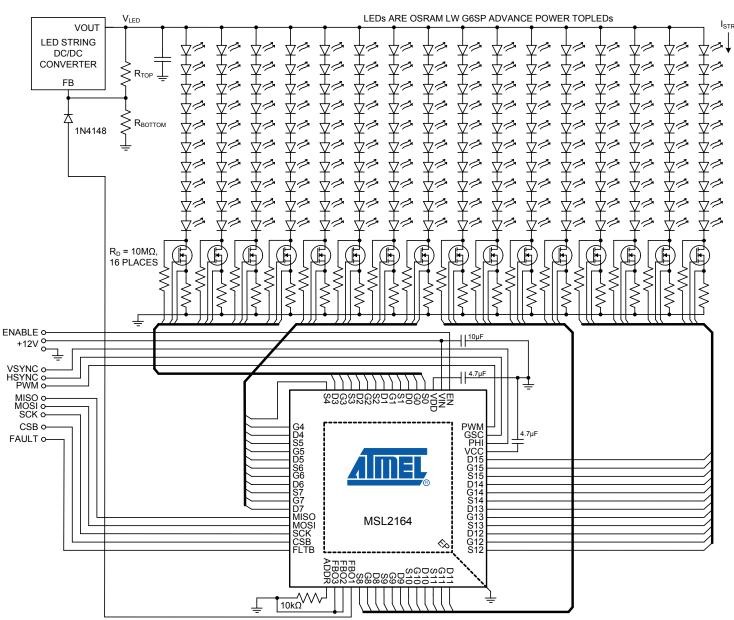


FIGURE 1. Typical Application Circuit



Detailed Description

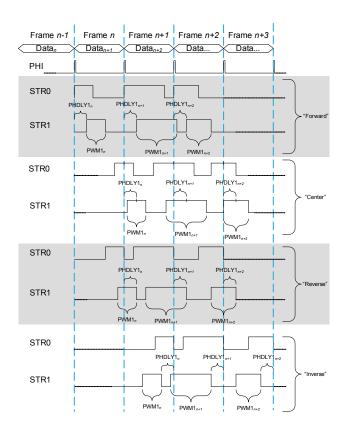
The MSL2164 and MSL2166 are highly integrated, flexible, 16-string LED drivers that use external MOSFETs to allow high LED string currents and/or voltage. They include power supply control to maximize efficiency and an advanced PWM dimming control circuit for regional dimming and 3D LED backlights. The drivers optionally connect to a video subsystem to offer a simple architecture for use in LCD TV backlight applications. Up to eight devices easily connect together to drive large numbers of LED strings in a system. The drivers provide multiple methods of controlling LED brightness, through both LED regulation current control and through PWM dimming. Set the LED current to control color and use pulse width control for brightness management and motion blur reduction. An on-chip EEPROM stores all the default control register values, which are applied at start-up and reconfigured through the serial data interface.

The MSL2164/MSL2166 interface to a microcontroller or FPGA via SPI. The 20MHz bus addressable SPI interface supports up to eight devices per Chip Select line. LED PWM dimming is internally generated and synchronized to the video VSYNC and HSYNC signals or directly controlled by an external PWM drive signal applied to the PWM input. They also feature phase spreading when external PWM dimming, with a progressive 1/16 phase delay per string to reduce LED power supply transient load and reduce power supply input capacitor size.

PWM dimming is either synchronized to an external signal applied to PHI, generated from the internal oscillator for stand-alone applications or set directly by a signal at the PWM input. For video systems, derive the PHI signal from VSYNC. A 1x to 32x frequency multiplier processes PHI for PWM dimming at multiples of the video frame rate. Individually program each string's "on" time with up to 12-bit resolution when using the integrated PWM generator. The final PWM dimming resolution depends upon the ratio of the processed GSC to processed PHI frequencies, because the "on" time is an integer number of GSC clock cycles between 0 and 4095, and is scaled by the value of the 12-bit global intensity register. Phase delay is also an integer number of processed GSC clock cycles, to synchronize timing to the video frame. An on-chip frequency multiplier is provided in order to fully utilize the 12-bit dimming range. The "on" time count can be further scaled by a 12-bit global intensity value.

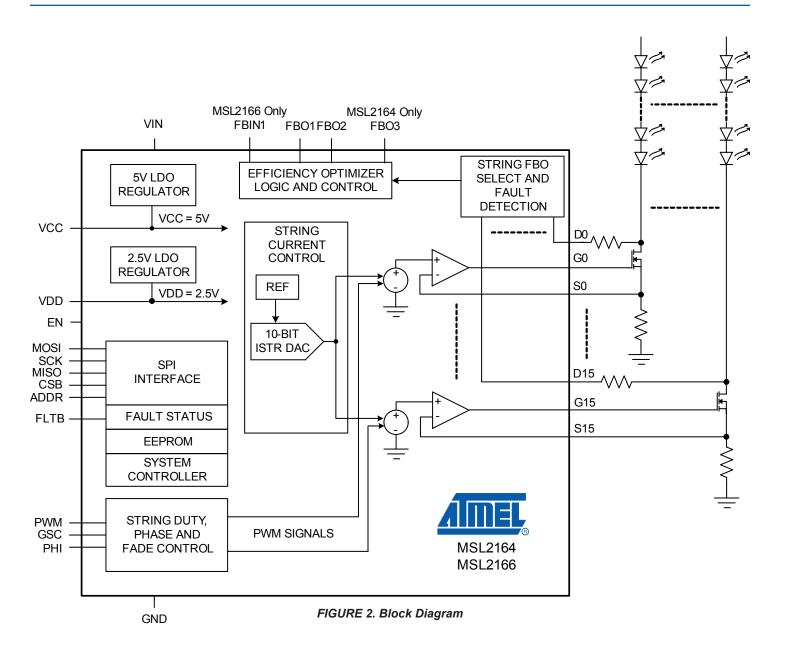
The processed GSC signal (the signal after being frequency multiplied or divided, from either internally or externally generated signal at GSC) precisely sets each string's phase delay so that it is synchronized to its physical position on the LCD panel, relative to the beginning, middle or end of the video frame. There are four different types of PWM modulation modes, each defined by the part of the "on" time or off-time set by the PHDLYn[11:0] register (part of the STRnSET register). The modes are "forward," "center,"

"reverse," and "inverse". All four modes use the PHDLYn register to set the defined edge, and PWMn[11:0] to set the "on" time as a number of processed GSC pulses. The four different modes and register definitions are illustrated in the figure below, showing the current waveforms. The delay for string 0 is held at 0, and the PWM width is the same for both strings and all the modes. Datan in the figure refers to both the dimming data and the phase delay data presented for the *n*th frame. For "forward" mode PHDLY*n* specifies the number of processed GSC cycles after the processed PHI edge that the string "on" time begins and the PWMn register specifies the "on" time. In this mode the falling edge varies with the "on" time width programmed in the PWMn register, with the rising edge held constant. In "center" mode, the delay is set from the processed PHI edge to the center of the PWM on pulse with width set by the PWMn register. Both the rising and falling edge vary based on the PWMn with the center held constant within a processed GSC cycle. In "reverse" mode, the PHDLYn sets the delay from the next frame's processed PHI edge to the falling edge of the PWM "on" time and the PWMn register determines the PWM "on" time. Therefore the rising edge varies with PWMn and the falling edge is held constant. In "inverse" mode, the delay is set from the next frames PHI edge backwards to the falling edge of the "on" time. The rising edge varies with the PWMn register, while the falling edge is held constant.



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Block Diagram





Package / Pin Out

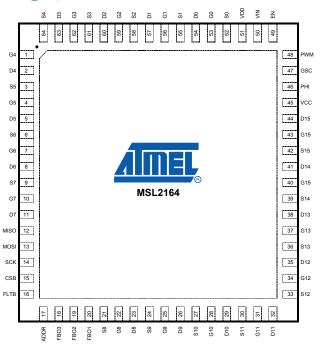


FIGURE 3: Pinning 64-Pin TQFN MSL2164 (9 x 9mm)

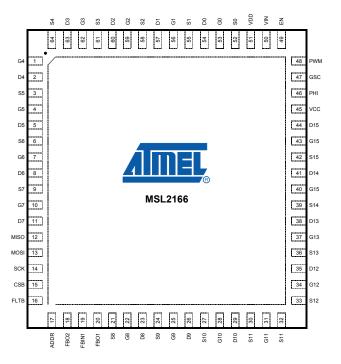


FIGURE 4: Pinning 64-Pin TQFN MSL2166 (9 x 9mm)

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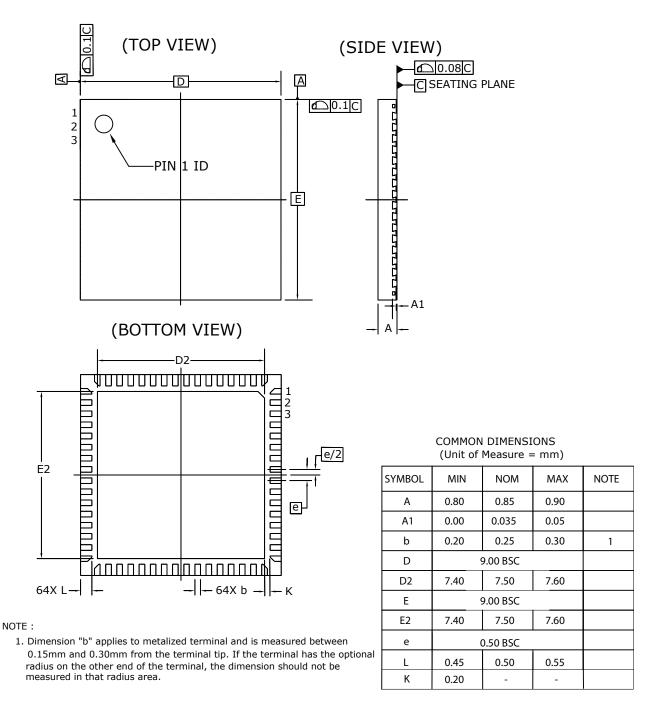


FIGURE 5. Package Dimensions: 64-pin, 9mm x 9mm x 0.85mm TQFN (0.5mm pin pitch) with Exposed Pad.



Package Connection Description

Full scale LED current is reached when 500mV is across the current sense resistor. If unused, connect S10 to ground. Gate Output 10: External MOSFET Gate Drive Output for LED string 10. Connect G10 to the gate of the external MOSFET driving LED string 10. If unused, leave G10 unconnected. Drain Sense Input 10: External MOSFET Drain Sense Input for LED string 10. Connect D10 through a 10MΩ resistor to the drain of the external MOSFET driving LED string 10. If unused, connect D10 to ground. Source Sense Input 11: Source and Current Sense Input for LED string 11. Connect S11 to the source of the external MOSFET and to the current sense resistor for LED string 11. The full scale LED current is reached when 500mV is across the current sense resistor. If unused, connect S119 to ground. Gate Output 11: External MOSFET Gate Drive Output for LED string 11. Connect G11 to the gate of the external MOSFET driving LED string 11. If unused, leave G11 unconnected. Drain Sense Input 11: External MOSFET Drain Sense Input for LED string 11. Connect D11 through a 10MΩ resistor to the drain of the external MOSFET driving LED string 11. If unused, connect D11 to ground. Source Sense Input 12: Source and Current Sense Input for LED string 12. Connect S12 to the source of the external MOSFET and to the current sense resistor for LED string 12. The full scale LED current is reached when 500mV is across the current sense resistor. If unused, connect S12 to ground. Source Sense Input 19: External MOSFET Drain Sense Input for LED string 10. Connect S10 to the source of the external MOSFET and to the current sense resistor for LED string 12. The full scale LED current is reached when 500mV is across the current sense resistor. If unused, connect S12 to ground. Source Sense Input 10: Source and Current Sense Input for LED string 10. Connect S10 to the source of the external MOSFET driving LED string 9. If unused, connect D9 to ground. Source Sense Input 10: Source and Current Sense Input for LED string 10. Connect S10 to the sour	PIN#	MSL2166	MSL2164	PIN DESCRIPTION
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10 MSO	10	G7	G7	Gate Output 7: External MOSFET Gate Drive Output for LED string 7. Connect G7 to the gate of the external MOSFET driving LED string 7. If unused, leave G7 unconnected.
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SCX SCX BCX BCX BCX BCX BCX BCX BCX BCX BCX B	12	MISO	MISO	Master Input Slave Output: MISO is the MSL2164/MSL2166 (slave) SPI serial data output and the master data input. Connect MISO to the SPI master data input
CSB CSB CNp Select Barr CSB is the SR Interface drip select input. Drine CSB ton to enable SPI transactions. FILTB Fault Indication Output (Cypen Dran, Active Low). Open drian output FLTB sinks current to ROV interneer a fault is detected, FLTB remains low until the fault registers are read, and reassent in this elast pessible. FIRDB ADDR ADDR Stown D Selection Inputs: Connect ADDR to ROV through a resistor to set the serial interface address. FIRDB C - Efficiency Optimizer Output 3: Connect FRO3 to the third power supply's feetback node. FIRDB C - Efficiency Optimizer Output 3: Connect FRO3 to the third power supply's feetback node. FIRDB FRO1 Fro	13	MOSI	MOSI	Master Output Slave Input: MOSI is the MSL2164/MSL2166 (slave) SPI serial data input and the master data output. Connect MOSI to the SPI master data output.
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ADDR ADDR ADDR Stave ID Selection Injusts: Connect ADDR to GND through a resistor to set the serial interface address. FB02	15	CSB	CSB	
FB02 - Efficiency Optimizer Output 3: Connect FB03 to the third power supply's feedback node. FB04 - FB05 - Efficiency Optimizer Output 2: Connect FB07 to the second power supply's feedback node. FB05 - FB06 - FB07 - FB07 - Efficiency Optimizer Output 2: Connect FB07 to the second power supply's feedback node. FB07 - FB07 - FB07 - Efficiency Optimizer Input 1: Connect FB01 to fB07 to fthe next device when chaining devices (Figure 8-5). If unused connect FB11 to ground. FB07 -				reasserts if the fault persists.
FB02 FG02 FG03 FG03 FG03 FG03 FG03 FG03 FG03 FG03	17	ADDR		· · · · · · · · · · · · · · · · · · ·
FBN1 - FB02 Efficiency Optimizer Output 2: Connect FB02 to the second power supply's feedback node. FBN1 - FB01 FB01 FB01 FB01 FB01 FB01 FB01 or the rext device when chaining devices (Figure 8-5). If unused connect FB1 to ground. Efficiency Optimizer Output 1: Connect FB01 to the rext device when chaining devices (Figure 8-5). If unused connect FB1 to ground. Efficiency Optimizer Output 1: Connect FB01 to the rext device when FB00 to the rest power supply's feedback node. Source Sense Input 8: Source and Current Sense Input for LED string 8. Connect SB1 to the source of the external MOSFET and to the current sense resistor for LED string 8. The full scale LED current is reached when FB00 the Insurance of Led to the gate of the external MOSFET data of the current sense resistor for LED string 8. The full scale LED current is reached when FB00 the Sense Input for LED string 9. Connect SB1 to the source of the external MOSFET driving LED string 8. If unused, connect SB1 to ground. Source Sense Input 8: Source and Current Sense Input for LED string 9. Connect SB1 to the source of the external MOSFET driving LED string 9. The full scale LED current is reached when FB00 the Current sense resistor if unused, connect SB1 to ground. Source Sense Input 9: Source and Current Sense Input for LED string 9. Connect SB1 to the source of the external MOSFET driving LED string 9. The full scale LED current is reached when FB00 to LED string 9. Connect SB1 to the source of the external MOSFET driving LED string 9. If unused, connect SB1 to ground. Source Sense Input 9: Source and Current Sense Input for LED string 9. Connect SB1 to the source of the external MOSFET driving LED string 9. If unused, connect SB1 to ground. Source Sense Input 9: Source and Current Sense Input for LED string 9. Connect SB1 to the source of the external MOSFET driving LED string 9. If unused, connect SB1 to ground. Source Sense Input 10: Source and Current Sense Input for LED string 10. Connect SB1 to the source of the external MOSFET driving	18	-		
FBINI - Efficiency Optimizer Input 1: Connect FBI to FBO1 of the next device when chaining devices (Figure 8-5). If unused connect FBI to ground. FBO1 FBO1 FBO1 FBO1 Efficiency Optimizer Output 1: Connect FBI to the first power supply's feedback node. Source Sense Input 8: Source and Current Sense Input for IED string 8. Connect SB to the source of the external MOSFET and to the current sense resistor for LED string 8. The full scale LED current is reached when 500m/v is across the current sense resistor. If unused, connect SB to ground. BB DB DWan Sense Input 8: External MOSFET Drain Sense Input for LED string 8. Connect CB to the spat or the external MOSFET and to the current sense resistor for LED string 9. The full scale LED current is reached when 500m/v is across the current sense resistor. If unused, connect SB to ground. Source Sense Input 9: External MOSFET Drain Sense Input for LED string 9. Connect SB to the source of the external MOSFET and to the current sense resistor for LED string 9. The full scale LED current is reached when 500m/v is across the current sense resistor. If unused, connect SB to ground. Source Sense Input 9: External MOSFET Drain Sense Input for LED string 9. Connect SB to the source of the external MOSFET and to the current sense resistor for LED string 9. The full scale LED current is reached when 500m/v is across the current sense resistor. If unused, connect SB to ground. BB DB D		FBU2		
FB01 FB01 FB01 Efficiency Optimizer Output 1 : Connect FB01 to the first power supply's feedback node. Source Sense Input 8 : Source and Current Sense Input for LED string 8. Connect SB to ground. GB GB GB Output 8 : External MOSFET Gate Drive Output for LED string 8. Connect SB to ground. BB DB Day Day Sense Input 8 : External MOSFET Gate Drive Output for LED string 8. Connect GB to the gate of the external MOSFET driving LED string 8. If unused, leave GB unconnected. Connect DB to ground. Connect DB to ground. GB GB Output 8 : External MOSFET Gate Drive Output for LED string 8. Connect GB to the gate of the external MOSFET driving LED string 8. If unused, connect DB to ground. Connect DB to ground. Connect DB to ground. GB GB Output 9 : External MOSFET Gate Drive Output for LED string 9. Connect GB to the gate of the external MOSFET and to the current sense resistor for LED string 9. The full scale LED current is reached when SOOM's across the current sense resistor. If unused, connect SB to ground. Connect DB to ground. Connect	19	- EDINI1		
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D9 Drain Serse Input 9: External MOSFET Drain Sense Input for LED string 9. Connect D9 through a 10MΩ resistor to the drain of the external MOSFET driving LED string 9. If unused, connect D9 to ground. Source Sense Input 10: Source and Current Sense Input for LED string 10. Connect S10 to the source of the external MOSFET and to the current sense resistor for LED string 10. The full scale LED current is reached when 500mV is across the current sense resistor. If unused, connect S10 to ground. B10 G10 Gate Output 10: External MOSFET Gate Drive Output for LED string 10. Connect G10 to the gate of the external MOSFET driving LED string 10. If unused, leave G10 unconnected. D10 Drain Sense Input 10: External MOSFET Drain Sense Input for LED string 10. Connect D10 through a 10MΩ resistor to the drain of the external MOSFET driving LED string 10. If unused, connect D10 to ground. S11 S11 S11 Source Sense Input 11: Source and Current Sense Input for LED string 11. Connect S11 to the source of the external MOSFET and to the current sense resistor for LED string 11. The full scale LED current is reached when 500mV is across the current sense resistor. If unused, connect S119 to ground. S12 D11 D11 Drain Sense Input 11: External MOSFET Drain Sense Input for LED string 11. Connect G11 to the gate of the external MOSFET driving LED string 11. If unused, leave G11 unconnected. D10 Drain Sense Input 11: External MOSFET Drain Sense Input for LED string 11. Connect G11 to the gate of the external MOSFET driving LED string 11. If unused, connect D11 to ground. S12 S12 Source Sense Input 12: Source and Current Sense Input for LED string 12. Connect S12 to the source of the external MOSFET and to the current sense resistor for LED string 12. The full scale LED current is reached when 500mV is across the current sense resistor. If unused, connect S12 to ground. S13 S10 S10 Source Sense Input 10: Source and Current Sense Input for LED string 10. Connect S10 to the source of the external MOSFET and to the current sense resi	24	S9	S9	
27 S10 S10 Source Sense Input 10: Source and Current Sense Input for LED string 10. Connect S10 to the source of the external MOSFET and to the current sense resistor for LED string 10. The full scale LED current is reached when 500mV is across the current sense resistor. If unused, connect S10 to ground. 28 G10 G10 Gate Output 10: External MOSFET Gate Drive Output for LED string 10. Connect G10 to the gate of the external MOSFET driving LED string 10. If unused, connect S10 to ground. 29 D10 D10 Drain Sense Input 10: External MOSFET Drain Sense Input for LED string 10. Connect D10 through a 10MΩ resistor to the drain of the external MOSFET driving LED string 10. If unused, connect D10 to ground. 30 S11 S11 S11 Source sense Input 11: Source and Current Sense Input for LED string 11. Connect S11 to the source of the external MOSFET and to the current sense resistor for LED string 11. The full scale LED current is reached when 500mV is across the current sense resistor. If unused, connect S119 to ground. 31 G11 G11 Gate Output 11: External MOSFET Gate Drive Output for LED string 11. Connect G11 to the gate of the external MOSFET driving LED string 11. If unused, leave G11 unconnected. 32 D11 D11 D11 Drain Sense Input 11: External MOSFET Drain Sense Input for LED string 11. Connect D11 through a 10MΩ resistor to the drain of the external MOSFET driving LED string 11. If unused, connect D11 to ground. 33 S12 S12 S12 Source Sense Input 12: Source and Current Sense Input for LED string 12. Connect S12 to the source of the external MOSFET and to the current sense resistor for LED string 12. The full scale LED current is reached when 500mV is across the current sense resistor. If unused, connect S12 to ground. 26 D9 D9 D9 Carrent Sense Input 10: Source and Current Sense Input for LED string 10. Connect D10 through a 10MΩ resistor to the drain of the external MOSFET driving LED string 10. The full scale LED current Sense Input 10: Source and Current Sense Input for LED string 10. Connect S10 to the source of the	25	G9	G9	Gate Output 9: External MOSFET Gate Drive Output for LED string 9. Connect G9 to the gate of the external MOSFET driving LED string 9. If unused, leave G9 unconnected.
S10 S10 S10 full scale LED current is reached when 500mV is across the current sense resistor. If unused, connect S10 to ground. Gate Output 10: External MOSFET Gate Drive Output for LED string 10. Connect G10 to the gate of the external MOSFET driving LED string 10. If unused, leave G10 unconnected. D10 Drain Sense Input 10: External MOSFET Drain Sense Input for LED string 10. Connect D10 through a 10MΩ resistor to the drain of the external MOSFET driving LED string 10. If unused, connect D10 to ground. S11 S11 Source Sense Input 11: Source and Current Sense Input for LED string 11. Connect S11 to the source of the external MOSFET and to the current sense resistor for LED string 11. The full scale LED current is reached when 500mV is across the current sense resistor. If unused, connect S119 to ground. Gate Output 11: External MOSFET Gate Drive Output for LED string 11. Connect G11 to the gate of the external MOSFET driving LED string 11. If unused, leave G11 unconnected. D11 Drain Sense Input 11: External MOSFET Drain Sense Input for LED string 11. Connect D11 through a 10MΩ resistor to the drain of the external MOSFET driving LED string 11. If unused, connect D11 to ground. S12 S12 Source Sense Input 12: Source and Current Sense Input for LED string 12. Connect S12 to the source of the external MOSFET and to the current sense resistor for LED string 12. The full scale LED current is reached when 500mV is across the current sense resistor. If unused, connect S12 to ground. D13 S10 S00 S00 S00 S00 S00 S00 S00 S00 S00	26	D9	D9	
Drain Sense Input 10: External MOSFET Drain Sense Input for LED string 10. Connect D10 through a 10MΩ resistor to the drain of the external MOSFET driving LED string 10. If unused, connect D10 to ground. Source Sense Input 11: Source and Current Sense Input for LED string 11. Connect S11 to the source of the external MOSFET and to the current sense resistor for LED string 11. The full scale LED current is reached when 500mV is across the current sense resistor. If unused, connect S119 to ground. Source Sense Input 11: External MOSFET Gate Drive Output for LED string 11. Connect G11 to the gate of the external MOSFET driving LED string 11. If unused, leave G11 unconnected. Drain Sense Input 11: External MOSFET Drain Sense Input for LED string 11. Connect D11 through a 10MΩ resistor to the drain of the external MOSFET driving LED string 11. If unused, connect D11 to ground. Source Sense Input 12: Source and Current Sense Input for LED string 12. Connect S12 to the source of the external MOSFET and to the current sense resistor for LED string 12. The full scale LED current is reached when 500mV is across the current sense resistor. If unused, connect S12 to ground. Source Sense Input 19: External MOSFET Drain Sense Input for LED string 9. Connect D9 through a 10MΩ resistor to the drain of the external MOSFET driving LED string 10. The full scale LED current is reached when 500mV is across the current sense resistor. If unused, connect S12 to ground. Source Sense Input 10: Source and Current Sense Input for LED string 10. Connect S10 to the source of the external MOSFET and to the current sense resistor for LED string 10. The full scale LED current is reached when 500mV is across the current sense resistor. If unused, connect S10 to ground. Source Sense Input 10: External MOSFET Gate Drive Output for LED string 10. Connect S10 to the source of the external MOSFET and to the current sense resistor for LED string 10. The full scale LED current is reached when 500mV is across the current sense resistor. If unu	27	S10	S10	Source Sense Input 10: Source and Current Sense Input for LED string 10. Connect S10 to the source of the external MOSFET and to the current sense resistor for LED string 10. The full scale LED current is reached when 500mV is across the current sense resistor. If unused, connect S10 to ground.
unused, connect D10 to ground. Source Sense Input 11: Source and Current Sense Input for LED string 11. Connect S11 to the source of the external MOSFET and to the current sense resistor for LED string 11. The full scale LED current is reached when 500mV is across the current sense resistor. If unused, connect S119 to ground. Source Sense Input 11: External MOSFET Gate Drive Output for LED string 11. Connect G11 to the gate of the external MOSFET driving LED string 11. If unused, leave G11 unconnected. Drain Sense Input 11: External MOSFET Drain Sense Input for LED string 11. Connect D11 through a 10MΩ resistor to the drain of the external MOSFET driving LED string 11. If unused, connect D11 to ground. Source Sense Input 12: Source and Current Sense Input for LED string 12. Connect S12 to the source of the external MOSFET and to the current sense resistor for LED string 12. The full scale LED current is reached when 500mV is across the current sense resistor. If unused, connect S12 to ground. Source Sense Input 10: Source and Current Sense Input for LED string 9. Connect D9 through a 10MΩ resistor to the drain of the external MOSFET driving LED string 9. If unused, connect D9 to ground. Source Sense Input 10: Source and Current Sense Input for LED string 10. Connect S10 to the source of the external MOSFET and to the current sense resistor for LED string 10. The full scale LED current is reached when 500mV is across the current sense resistor. If unused, connect S10 to ground. Source Sense Input 10: Source and Current Sense Input for LED string 10. Connect G10 to the gate of the external MOSFET driving LED string 10. If unused, leave G10 unconnected. Source Sense Input 10: External MOSFET Drain Sense Input for LED string 10. Connect G10 to the gate of the external MOSFET driving LED string 10. If unused, connect D10 to ground. Source Sense Input 10: External MOSFET Drain Sense Input for LED string 10. Connect G10 to the gate of the external MOSFET driving LED string 10. If unused, connect D10 to groun	28	G10	G10	
S11 S11 full scale LED current is reached when 500mV is across the current sense resistor. If unused, connect S119 to ground. G11 Gate Output 11: External MOSFET Gate Drive Output for LED string 11. Connect G11 to the gate of the external MOSFET driving LED string 11. If unused, leave G11 unconnected. D11 D11 D11 Drain Sense Input 11: External MOSFET Drain Sense Input for LED string 11. Connect D11 through a 10MΩ resistor to the drain of the external MOSFET driving LED string 11. If unused, connect D11 to ground. Source Sense Input 12: Source and Current Sense Input for LED string 12. Connect S12 to the source of the external MOSFET and to the current sense resistor for LED string 12. The full scale LED current is reached when 500mV is across the current sense resistor. If unused, connect S12 to ground. D12 D13 D13 D2 D3	29	D10	D10	
Drain Sense Input 11: External MOSFET Drain Sense Input for LED string 11. Connect D11 through a 10MΩ resistor to the drain of the external MOSFET driving LED string 11. If unused, connect D11 to ground. Source Sense Input 12: Source and Current Sense Input for LED string 12. Connect S12 to the source of the external MOSFET and to the current sense resistor for LED string 12. The full scale LED current is reached when 500mV is across the current sense resistor. If unused, connect S12 to ground. Day D9 D9 D7 Drain Sense Input 9: External MOSFET Drain Sense Input for LED string 9. Connect D9 through a 10MΩ resistor to the drain of the external MOSFET driving LED string 9. If unused, connect D9 to ground. Source Sense Input 10: Source and Current Sense Input for LED string 10. Connect S10 to the source of the external MOSFET and to the current sense resistor for LED string 10. The full scale LED current is reached when 500mV is across the current sense resistor. If unused, connect S10 to ground. Source Sense Input 10: Source and Current Sense Input for LED string 10. Connect S10 to the source of the external MOSFET and to the current sense resistor for LED string 10. The full scale LED current is reached when 500mV is across the current sense resistor. If unused, connect S10 to ground. Source Sense Input 10: External MOSFET Gate Drive Output for LED string 10. Connect G10 to the gate of the external MOSFET driving LED string 10. If unused, connect D10 to ground. D10 D7	30	S11	S11	Source Sense Input 11: Source and Current Sense Input for LED string 11. Connect S11 to the source of the external MOSFET and to the current sense resistor for LED string 11. The full scale LED current is reached when 500mV is across the current sense resistor. If unused, connect S119 to ground.
1 unused, connect D11 to ground. 1 source Sense Input 12: Source and Current Sense Input for LED string 12. Connect S12 to the source of the external MOSFET and to the current sense resistor for LED string 12. The full scale LED current is reached when 500mV is across the current sense resistor. If unused, connect S12 to ground. 2 pure by S10	31	G11	G11	
512 full scale LED current is reached when 500mV is across the current sense resistor. If unused, connect S12 to ground. Drain Sense Input 9: External MOSFET Drain Sense Input for LED string 9. Connect D9 through a 10MΩ resistor to the drain of the external MOSFET driving LED string 9. If unused, connect D9 to ground. Source Sense Input 10: Source and Current Sense Input for LED string 10. Connect S10 to the source of the external MOSFET and to the current sense resistor for LED string 10. The full scale LED current is reached when 500mV is across the current sense resistor. If unused, connect S10 to ground. G10 Gate Output 10: External MOSFET Gate Drive Output for LED string 10. Connect G10 to the gate of the external MOSFET driving LED string 10. If unused, leave G10 unconnected. D10 D10 Drain Sense Input 10: External MOSFET Drain Sense Input for LED string 10. Connect D10 through a 10MΩ resistor to the drain of the external MOSFET driving LED string 10. If unused, connect D10 to ground. Source Sense Input 11: Source and Current Sense Input for LED string 11. Connect S11 to the source of the external MOSFET and to the current sense resistor for LED string 11. The	32	D11	D11	unused, connect D11 to ground.
27 S10 S10 S10 S10 Source Sense Input 10 : Source and Current Sense Input for LED string 10. Connect S10 to the source of the external MOSFET and to the current sense resistor for LED string 10. The full scale LED current is reached when 500mV is across the current sense resistor. If unused, connect S10 to ground. 28 G10 G10 Gate Output 10: External MOSFET Gate Drive Output for LED string 10. Connect G10 to the gate of the external MOSFET driving LED string 10. If unused, leave G10 unconnected. 29 D10 D10 Drain Sense Input 10: External MOSFET Drain Sense Input for LED string 10. Connect D10 through a 10MΩ resistor to the drain of the external MOSFET driving LED string 10. If unused, connect D10 to ground. 30 S11 S11 Source Sense Input 11: Source and Current Sense Input for LED string 11. Connect S11 to the source of the external MOSFET and to the current sense resistor for LED string 11. The	33	S12	S12	full scale LED current is reached when 500mV is across the current sense resistor. If unused, connect S12 to ground.
full scale LED current is reached when 500mV is across the current sense resistor. If unused, connect S10 to ground. G10 Gate Output 10: External MOSFET Gate Drive Output for LED string 10. Connect G10 to the gate of the external MOSFET driving LED string 10. If unused, leave G10 unconnected. D10	26	D9	D9	connect D9 to ground.
D10 Drain Sense Input 10: External MOSFET Drain Sense Input for LED string 10. Connect D10 through a 10MΩ resistor to the drain of the external MOSFET driving LED string 10. If unused, connect D10 to ground. Source Sense Input 11: Source and Current Sense Input for LED string 11. Connect S11 to the source of the external MOSFET and to the current sense resistor for LED string 11. The	27	S10	S10	· · · · · · · · · · · · · · · · · · ·
unused, connect D10 to ground. unused, connect D10 to ground. Source Sense Input 11 : Source and Current Sense Input for LED string 11. Connect S11 to the source of the external MOSFET and to the current sense resistor for LED string 11. The	28	G10	G10	
	29	D10	D10	unused, connect D10 to ground.
	30	S11	S11	Source Sense Input 11: Source and Current Sense Input for LED string 11. Connect S11 to the source of the external MOSFET and to the current sense resistor for LED string 11. The full scale LED current is reached when 500mV is across the current sense resistor. If unused, connect S119 to ground.

16-String High-Efficiency LED Drivers for LCD TVs with Advanced Dimming Modes

PIN#	MSL2166	MSL2164	PIN DESCRIPTION
31	G11	G11	Gate Output 11: External MOSFET Gate Drive Output for LED string 11. Connect G11 to the gate of the external MOSFET driving LED string 11. If unused, leave G11 unconnected.
32	D11	D11	Drain Sense Input 11: External MOSFET Drain Sense Input for LED string 11. Connect D11 through a 10MΩ resistor to the drain of the external MOSFET driving LED string 11. If unused, connect D11 to ground.
33	S12	S12	Source Sense Input 12: Source and Current Sense Input for LED string 12. Connect S12 to the source of the external MOSFET and to the current sense resistor for LED string 12. The full scale LED current is reached when 500mV is across the current sense resistor. If unused, connect S12 to ground.
34	G12	G12	Gate Output 12: External MOSFET Gate Drive Output for LED string 12. Connect G12 to the gate of the external MOSFET driving LED string 12. If unused, leave G12 unconnected.
35	D12	D12	Drain Sense Input 12: External MOSFET Drain Sense Input for LED string 12. Connect D12 through a 10MΩ resistor to the drain of the external MOSFET driving LED string 12. If unused, connect D12 to ground.
36	S13	S13	Source Sense Input 13: Source and Current Sense Input for LED string 13. Connect S13 to the source of the external MOSFET and to the current sense resistor for LED string 13. The full scale LED current is reached when 500mV is across the current sense resistor. If unused, connect S13 to ground.
37	G13	G13	Gate Output 13: External MOSFET Gate Drive Output for LED string 13. Connect G13 to the gate of the external MOSFET driving LED string 13. If unused, leave G13 unconnected.
38	D13	D13	Drain Sense Input 13: External MOSFET Drain Sense Input for LED string 13. Connect D13 through a 10MΩ resistor to the drain of the external MOSFET driving LED string 13. If unused, connect D13 to ground.
39	S14	S14	Source Sense Input 14: Source and Current Sense Input for LED string 14. Connect S14 to the source of the external MOSFET and to the current sense resistor for LED string 14. The full scale LED current is reached when 500mV is across the current sense resistor. If unused, connect S14 to ground.
40	G14	G14	Gate Output 14: External MOSFET Gate Drive Output for LED string 14. Connect G14 to the gate of the external MOSFET driving LED string 14. If unused, leave G14 unconnected.
41	D14	D14	Drain Sense Input 14: External MOSFET Drain Sense Input for LED string 14. Connect D14 through a 10MΩ resistor to the drain of the external MOSFET driving LED string 14. If unused, connect D14 to ground.
42	S15	S15	Source Sense Input 15: Source and Current Sense Input for LED string 15. Connect S15 to the source of the external MOSFET and to the current sense resistor for LED string 15. The full scale LED current is reached when 500mV is across the current sense resistor. If unused, connect S15 to ground.
43	G15	G15	Gate Output 15: External MOSFET Gate Drive Output for LED string 15. Connect G15 to the gate of the external MOSFET driving LED string 15. If unused, leave G15 unconnected.
44	D15	D15	Drain Sense Input 15: External MOSFET Drain Sense Input for LED string 15. Connect D15 through a 10MΩ resistor to the drain of the external MOSFET driving LED string 15. If unused, connect D15 to ground.
45	VCC	VCC	5V internal LDO Regulator Output: VCC is the 5V source that powers internal circuits. Bypass VCC to GND with a 4.7µF or greater ceramic capacitor placed close to the MSL2164/MSL2166.
46	PHI	PHI	Phase Synchronization Input: Drive PHI with an external signal from 40Hz to 10kHz to synchronize the MSL2164/MSL2166's internal PWM dimming to the external signal. In video systems drive PHI with VSYNC.
47	GSC	GSC	Gate Shift Clock Input: Drive GSC with the gate shift clock of the video signal, from the PHI frequency up to 1.5MHz. In video systems drive GSC with HSYNC.
48	PWM	PWM	PWM Input: Pulse-Width modulation control input. Drive PWM with a pulse-width modulated signal with duty cycle ranging from 0% to 100% and frequency up to 5kHz.
49	EN	EN	Enable (On/Off) Control Input: Drive EN high to turn on the MSL2164/MSL2166, drive EN low to turn it off. For automatic startup connect EN to V _{IN} . Driving EN low-to-high turns on the MSL2164/MSL2166 and initiates a boot load of the EEPROM data into the control registers.
50	V _{IN}	V _{IN}	Supply Voltage Input: Connect a 12V ±10% supply to VIN. Bypass VIN to GND with a 10μF ceramic capacitor placed close to VIN.
51	VDD	VDD	2.5V internal LDO Regulator Output: VDD is the 2.5V source that powers internal logic. Bypass VDD to GND with a 4.7μF ceramic capacitor placed close to the MSL2164/MSL2166.
52	S0	S0	Source Sense Input 0: Source and Current Sense Input for LED string 0. Connect S0 to the source of the external MOSFET and to the current sense resistor for LED string 0. The full scale LED current is reached when 500mV is across the current sense resistor. If unused, connect S0 to ground.
53	G0	G0	Gate Output 0: External MOSFET Gate Drive Output for LED string 0. Connect G0 to the gate of the external MOSFET driving LED string 0. If unused, leave G0 unconnected.
54	D0	D0	Drain Sense Input 0: External MOSFET Drain Sense Input for LED string 0. Connect D0 through a 10MΩ resistor to the drain of the external MOSFET driving LED string 0. If unused, connect D0 to ground.
55	S1	S1	Source Sense Input 1: Source and Current Sense Input for LED string 1. Connect S1 to the source of the external MOSFET and to the current sense resistor for LED string 1. The full scale LED current is reached when 500mV is across the current sense resistor. If unused, connect S1 to ground.
56	G1	G1	Gate Output 1: External MOSFET Gate Drive Output for LED string 1. Connect G1 to the gate of the external MOSFET driving LED string 1. If unused, leave G1 unconnected.
57	D1	D1	Drain Sense Input 1: External MOSFET Drain Sense Input for LED string 1. Connect D1 through a 10MΩ resistor to the drain of the external MOSFET driving LED string 1. If unused, connect D1 to ground.
58	S2	S2	Source Sense Input 2: Source and Current Sense Input for LED string 2. Connect S2 to the source of the external MOSFET and to the current sense resistor for LED string 2. The full scale LED current is reached when 500mV is across the current sense resistor. If unused, connect S2 to ground.
59	G2	G2	Gate Output 2: External MOSFET Gate Drive Output for LED string 2. Connect G2 to the gate of the external MOSFET driving LED string 2. If unused, leave G2 unconnected.
60	D2	D2	Drain Sense Input 2: External MOSFET Drain Sense Input for LED string 2. Connect D2 through a 10MΩ resistor to the drain of the external MOSFET driving LED string 2. If unused, connect D2 to ground.
61	S3	S3	Source Sense Input 3: Source and Current Sense Input for LED string 3. Connect S3 to the source of the external MOSFET and to the current sense resistor for LED string 3. The full scale LED current is reached when 500mV is across the current sense resistor. If unused, connect S3 to ground.
62	G3	G3	Gate Output 3: External MOSFET Gate Drive Output for LED string 3. Connect G3 to the gate of the external MOSFET driving LED string 3. If unused, leave G3 unconnected.
63	D3	D3	Drain Sense Input 3: External MOSFET Drain Sense Input for LED string 3. Connect D3 through a 10MΩ resistor to the drain of the external MOSFET driving LED string 3. If unused, connect D3 to ground.
64	S4	S4	Source and Current Sense Input for LED string 4. Connect S4 to the source of the external MOSFET and to the current sense resistor for LED string 4. The full scale LED current is reached when 500mV is across the current sense resistor. If unused, connect S4 to ground.
EP	EP	EP	Exposed Paddle, Power Ground: EP is the exposed die attach paddle which acts as a low thermal resistance path for the die and as power ground. Connect EP to system ground, and to GND using short, wide traces.



Register Map and the EEPROM

Control the MSL2164/MSL2166 using the registers in the range 0x00 through 0xBF. Two additional registers, 0xC0 and 0xC1, control EEPROM reading and writing. The control register power-on values are stored in EEPROM, and can be changed through the serial interface.

ADDRESS AND			REGISTER DATA									
REGISTER NA	AME	FUNCTION	D7	D6	D5	D4	D3	D2	D1	D0		
0x00	STRINGENO	150011 5 11	STR7EN	STR6EN	STR5EN	STR4EN	STR3EN	STR2EN	STR1EN	STROEN		
0x01	STRINGEN1	LED String Enables	STR15EN	STR14EN	STR13EN	STR12EN	STR11EN	STR10EN	STR9EN	STR8EN		
0x02	CONFIG	Configuration	SLEEP	-	-	-	FLDBKEN		STRSCDLY[2:0]			
0x03	FLTEN	Fault Enable	-	-	-	PHIMAXFEN	GSCMAXFEN	STRSCFEN	STROCFEN	FBOOCFEN		
0x04	STRFLTEN0		FEN7	FEN6	FEN5	FEN4	FEN3	FEN2	FEN1	FENO		
0x05	STRFLTEN1	String Fault Enable	FEN15	FEN14	FEN13	FEN12 FEN11		FEN10	FEN9	FEN8		
0x06	FLTSTATUS	Fault Status	FLTBDRV	-	-	PHIMAXFLT	GSCMAXFLT	STRSCFLT	STROCFLT	FBOOCFLT		
0x07	OCSTATO		OC7	006	005	OC4 OC3		0C2	OC1	OCO		
0x08	OCSTAT1	String Open Circuit Fault Status	OC15	0C14	0C13	0C12	0C11	0C10	009	OC8		
0x09	SCSTAT0		SC7	SC6	SC5	SC4	SC3	SC2	SC1	SCO		
0x0A	SCSTAT1	String Short Circuit Fault Status	SC15	SC14	SC13	SC12	SC11	SC10	SC9	SC8		
0x0B thru 0x0l			00.0	0011		IUSED	0011	00.0		000		
0x0F	OSCFREQ	Oscillator Frequency			-	-	_	T	OSCFREQ[2:0]			
0x10	FBOCTRLO		HDRMS	TEP[1:0]		DLY[1:0]	SETT	TLE[1:0]				
0x10	FBOCTRL1	Efficiency Optimizer		TEP[1:0]		TEP[1:0]	INITPWM	ACAL100	-	ICHKDIS		
0x11	FBOCTRL2	Control	-	ACALEN3	ACALEN2	ACALEN1	FB030CEN	FB020CEN	FB010CEN	FBOEN		
0x12	FBODACO			AUALLINO	AUALLINZ		C1[7:0]	I DOZOGEN	I DO TOOLN	I DOLIN		
0x13	FBODAC1	Efficiency Optimizer DAC Readback					C2[7:0]					
0x14 0x15	FBODAC2	Elliciency Optimizer DAC Neadback					C3[7:0]	-		-		
		Efficiency Optimizer Status	FDOOOC	FDOOOC	FD0100			FDO1 ACT	EDOCAL	EDOINITOAL		
0x16	FBOSTAT	Efficiency Optimizer Status	FB030C	FB020C	FB010C	FB03ACT	FB02ACT	FB01ACT	FBOCAL	FBOINITCAL		
0x17 thru 0x1	GSCCTRL	CCC Proposing Control	GSCCHK-SEL			IUSED	GSCMAXEN	GSCPOL	GSCPHI-SYNCEN	CCCINITENI		
0x20		GSC Processing Control	USUUTK-SEL	-	-	- 00000		I GOUPUL	I GOUPHI-DYNUEN	GSCINTEN		
0x21	GSCCNTR	Internal Clock Counter for GSC				GSCCN						
0x22						GSCCN	Iμ[10:Ω]	OCOMULI [4:03				
0x23	GSCMUL	GSC Multiplier	-	-	-	0000	N 177 03	GSCMUL[4:0]				
0x24	GSCDIV	GSC Divider				GSCD						
0x25	-GSCMAX	Max Oscillator Cycles Between					AX[7:0]					
0x26		GSC Pulses	D. 1101 11 CE			GSCMA	X[15:8]		Lauran			
0x27	PHICTRL	PHI Processing Control	PHICHK-SEL	-	-	-	-	PHIMAXEN	PHIPOL	PHIINTEN		
0x28	PHICNTR	Internal Clock Counter for PHI				PHICN						
0x29						PHICNT	R[15:8]					
0x2A	PHIMUL	PHI Multiplier	-	-	-			PHIMUL[4:0]				
0x2B		Min GSC Pulses Over PHI Period				PHIMA	X[7:0]					
0x2C			-	-	-	-			X[11:8]			
0x2D	PWMCTRL0	PWM Control	GINT+1EN	'1'	ALTEN	OVRFLOZEN	OVRFLOEN	PWMGLBLEN	PWMDIRECT	PWMEN		
0x2E	PWMCTRL1		-	-	-	-	EXTALTEN	PHOVR FLOZEN	PHOVR FLOEN	PHADLYEN		
0x2F					UNUSED							
0x30	-GINT	Global PWM Scaling				GINT	[7:0]					
0x31	GIITI	alobal i iiii odali ig						GINT	[11:8]			
0x32	ALTGINT	Alternate Global PWM Scaling				ALTGIN	VT[7:0]					
0x33	1			-				ALIGIN	JT[11:8]			
0x34	-ISTR	9-Bit Global String Current				ISTR	[7:0]		Lowe			
0x35						-				[9:8]		
0x36	PWMSTATUS	PWM & Counter Status		PHIMAXERRCNT[2:0		PHIMAX1FLT	PHIMULFLT	GSCMULFLT	PHICNTRFLT	GINT-MULERR		
0x37	PHIPCNTR	PHI Pulse Counter & Status	PHICNTRMAX	-	-			PHIMULCNTR[0:4				
0x38	GSCPCNTR	GSC Pulse Counter				GSCPLILSE	ECNTR[7:0]			-		
0x39			-			000,020						
0x3A	RESERVED			-	-	000, 020		SCPULSECNTR[12				
0x3B		Reserved	'0'	-	-	1		SCPULSECNTR[12	'0'	'0'		
10 00 0 05	PWMMODE	Reserved PWM Mode	'0'	-		3307 0230		SCPULSECNTR[12	'0'	'0' DDE[1:0]		
0x3C - 0x3F	PWMMODE	PWM Mode	'0'	-	UNUSED		G	SCPULSECNTR[12	'0'			
0x40		PWM Mode Phase Delay and EO Assignment		-					'0' PWMM0			
0x40 0x41	PWMMODE STROSET	Phase Delay and EO Assignment for String 0		TO[1:0]			G		'0'			
0x40 0x41 thru		PWM Mode Phase Delay and EO Assignment for String 0thru		TO[1:0]		PHDLY -	(0[7:0]		'0' PWMM0			
0x40 0x41 thru 0x5E	STROSETthru	Phase Delay and EO Assignment for String 0thru Phase Delay & EO Assignment for	FBOSE			PHDLY -	(0[7:0]	PHDLY	'0' PWMM(
0x40 0x41 thru 0x5E 0x5F	STROSET	Phase Delay and EO Assignment for String 0thru Phase Delay & EO Assignment for String 15	FBOSE	T15[1:0]		PHDLYtir	(0[7:0] 	PHDLY	'0' PWMM0			
0x40 0x41 thru 0x5E 0x5F 0x60	STROSETthru STR15SET	Phase Delay and EO Assignment for String 0thru Phase Delay & EO Assignment for	FBOSE		UNUSED -	PHDLYtir	(0[7:0] 	PHDLY	'0' PWMM(
0x40 0x41 thru 0x5E 0x5F	STROSETthru	Phase Delay and EO Assignment for String 0thru Phase Delay & EO Assignment for String 15	FBOSE		UNUSED -	PHDLYtir	(0[7:0] 	PHDLY	'0' PWMM(
0x40 0x41 thru 0x5E 0x5F 0x60	STROSETthru STR15SET	Phase Delay and EO Assignment for String 0thru Phase Delay & EO Assignment for String 15 11-Bit PWM Setting	FBOSE FBOSE	T15[1:0]	UNUSED - -	PHDLYif: PHDLY	(0[7:0] 	PHDLY	'0' PWMM(
0x40 0x41 thru 0x5E 0x5F 0x60 0x61	STROSETthru STR15SET	Phase Delay and EO Assignment for String 0thru Phase Delay & EO Assignment for String 15 11-Bit PWM Setting for String 0thru	FBOSE FBOSE	T15[1:0]	UNUSED - -	PHDLY	(O[7:0] 	PHDLY	'0' PWMM(
0x40 0x41 thru 0x5E 0x5F 0x60 0x61 thru	STROSETthru STR15SET	Phase Delay and EO Assignment for String 0thru Phase Delay & EO Assignment for String 15 11-Bit PWM Setting for String 0	FBOSE FBOSE	T15[1:0]	UNUSED - -	PHDLY	(O[7:0] 	PHDLY	'0' PWMM(
0x40 0x41 thru 0x5E 0x5F 0x60 0x61 thru 0x7E		Phase Delay and EO Assignment for String 0thru Phase Delay & EO Assignment for String 15 11-Bit PWM Setting for String 0thru	FBOSE FBOSE	T15[1:0]	UNUSED	PHDLY	(O[7:0] 	PHDLY	0(11:8) 0(11:8)			
0x40 0x41 thru 0x5E 0x5F 0x60 0x61 thru 0x7E	STROSETthru STR15SET	Phase Delay and EO Assignment for String 0thru Phase Delay & EO Assignment for String 15 11-Bit PWM Setting for String 0thru	FBOSE -	T15[1:0]	UNUSED	PHDLY	(O[7:0] 	PHDLY PHDLY	0' PWMM(0[11:8]			
0x40 0x41 thru 0x5E 0x60 0x61 thru 0x7E 0x7E 0x7E 0x80 0x81	STROSETthru STR15SET	Phase Delay and EO Assignment for String 0thru Phase Delay & EO Assignment for String 15 11-Bit PWM Setting for String 0thru 11-Bit PWM Setting for String 15 Phase Delay and EO Assignment	FBOSE ALTPHDLY0[7:0]	T15[1:0]	UNUSED	PHDLY	(O[7:0] 	PHDLY PHDLY	0[11:8] 15[11:8] 5[11:8]			
0x40 0x41 thru 0x5E 0x5F 0x60 0x61 thru 0x7E 0x7E 0x7F 0x80 0x81 thru	STROSETthru STR15SET	Phase Delay and EO Assignment for String 0thru Phase Delay & EO Assignment for String 15 11-Bit PWM Setting for String 0thru 11-Bit PWM Setting for String 15 Phase Delay and EO Assignment for String 0	FBOSE ALTPHDLY0[7:0]	T15[1:0]	UNUSED	PHDLY	(O[7:0] 	PHDLY PHDLY	0[11:8] 15[11:8] 5[11:8]			
0x40 0x41thru 0x5E 0x5F 0x60 0x61thru 0x7E 0x7F 0x80 0x81thru 0x81thru	STROSETthru STR15SET	Phase Delay and EO Assignment for String 0thru Phase Delay & EO Assignment for String 15 11-Bit PWM Setting for String 0thru 11-Bit PWM Setting for String 15 Phase Delay and EO Assignment for String 0thru Phase Delay and EO Assignment for String 0thru Phase Delay and EO Assignment	FBOSE ALTPHDLY0[7:0]	T15[1:0]	UNUSED	PHDLY	(O[7:0] 	PHDLY PHDLY PWM1 ALTPHE	0[11:8] 15[11:8] 5[11:8]			
0x40 0x41thru 0x5E 0x5E 0x60 0x61thru 0x7E 0x7F 0x80 0x81thru 0x9E 0x9F	STROSETthru STR15SET PWM0thru PWM15 ALTSTR0SETthru ALTSTR15SET	Phase Delay and EO Assignment for String 0thru Phase Delay & EO Assignment for String 15 11-Bit PWM Setting for String 0thru 11-Bit PWM Setting for String 15 Phase Delay and EO Assignment for String 0thru Phase Delay and EO Assignment for String 15	FBOSE FBOSE - - ALTPHDLY0[7:0]	T15[1:0] -	UNUSED	PHDLYtr PHDLY - PWMtr PWM1tr	G [70[7:0] Int 15[7:0] [70] [70] [70] [70] [70] [70] [70] [7	PHDLY PHDLY PWM1 ALTPHE	0[11:8] 15[11:8] 5[11:8]			
0x40 0x41thru 0x5E 0x5E 0x60 0x61thru 0x7E 0x7E 0x80 0x81thru 0x9E 0x9E 0xA0	STROSETthru STR15SET	Phase Delay and EO Assignment for String 0thru Phase Delay & EO Assignment for String 15 11-Bit PWM Setting for String 0thru 11-Bit PWM Setting for String 15 Phase Delay and EO Assignment for String 0thru Phase Delay and EO Assignment for String 0thru Phase Delay and EO Assignment	FBOSE FBOSE - - ALTPHDLY0[7:0]	T15[1:0] -	UNUSED	PHDLY	G [70[7:0] Int 15[7:0] [70] [70] [70] [70] [70] [70] [70] [7	PHDLY PHDLY PWM1 ALTPHE	0[11:8] 5[11:8] 5[11:8] LLY[11:8]			
0x40 0x41 thru 0x5E 0x60 0x61 thru 0x7E 0x7E 0x80 0x81 thru 0x9E 0x9E 0xA0 0xA1	STROSETthru STR15SET	Phase Delay and EO Assignment for String 0thru Phase Delay & EO Assignment for String 15 11-Bit PWM Setting for String 0thru 11-Bit PWM Setting for String 15 Phase Delay and EO Assignment for String 0thru Phase Delay and EO Assignment for String 15thru Phase Delay and EO Assignment for String 15 11-Bit PWM Setting for String 0	FBOSE - - ALTPHDLY0[7:0] -	T15[1:0] -	UNUSED	PHDLY	G /0[7:0] Inu 15[7:0] 0[7:0] PWM0[11:8] Inu 5[7:0] Inu Y15[7:0] M0[7:0]	PHDLY PHDLY PWM1 ALTPHE	0[11:8] 15[11:8] 5[11:8]			
0x40 0x41thru 0x5E 0x5F 0x60 0x61thru 0x7E 0x7F 0x7F 0x80 0x81thru 0x9E 0x9F 0xA0 0xA1thru	STROSETthru STR15SET PWM0thru PWM15 ALTSTR0SETthru ALTSTR15SET ALTPWM0thru	Phase Delay and EO Assignment for String 0thru Phase Delay & EO Assignment for String 15 11-Bit PWM Setting for String 0thru 11-Bit PWM Setting for String 15 Phase Delay and EO Assignment for String 0thru Phase Delay and EO Assignment for String 15thru 11-Bit PWM Setting for String 15thru	FBOSE - - ALTPHDLY0[7:0] -	T15[1:0] -	UNUSED	PHDLY	(O[7:0] 	PHDLY PHDLY PWM1 ALTPHE	0[11:8] 5[11:8] 5[11:8] LLY[11:8]			
0x40 0x41thru 0x5E 0x5F 0x60 0x61thru 0x7E 0x7F 0x80 0x81thru 0x9E 0x9F 0xA0 0xA1thru	STROSETthru STR15SET	Phase Delay and EO Assignment for String 0thru Phase Delay & EO Assignment for String 15 11-Bit PWM Setting for String 0thru 11-Bit PWM Setting for String 15 Phase Delay and EO Assignment for String 0thru Phase Delay and EO Assignment for String 15thru Phase Delay and EO Assignment for String 15 11-Bit PWM Setting for String 0	FBOSE ALTPHDLY0[7:0]	T15[1:0] - - - -	UNUSED	PHDLYtr PHDLY PWMtr PWM1tr ALTPHDL - ALTPWItr	(O[7:0] 	PHDLY PHDLY PWM1 ALTPHE ALTPHE	0 PWMM(0 11:8) 15[11:8] 5[11:8] 5[11:8] 0LY[11:8] M0[11:8]			
0x40 0x41thru 0x5E 0x5F 0x60 0x61thru 0x7E 0x7F 0x80 0x81thru 0x9E 0x9F 0xA0 0xA1thru 0xBE 0xBF	STROSETthru STR15SET PWM0thru PWM15 ALTSTR0SETthru ALTSTR15SET ALTPWM0thru ALTPWM15	Phase Delay and EO Assignment for String 0thru Phase Delay & EO Assignment for String 15thru 11-Bit PWM Setting for String 0thru 11-Bit PWM Setting for String 15 Phase Delay and EO Assignment for String 0thru Phase Delay and EO Assignment for String 15thru Phase Delay and EO Assignment for String 15thru 11-Bit PWM Setting for String 0thru	FBOSE - ALTPHDLY0[7:0] -	T15[1:0] -	UNUSED	PHDLY	G [70[7:0] Inu 15[7:0] Inu Inu.	PHDLY PHDLY PWM1 ALTPHE ALTPHE	0[11:8] 5[11:8] 5[11:8] LLY[11:8]			
0x40 0x41thru 0x5E 0x5F 0x60 0x61thru 0x7E 0x7F 0x80 0x81thru 0x9E 0x9F 0xA0 0xA1thru	STROSETthru STR15SET PWM0thru PWM15 ALTSTR0SETthru ALTSTR15SET ALTPWM0thru	Phase Delay and EO Assignment for String 0thru Phase Delay & EO Assignment for String 15 11-Bit PWM Setting for String 0thru 11-Bit PWM Setting for String 15 Phase Delay and EO Assignment for String 0thru Phase Delay and EO Assignment for String 15thru 11-Bit PWM Setting for String 15thru	FBOSE ALTPHDLY0[7:0]	T15[1:0] - - - -	UNUSED	PHDLYtr PHDLY PWMtr PWM1tr ALTPHDL - ALTPWItr	G /O[7:0] Inu 15[7:0] PWM0[11:8] Inu 5[7:0] Inu Y15[7:0] Inu M0[7:0]	PHDLY PHDLY PWM1 ALTPHE ALTPHE	0 PWMM(0 11:8) 15[11:8] 5[11:8] 5[11:8] 0LY[11:8] M0[11:8]			

16-String High-Efficiency LED Drivers for LCD TVs with Advanced Dimming Modes

Register Power-Up Defaults

REGISTER		POWER- UP CONDITION		REGISTER DATA							
NAME	AND ADDRESS	REGISTERS INITIALIZED FROM EEPROM	D7	D6	D5	D4	D3	D2	D1	DO	HEX
0x00	STRINGENO	LED strings G0 thru G7 enabled	1	1	1	1	1	1	1	1	0xFF
0x01	STRINGEN1	LED strings G8 thru G15 enabled	1	1	1	1	1	1	1	1	0xFF
0x02	CONFIG	Device awake, String current foldback disabled, String short circuit delay = 8µs	0	0	0	0	0	1	0	1	0x05
0x03	FLTEN	String short, string open and FBO open circuit faults enabled	0	0	1	0	0	1	1	1	0x27
0x04	STRFLTEN0	Fault detection enabled on all strings	1	1	1	1	1	1	1	1	0xFF
0x05	STRFLTEN1		1	1	1	1	1	1	1	1	0xFF
0x0F	OSCFREQ	$f_{OSC} = 20MHz$	0	0	0	0	0	1	0	0	0x04
0x10	FB0CTRL0	Triode confirmation delay = 2µs FBO power supply correction delay = 4ms	0	1	0	0	1	0	0	1	0x49
0x11	FBOCTRL1	Efficiency Optimizer recalibration delay = 1s Efficiency Optimizer Headroom steps = 6 Short circuit confirmation delay = 4µs	0	0	0	1	1	0	0	1	0x18 0x7F
0x12	FBOCTRL2	Efficiency optimizer operates 1 step at a time PWM duty cycle = programmed value during initial calibration Auto-calibrations enabled	0 (0)	(0)	(1)	(1)	(0)	(1)	(1)	(1)	(0x37 MSL2166)
0x20	GSCCTRL	GSC synchronized to the falling edge of an external signal	0	0	0	0	0	0	0	0	0x00
0x21	GSCCNTR	Although disabled, internal GSC frequency = 20MHz / (80 + 1) = 246.914 kHz	0	0	0	1	0	0	1	1	0x50
0x22	GOCCIVIN	Although disabled, internal GSC frequency = 2014inz / (80 + 1) = 240.914 knz	0	0	0	0	0	0	0	0	0x00
0x23	GSCMUL	GSC multiplied by 1	0	0	0	0	0	0	0	0	0x00
0x24	GSCDIV	GSC not divided	0	0	0	0	0	0	0	0	0x00
0x25	GSCMAX	Although disabled, GSC max count is set to 174 clock cycles	1	0	1	0	1	1	1	0	0xAE
0x26		· · · · · · · · · · · · · · · · · · ·	0	0	0	0	0	0	0	0	0x00
0x27	PHICTRL	PHI synchronized to the falling edge of an external signal	0	0	0	0	0	0	0	0	0x00
0x28	PHICNTR	Although disabled, internal PHI frequency = 20MHz / (8 * (10416 + 1)) = 240Hz	1	0	1	1	0	0	0	0	0xB0
0x29	DI III II II	DIII	0	0	1	0	1	0	0	0	0x28
0x2A	PHIMUL	PHI multiplier = 1 (register setting + 1)	0	0	0	0	0	0	0	0	0x00
0x2B	PHIMAX	No PHI min	0	0	0	0	0	0	0	0	0x34 0x10
0x2C 0x2D	DWMCTDLO		0	0	0	0	0	0	0	0	0xT0
0x2D 0x2E	PWMCTRL0 PWMCTRL1	PWM overflow, GINT plus one, Phase delay and PWM operation enabled	0	0	0	0	0	1	1	1	0xD9 0x07
0x2E	FWWCINLI		1	1	1	1	1	1	1	1	0x07 0xFF
0x30	GINT	Global intensity set to (4095+ 1) / 4096 = 100%	0	0	0	0	1	1	1	1	0x0F
0x32			0	1	1	1	1	1	1	1	0xFF
0x33	ALTGINT	Global intensity set to (2047 + 1) / 4096 = 50.00%	0	0	0	0	0	1	1	1	0x07
0x34			1	1	1	1	1	1	1	1	0xFF
0x35	ISTR	Strings current set at 25% of R _s setting	0	0	0	0	0	0	0	1	0x01
0x3A	RESERVED	Set for internal PWM	0	0	0	0	0	0	0	0	0x00
0x3B	PWMMODE	Set for Trailing PWM mode	0	0	0	0	0	0	1	0	0x02
0x40	OTDOOFT		0	0	0	0	0	0	0	0	0x00
0x41	STROSET		0	1	0	0	0	0	0	0	0x40
thru		All strings set to zero phase delay with strings assigned as follows: FBO1: All Strings; FBO2: None; FBO3: None									
0x5E	STR15SET	1 DOZ. NOTIE, 1 DOS. NOTIE	0	0	0	0	0	0	0	0	0x00
0x5F	SINIUSEI		0	1	0	0	0	0	0	0	0x40
0x60	PWM0		0	0	0	0	0	0	0	0	0x00
0x61	1 VVIVIO		0	0	0	0	0	0	1	0	0x02
thru		All strings set with PWM value = 512 GSC cycles									
0x7E	PWM15		0	0	0	0	0	0	0	0	0x00
0x7F			0	0	0	0	0	0	1	0	0x02
0x80	ALTSTROSET		0	0	0	0	0	0	0	0	0x00
0x81		All III	0	0	0	0	0	0	0	0	0x00
thru		All strings set to zero phase delay.			I .		 I o		T	1 ^	
0x9E	ALTSTR15SET		0	0	0	0	0	0	0	0	0x00
0x9F			0	0	0	0	0	0	0	0	0x00
0xA0	ALTPWMO		0	0	0	0	0	0	0	0	0x00 0x01
0xA1		All strings out with DIAM with a CEC CCC strings	0	0	0	0	0	0	0	1	UXUT
thru		All strings set with PWM value = 256 GSC cycles			Ι ο						0.00
0xBE	ALTPWM15		0	0	0	0	0	0	0	0	0x00 0x01
0xBF		REGISTERS WITH FIXED INITIAL VALUES	0	0	0	0	0	0	0	1	UXUT
OvCO	E2ADDR		0	0	0	0	0	0	0	0	0x00
0xC0 0xC1	E2CTRLSTA	EEPROM 7 bit address = 0x00	0	0	0	0	0	0	0	0	<u> </u>
UXUT	EZUINLƏIA	EEPROM read/write disabled	U	U	l U	LU	LU	U	LU	U	0x00



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