

# Application Brief 42023

## PWM Methods for Expanding CCFL Dimming Range Using the ML4877 or ML4878

### INTRODUCTION

Common methods for dimming Cold Cathode Fluorescent Lamps (CCFLs) using the ML4878 or the ML4877 are to either regulate the lamp current, or regulate the average current feeding the CCFL inverter. This dimming method has been referred to as analog dimming. Controlling the lamp brightness in this manner results in a typical dimming range of 10:1. The dimming range is limited at low intensities due to parasitic capacitance along the lamp, leaving insufficient current to sustain an arc across the whole length of the tube. This phenomenon is commonly referred to as the "thermometer effect". Once the lowest sustainable point has been reached, further reduction in lamp current reduces the length of the lamp that is illuminated, much like a thermometer.

The PWM technique is commonly used to overcome this problem; hence expanding the dimming range. The technique simply pulses the backlight at the full rated lamp current, thereby modulating intensity by varying the percent of time that the lamp is operating at the full rated current. This technique can be easily adapted to all of the Micro Linear backlight integrated circuit controllers, and can facilitate dimming ranges greater than 40:1 for a single 2.5W CCFL. Micro Linear solutions provide an added advantage for PWM operation in that they are all closed loop solutions, maintaining excellent line regulation, even during PWM operation. This document will provide a simple method for modifying the ML4878 and the ML4877 evaluation boards for PWM operation.

### PWM OPERATION

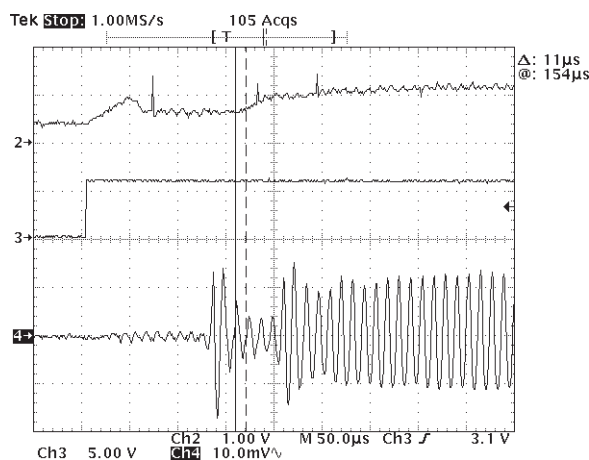
When operating the ML4878 and ML4877 in the normal analog dimming mode, the closed loop bandwidth required is very low compared to the switching frequency. The loop is typically compensated with a single pole roll-off at less than 100Hz for an inverter that may be switching at frequencies higher than 50kHz.

This bandwidth is unacceptable when operating in the PWM mode. For a PWM signal switching at 100Hz, a 500 $\mu$ s transient response time (no load to full load) will result in a maximum duty of 95%. In order to achieve this kind of response time, changes in the compensation components are required.

For the ML4878 application, reducing the compensation capacitor (COMP) to 470pF results in the transient response shown in Figure 1.

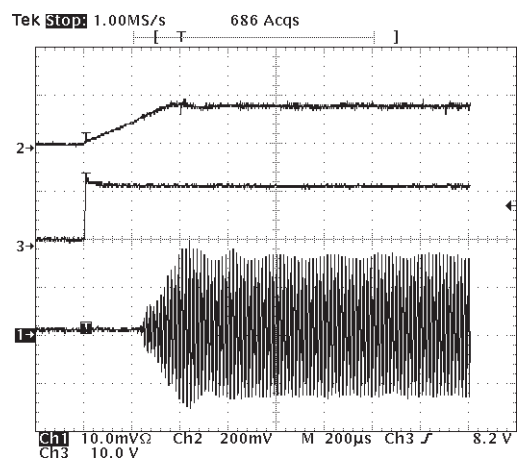
For the ML4877, reducing the compensation capacitor and resistor (C4 and R3, Figure 4) to 2700pF and 6.8k $\Omega$  respectively will result in the transient response shown in Figure 2.

For both devices, the PWM control signal is an open collector output. Figures 3 and 4 are schematics of the suggested implementation for each device.



**Figure 1. ML4878 Transient Response Optimized for PWM Dimming**

Channel 2	COMP	1V/div
Channel 3	PWM Control	5V/div
Channel 4	Lamp Current	5mA/div



**Figure 2. ML4877 Transient Response Optimized for PWM Dimming**

Channel 2	LEA OUT	2V/div
Channel 3	PWM Control	10V/div
Channel 1	Lamp Current	5mA/div

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## PWM OPERATION (Continued)

Note that for the ML4877, there are two possible methods for the PWM control. One method of PWM control is to pull low on the error amp output (LEA OUT), while the other is to modulate the error amp reference (LEA+).

### CONCLUSIONS

PWM dimming can significantly extend the dimming range capabilities of the topologies supported by Micro Linear's CCFL backlight controller ICs. Greater than 40:1 dimming is possible using a single 2.5W lamp. Multiple lamp configurations can also take advantage of this PWM

technique, providing extended dimming ranges and uniform dimming. PWM control of multiple lamps eliminates the typical problem of one lamp extinguishing prior to others at low intensities. Lamp layout and parasitics are no longer limitations on the display dimming capabilities.

Practical applications include AMLCD and STN passive displays for various end systems. The extended dimming range provides display solutions that can output more levels of light over a diverse range of environmental conditions.

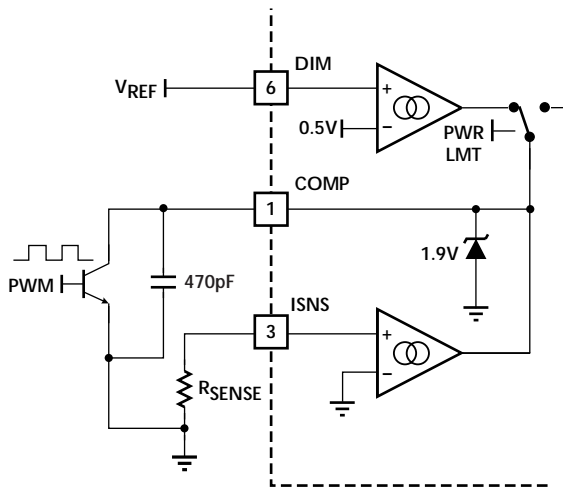


Figure 3. ML 4878 PWM Dimming Control

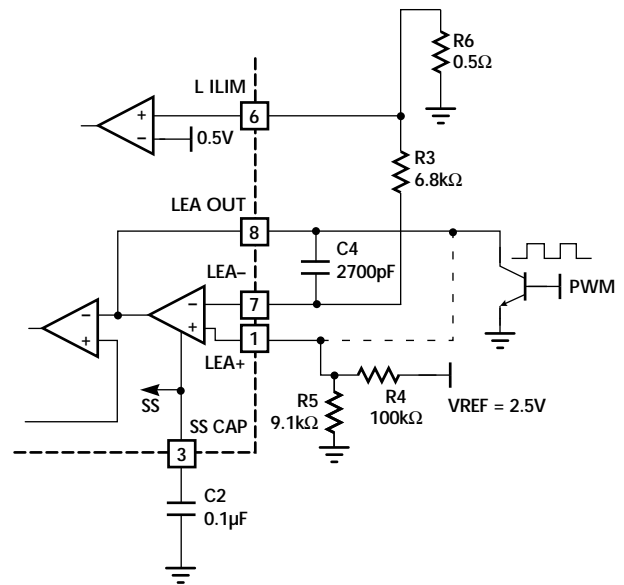


Figure 4. ML4877 PWM Dimming Control

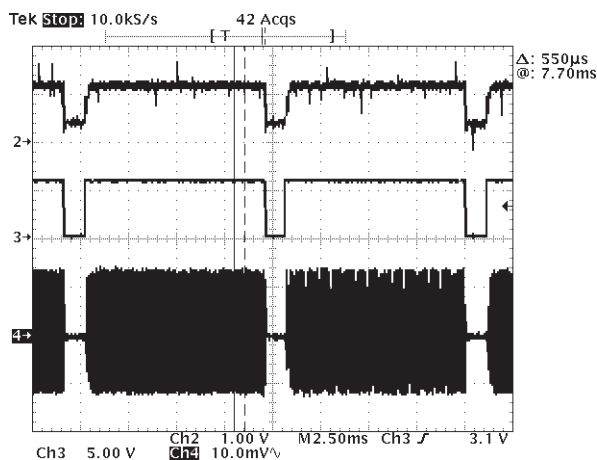


Figure 5. ML4878 PWM at 90%  
 Channel 2 COMP 1V/div  
 Channel 3 PWM Control 5V/div  
 Channel 4 Lamp Current 5mA/div

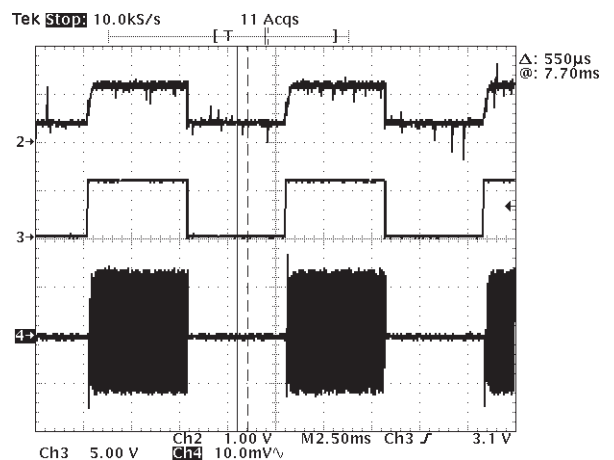
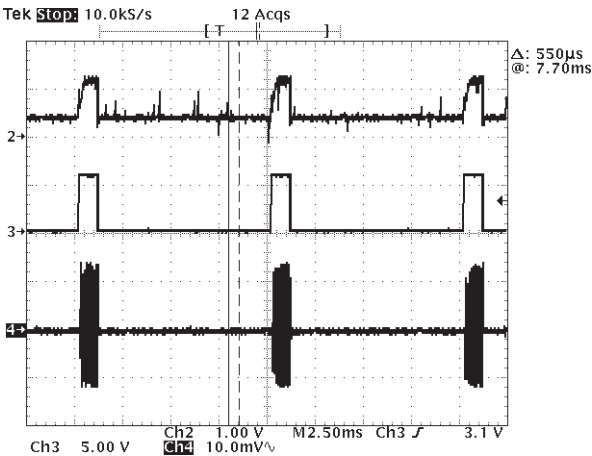
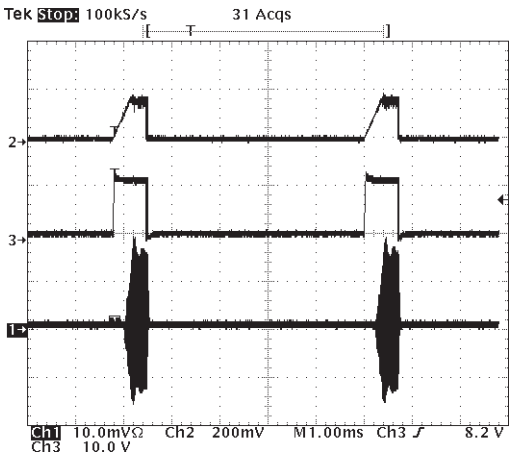


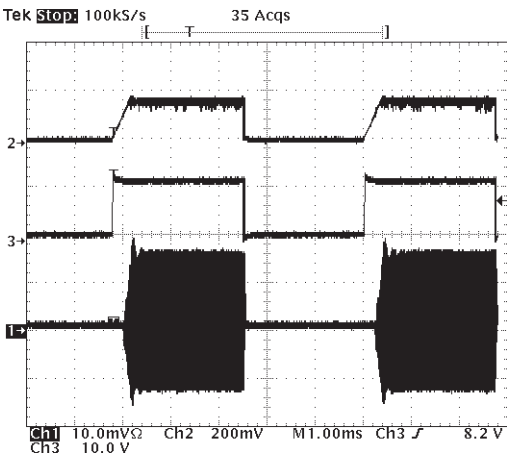
Figure 6. ML4878 PWM at 50%  
 Channel 2 CCOMP pin 1 1V/div  
 Channel 3 PWM Control 5V/div  
 Channel 4 Lamp Current 5mA/div



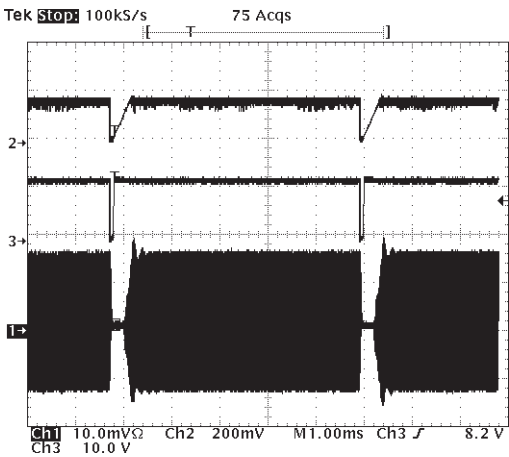
**Figure 7. ML4878 PWM at 10%**  
 Channel 2 CCOMP pin 1 1V/div  
 Channel 3 PWM Control 5V/div  
 Channel 4 Lamp Current 5mA/div



**Figure 8: ML4877 PWM Dimming**  
 Channel 2 LEA OUT 2V/div  
 Channel 3 PWM Control 10V/div  
 Channel 1 Lamp Current 5mA/div



**Figure 9: ML4877 PWM Dimming**  
 Channel 2 LEA OUT 2V/div  
 Channel 3 PWM Control 10V/div  
 Channel 1 Lamp Current 5mA/div



**Figure 10: ML4877 PWM Dimming**  
 Channel 2 LEA OUT 2V/div  
 Channel 3 PWM Control 10V/div  
 Channel 1 Lamp Current 5mA/div

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