Keysight Technologies

Testing LCD Backlight Inverters using the N6700 Modular Power System (MPS)

Application Note

Introduction

This application note describes how to use the Keysight Technologies, Inc. N6700 Modular Power System (MPS) to test the backlight inverter of a Liquid Crystal Display (LCD). Testing the inverters used to power and control the backlights of LCDs (coldcathode-fluorescent-lamp, or CCFL) requires multiple sequenced output voltages of different power ratings and precise timing with up to millisecond resolution or better. The N6700 MPS provides the flexibility and features needed in order to make the required tests and reduce costs by eliminating the need for multiple instruments and providing simple programming.

Description

During the design validation process, it is essential for an LCD manufacturer to test the CCFL inverter to its specifications. They do this in order to ensure that the inverter chosen will perform as expected and does not shorten the life of the CCFL backlight, which is one of the key components of an LCD screen. Thousands of on/off tests are performed over a range of temperatures from low to high in order to ensure the proper operation of the inverter and guarantee the life of the backlight.

Problem

An inverter usually takes multiple input signals, such as V_{IN}, which is the main power input, analog dimming, digital dimming, and on/off. To ensure proper operation of the inverter and ultimately the backlight, these signals are precisely sequenced to within a resolution of one millisecond. In order to properly test the inverter to these input signal specifications, you need to be able to precisely create, control, and reproduce these very different signals.

Trying to piece together the test and measurement equipment necessary to perform this task can prove time consuming and costly. This equipment can consist of an oscilloscope with a current probe or current shunt, a DMM, a function generator, and a power supply. However, even after piecing together a costly system, such as the one above, the required functionality may still be missing.

An alternative to piecing together test equipment might be to use the actual power/control board used in the finished product, however, this would also prove very time consuming and costly. The actual board does not provide the capability to simply and easily reprogram for multiple tests nor does it provide measurement or monitoring capabilities, which are essential to confirming proper operation. In order to measure and monitor the tests being performed, it would be necessary to introduce test and measurement equipment in between the board and the inverter being tested creating a very complicated and potentially unreliable system.

Example: 26 inch LCD TV

Most leading manufacturers of LCD TVs have strict specifications regarding the backlight inverters they use in their TVs. Figure 1 below is a graph of four typical signals and the necessary timing between the signals in order for the inverter to function properly. Table 1 lists common specifications for these signals.

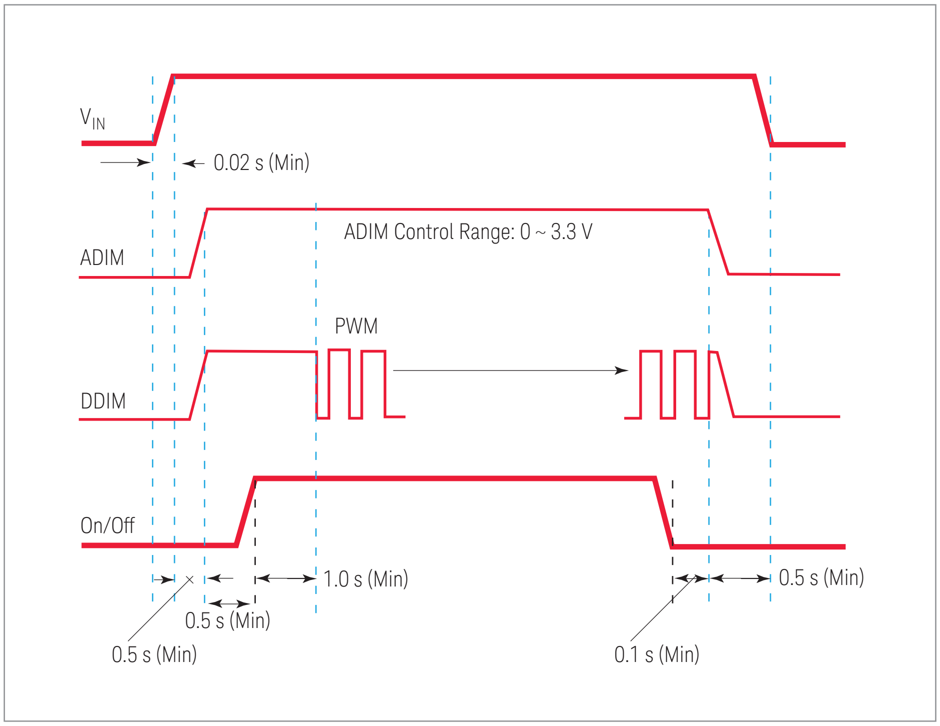

Figure 1. Typical Inverter Input Timing Graph

Table 1. Typical Inverter Signal Specification

Signal	Description	Specifications			
		Minimum	Typical	Maximum	Other
V_{IN}	Input Voltage	21.6 V	24 V	26.4 V	Max Power ~160 W
	Input Current	–	3.0 A	6 A	
Analog Dimming Control (ADIM)	High	–	3.3 A	–	10 mV Resolution
	Low	–	0 V	–	
Digital Dimming Control (DDIM)	PWM Frequency	100 Hz	–	300 Hz	0% to 100% Duty Cycle
	PWM Dimming Range	33%	–	100%	V_{IN} = 24 V V_{ADIM} = 3.3 V
On/Off	On/High	2.3 V	–	5.0 V	10 mV Resolution
	Off/Low	0 V	–	0.9 V	

In order to properly reproduce the four signals, you need a system that can precisely create as well as sequence them. You also need a system that can produce over 100 W of power since most backlights require this much power or more. The power input signal V_{IN}, the first signal in the graph, can require up to ~160 W of power (maximum voltage of 26.4 V multiplied by a maximum current of 6 A). Larger TVs will require even more power since they will have more CCFL backlights.

Solution: The Keysight Technologies, Inc. N6700 MPS

The N6700 MPS has the features and covers the necessary power ranges in order to properly reproduce these signals without the need for any extra equipment. It is a compact, 1 U mainframe and module based system, where one mainframe can hold up to four power modules. There are three mainframes (400 W, 600 W, and 1200 W) as well as three module performance tiers, from basic to precision, which can be mixed and matched in any mainframe to suit the needs of your test system. Table 2 shows the requirements for each signal along with the recommended modules for this test system. Each module meets or exceeds the requirements.

Table 2. Requirements Summary and Recommended Modules

Signal	Requirements Summary	Recommended N6700 MPS Module	Required Module Features
V_{IN}	20 V – 28 V 6 A Maximum Maximum Power ~160 W Slew 0 to 24 V in 0.02 s	N6774A 35 V, 8.5 A 300 W	300 W Basic Module Output Sequencing (1 ms Resolution) Slew Rate Control to 2400 V/s
Analog Dimming Control (ADIM)	0 V – 5 V 2 A Maximum Maximum Power ~10 W 10 mV Resolution	N6751A 50 V, 5 A 50 W	High Performance 100 W Module Output Sequencing (1 ms Resolution)
Digital Dimming Control (DDIM)	2 V – 5 V 1 A Maximum Maximum Power ~5 W Pulse Width Modulated Signal 100 Hz to 300 Hz 0% to 100% Duty Cycle	N6762A 50 V, 3 A 100 W	Precision 100 W Module Low (5.5 V) Range Output Sequencing (1 ms Resolution) LIST Mode for PWM Signal Slew Rate of 3000 V/s or better for extreme case PWM signal
On/Off	0 V – 5 V 2 A Maximum Maximum Power ~10 W 10 mV Resolution	N6751A 50 V, 5 A 50 W	High Performance 50 W Module Output Sequencing (1 ms Resolution)

V_{IN}

V_{IN} is supplied by an N6774A module. The Keysight N6774A is a 35 V/8.5 A Basic DC Power Module that is capable of supplying 300 W. It more than adequately covers the power for the backlight of the example 26 inch LCD TV, while also providing ample margin. However, if testing larger LCD TVs, which have more CCFL backlights that require more power, you can easily parallel it with other N6774A modules for greater output current. Other modules in the N6770 family could also be used if your voltage requirements are different (up to 100 V). Slew rate control is used on this output to control the speed of turn-on in order to match the specification illustrated in Figure 1. Slew rate control provides the ability to program in Volts per second (V/s) the speed at which the voltage will slew from one programmed value to the next. This feature is used to either speed up or slow down the transition from voltage to voltage when necessary. Although slew rate control is only required on V_{IN}, all of the modules available for the N6700 MPS have this capability.

On/Off and Analog Dimming

The On/Off and Analog Dimming signals are supplied by the Keysight N6750 High-Performance, Autoranging DC Power Modules, which are 50 W or 100 W. Both signals are provided by the N6751A. This module provides the necessary features for the signals. It can also be coupled with Option 054, High-Speed Test Extensions, which adds LIST mode and digitization. If more precise programming and measurement accuracy is needed, the Keysight N6760 family could be used for these signals.

Digital Dimming, PWM

The pulse-width modulated digital dimming signal is supplied by an N6762A Module. The Keysight N6760 Precision DC Power Module family provides a higher level of accuracy and includes Option 054 as standard equipment. These modules also incorporate dual voltage ranges (0 – 5.5 V or 0 – 50 V). The lower range provides more accurate programming and measurement than the higher range.

The N6762A also incorporates LIST mode. LIST mode provides the ability for up to 512 programmed voltage and/or current points. This ability is best described as a “power arbitrary waveform generator” that can create almost any waveform. Using the speed (0 to 5 V in 160 µs) and accuracy of the N6762A with LIST mode will adequately reproduce the PWM signal necessary for digital dimming.

Output Delay (Sequencing)

Output delay is used on each output channel of the system in order to precisely time the outputs to within the 1 ms required resolution. Delays can be programmed for each output and when the output-on command is sent the programmed delay must pass before the output will actually turn on. This is done to microsecond accuracy, but is limited to one mainframe. An alternate way of sequencing outputs both within a mainframe and between mainframes is by using LIST mode and LIST triggers, but this is beyond the scope of this document.

Summary

Precise, repeatable reproduction and sequencing of input signals is essential in order to properly test LCD backlight inverters. Many different problems can arise when trying to accomplish this task using conventional test and measurement equipment, which can become time consuming and costly. The Keysight N6700 MPS solves these problems in one simple system. The N6700 MPS can easily synchronize outputs using the output delay feature. The breadth of modules available for the N6700 MPS provide the varied levels of capabilities needed to produce the high-power V_{IN} signal with an N6774A and the complicated low-power PWM digital dimming signal with the N6762A.

The system is also easily expandable when the need to test larger LCDs arises. Larger LCDs require either more or larger backlights, which will require more power. Modules can be easily paralleled using the unique virtual channel feature in the N6700 MPS to achieve the higher power requirements. However, adding modules to the system also means adding additional mainframes. The N6700 mainframes have the ability to precisely trigger between one another by programming one of the eight digital I/O pins to an external trigger in/out. The benefit of this system is that no matter what the inverter specification is, whether very strict or not, low or high power, analog or digital dimming, the N6700 MPS has the flexibility to accommodate each individual situation.

Other Relevant Application Notes/References

Publication title	Pub number
Application Note: *Simplify Multiple Bias Voltage Sequencing and Ramping for PC Motherboard Test*	5989-1676EN

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