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THE ERG SFW INVERTER SERIES

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Liquid crystal display (LCD) backlight specialist Endicott Research Group, Inc. designs and manufactures DC to AC inverters used to power backlights that use cold cathode fluorescent lamps (CCFL) as well as light sources and drivers for backlights that use light emitting diodes (LEDs) as a light source. CCFL backlights have been the light source for LCD backlights for years, while LED backlights are just beginning to be used in applications that require added reliability and brightness (at a higher cost, however.)

What are “Smart Force” Inverters?

Today’s energy and cost conscious display applications require efficient inverters that operate over a wide range of displays and minimize input power requirements. These requirements are especially important with the ever increasing number of display products that use battery power, which further requires the inverter to operate seamlessly over a wide range of input voltages. Most of these applications utilize LCDs in the 5.7” to 15” diagonal range and backlights with one or two CCFLs. Using the basic inverter design concepts that have been the keystone of ERG inverters for the past 29 years, ERG engineers sharpened their pencils and produced the extremely low-profile SFW (SF for Smart Force, W for Wide input voltage) Series of DC-AC inverters.

The SFW Series provides feature-rich, highly intelligent inverters with a wide input voltage range (8-18 Vdc), open lamp detection, a wide dimming range using onboard pulse width modulation (PWM), brightness control, and lamp current regulation. Available in single and dual-lamp versions, they feature an extremely low profile (< 6 mm high) and a ruggedized transformer that has helped these inverters test successfully at a very wide range temperatures. SFW inverters feature direct display connection, a start voltage of 1800 Vrms, and an operating temperature range of -30° to 70°C. Two single-lamp versions are available: one with the JST output connector SM02(8.0) B-BHS-TB (SFWA160JF*), and one with the JST SM02B-BHSS-1 connector (SFWA160J2F).

How Do They Work?

The basic design of all ERG inverters involves a low voltage oscillator that converts a DC input, typically 5 to 12 Vdc, into a low voltage AC waveform that is boosted to the high voltages (1000 to 2000 Vrms) required to start CCFL ignition. Once the CCFL is lighted, the voltage and current required to maintain stable light output is typically 500 to 1000 Vrms and 5-6 mArms. The low voltage oscillator may be a discrete-component Royer’s oscillator or may utilize an integrated circuit to provide the required AC input to the transformer. The voltage boost as well as isolation is provided by a step-up transformer. Maintaining stable LCD brightness requires inverter output current that remains stable over variations in input voltage and operating temperature.

The SFW Series monitors output current and actively adjusts transformer input to maintain a +/- 5% output current regulation. CCFL start or strike voltages vary widely with temperature, increasing dramatically at lower temperatures. At startup, the SFW Series monitors CCFL current while the strike voltage is increased to a maximum of 1800 Vrms. Once the CCFL lights, the SFW reduces the voltage to the level required to maintain stable CCFL operation. If the CCFL is damaged or if the connection to the CCFL is open, the SFW open lamp detection function senses this and shuts down inverter operation pending fault correction.

How They Are Tested

Electrically, the CCFL load can be simply represented as a RC load that varies not only among lamp designs but also with temperature and packaging. Lamp size and electrochemistry for displays in the 5.7” to 15” range offer start voltages from 1000 to 1800 Vrms, sustaining voltages in the 500 to 1000Vrms range, and lamp currents in the 5-6 mArms range. The start voltage increases with lamp age and with decreasing temperature. The sustaining voltage and lamp current also vary across the wide variety of CCFLs used in backlights. Additionally, variations in CCFL packaging provide variations in capacitive losses across different LCD assemblies that need to be considered.

ERG development engineers have years of experience with CCFL backlights and, especially, with LCD packaging variations, and they have developed a very effective design verification regime that is used to validate the SFW Series design over the expected range of CCFL loads, input voltages, temperatures and packaging variations.

Dimming/Brightness Control

Dimming or brightness control is also a key design consideration in providing effective display function in night and daytime ambient light conditions. CCFL brightness is controlled by pulse width modulation (PWM) dimming wherein the lamps are pulsed at a low frequency, typically 100-200Hz, and the duty cycle for each cycle is varied from zero to 100%. A duty cycle of 50% will then provide display brightness approximately half that provided at a duty cycle of 100%. Brightness stability at short duty cycles is the typical challenge for inverter design, so the SFW Series design validation also included high dimming (low duty cycle) validation over variations in input voltage and temperature.

After the SFW Series design was verified, ERG engineers then devised test specifications used by the ERG manufacturing team to validate proper function of each SFW inverter produced. The manufacturing team tests 100% of all products to ensure proper

function. The test data for each inverter, and there are thousands manufactured every week, is recorded and saved with appropriate manufacturing identification to provide a permanent record of the efficacy of each inverter produced. This data is used by ERG to monitor process stability and to provide a solid base of technical data on which to base product or process improvements.

Design Challenges Met by the SFW Series

As always, the key challenges in designing a high voltage inverter are transformer design, ground plane integrity and high voltage clearance.

The SFW Series transformer challenges focused on meeting the 1800 Vrms requirement, passing 2000 Vdc high potential (HIPOT) testing, and achieving the correct leakage inductance, which determines the inverter oscillation frequency (55 KHz). The number of transformer secondary sections, how they are wound and the physical dimensions all contributed to meeting these challenges.

PCB layout for these high voltage inverters involved maintaining the clearances between high voltage traces and components that are required to guard against any high voltage arcing across the PCB surface. Another design and layout challenge – maintaining proper ground plane integrity – was also key to providing regulated current control over the expected input voltage and output load variations.

Test Equipment Used

The engineering lab at ERG is well equipped with equipment useful for high voltage analog design. The key instruments are:

- Tektronix CT-2 Current Probe
- Fluke 45 digital voltmeter
- Fluke PM3394A oscilloscope
- Fluke 87V digital voltmeter
- Tektronix TCPA300 AC/DC current probe

The Software

ERG engineers use a software design tool developed in-house that provides the basic design parameters for the low voltage oscillator, transformer and ballast sections of the CCFL inverter designs. Engineers use this design tool to provide the starting point for inverter designs. Further design refinements, if needed, are completed by evaluating design prototypes.

ERG manufacturing test stations also include company-created software to provide automatic input voltage regulation, inverter output measurement and data recording for each inverter produced. There are numerous test stations throughout the factory that provide the manufacturing teams with a time-efficient 100% test process.

** NOTE: The single-lamp version of the SFW Series (P/N SFWA160JF) is a drop-in replacement for TDK's CXA-L0612A-VJL DC/AC inverter. However, the SFW inverter offers a wider range of dimming and there is not a 16-week wait for a production order. ERG typically keeps the Smart Force Line of CCFL inverters in stock, and pricing is extremely competitive.*

ERG's new SFW Series of CCFL inverters are available directly or from ERG's extensive distributor network. Pricing is \$12.75 in 1,000-piece quantities for the SFWA160JF single-lamp inverter. For additional pricing, contact ERG. Shipment is typically next day (stock) to 4 weeks A.R.O.

For more information, contact:



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