APPLICATION NOTE – 1017

Topic: ELIMININATING DC IN THE ELECTRIC GLASS MELTING FURNACE

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INTRODUCTION

Most of us have heard that DC in a glass tank causes many problems. However, many of us don't know what the problems are or why they are a problem. DC present in the molten glass causes bubbling, discoloration and increases electrode wear. When HDR Power Systems entered the glass melting power supply business, we knew we had to address the DC component issue. Our new "DC Elimination" circuit had to be innovative, inexpensive yet extremely accurate and reliable.

Figure 1 – 2500kW Glass Melting Power Supplies designed and manufactured by HDR Power Systems

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The end product being made from the molten glass determines whether or not the problems associated with the DC component are a problem. Rather than develop a circuit for each specific type of glass, HDR designed a circuit board that works well in all the different glass melting applications – fiberglass, flat glass, instrument, etc.

WHAT CAUSES THE DC COMPONENT

DC in the glass is the result of two sources. The first is chemical reaction between the molten glass and dissimilar metals reacting. Much like a battery. The battery effect must be corrected by the furnace designer and/or operator. The second is a DC component that is the result of uneven firing of the plus and minus SCR in the power supply. In most power supplies, the DC component is typically 150mV DC or more without any correction. DC component values over 25mV are considered damaging and most glass manufacturers want the DC component to be less than +/– 5mV. Figure 2a shows a pair of SCRs firing without any DC correction. Figure 2b shows the same pair of SCRs firing with HDR's DC Correction circuit turned on. As you can see, the zero line in Figure 2a shifts off real zero without DC elimination. If the zero line is above the real zero line, you have a positive DC component. The opposite is true if the zero line is below the real zero line. Whether the DC component is positive or negative normally makes no difference to the glassmaker.

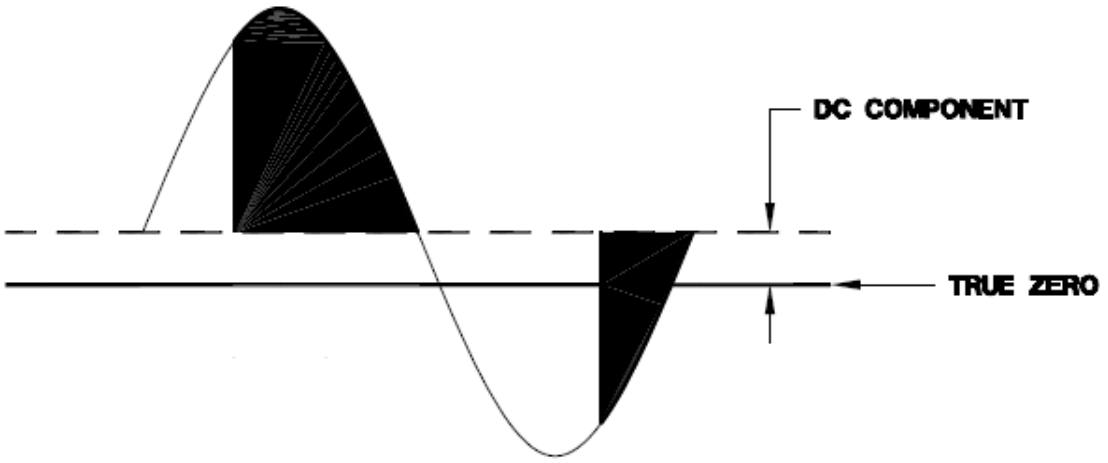

Figure 2a – SCRs firing without DC correction

The conduction angles in the positive and negative half cycles and the DC Component of Figure 2a have been exaggerated for illustrative purposes. The positive and negative half cycles in Figure 2b illustrate what the perfect chopped sinewave should look like. The shaded area inside the sinewave indicates the conduction period.

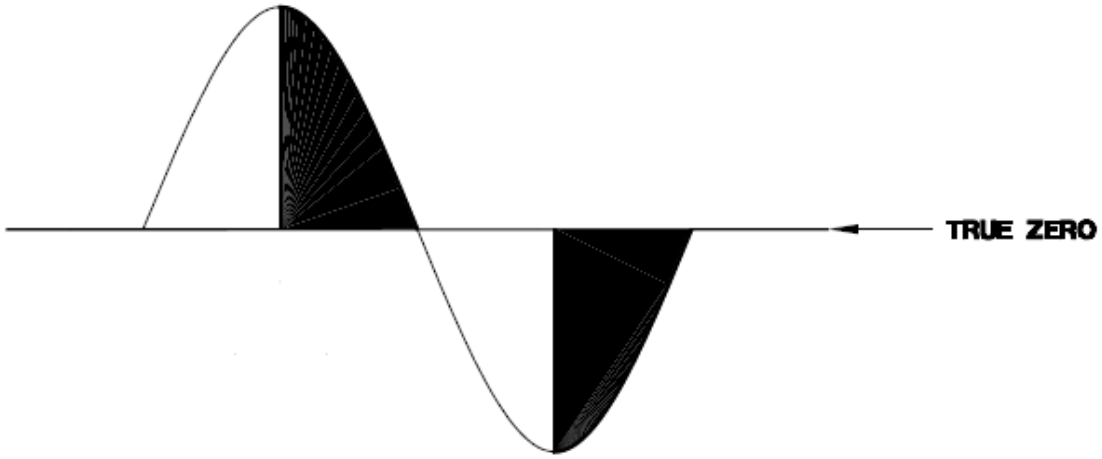

Figure 2b – SCRs firing with HDR's DC Elimination Circuit operating

THE PROBLEM WITH MOST MANUFACTURERS POWER SUPPLIES

Although most power supply manufacturers have some type of DC Elimination circuit it is not very precise and works well at only one operating point. These manufacturers "fine tune" their DC Elimination circuit for operation at the expected operating point. However, as the power supply's output voltage changes or varies from this pre-determined operating point, the DC component will usually increase which is undesirable.

Note: DC components are only present in the glass when the SCRs are directly melting the glass via electrodes. If the electrodes are transformer coupled, no DC will be present since DC is not transferred through a transformer. An example would be forehearth controls with transformer coupled electrodes. However, the incoming power for nearly all direct melting applications is at a medium to high voltage such as 13.2kV. This requires the SCRs to be on the secondary of a step-down transformer, which creates the requirement for DC Elimination circuitry.

HDR's SOLUTION

HDR developed an innovative method for detecting and separating the DC component from the AC voltage. We then amplify this small signal and adjust both the positive and negative half cycle SCRs. Correcting using both half cycles provides much more accurate elimination of the DC component. Most power supply manufactures only correct by adjusting either the positive or negative half cycle but not both.

In addition to adjusting both half cycles, HDR added an integral control loop that continuously adjusts the two half cycles to maintain near zero DC component values. This provides the user minimal DC component over a range of approximately 10% to over 90% of the output voltage. This is compared to others "fine tuning" to a specific operating point.

HDR also has an adjustable DC Component Trip Level with a relay output. This provides the user an indication and opportunity to make adjustments or repairs before the glass or electrodes are damaged. It includes an adjustable time delay so during start-up and/or occasional operation below 10% or above 90% output voltage, false alarms aren't present. A DC Component meter output is also available. It's output is +/- 5Vdc scaled designed to drive a zero-center meter with a scale of +/- 50mV.

The result of HDR's DC Elimination circuit is essentially zero DC component. Users have been amazed at how precise the circuit operates.

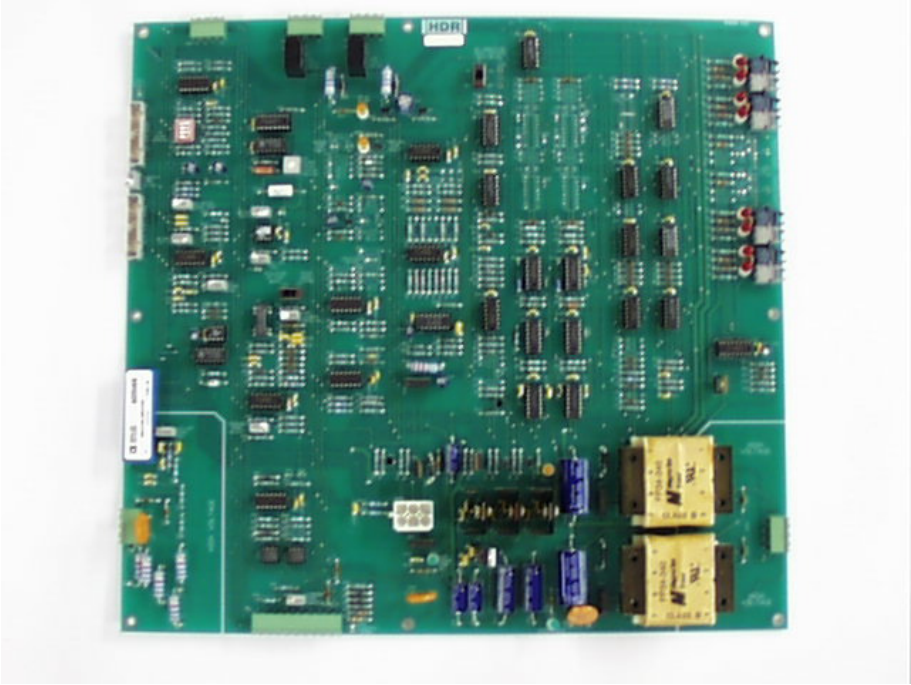

Figure 3 – HDR Power Systems' Glass Melting Power Supply Circuit Board

OTHER FEATURES OF HDR's GLASS MELTING CIRCUIT BOARD

In addition to the DC Elimination features, HDR's circuit includes the following:

- Optical Gating of SCRs
- Parallel or Series-Parallel firing of SCRs
- Optically Isolated Command Signal Input
- Primary and Secondary RMS Current Limit
- VIPR (voltage, current, power or resistance) regulation

Each of these features has been or will be covered in future application notes.

SUMMARY

HDR's Glass Melting Power Supply circuit board's DC Elimination circuit far exceeds the industry's previous standards. It not only maintains near zero DC component over a wider operating range but has additional circuits that are beneficial to users.