Hybrid DC-DC Converters Excel in AC Applications

Hybrid DC-DC converters are rapidly dominating the next generation of high performance military and aerospace applications due to their small size.

However, physical volume reduction of miniature AC input converters have lagged behind their DC input counterparts. This is unfortunate, since many AC applications also demand the small size, light weight and high performance. By using a small rectifier and filter ahead of a suitable hybrid DC-DC converter, a very small AC/DC power supply may be implemented.

Primitive hybrid DC-DC converters were not regulated at all or had relatively narrow input voltage ranges. Second generation parts operate over a 2 1/2 :1 or 3:1 range. This is an impractically narrow range for running on highly pulsating full wave rectified AC.

For wide operating voltage range DC-DC converters, the choice of circuit topology is critical. It has been shown that the flyback topology is well suited for extreme operating voltage ranges. Reference #2 discusses a flyback construction operating over a 37:1 range.

The most common nominal voltage range for DC input units is 28 VDC followed by 270 VDC and 120 VDC. The 120 VDC range is used by the International Space Station Alpha program as well as some newer satellites. Modular Devices, Inc. is now manufacturing four families of hybrid 120 VDC input converters using flyback topology, ranging in power from 6.5 to 80 watts. The operating range of these parts encompasses 200 VDC on the high end to 80 VDC on the low end. In addition, these converters are current mode types and have a high degree of ripple rejection.

The wide operating voltage range feature makes this series of parts ideal for operating on pulsating DC derived from direct full wave rectification of nominal 115 VAC inputs.

A typical circuit configuration is shown in Figure 18. AC voltage is fed to a bridge rectifier, then to a capacitor in parallel with the DC-DC converter. For low power outputs the capacitor is not necessary since the internal capacitor of the DC-DC converter suffices

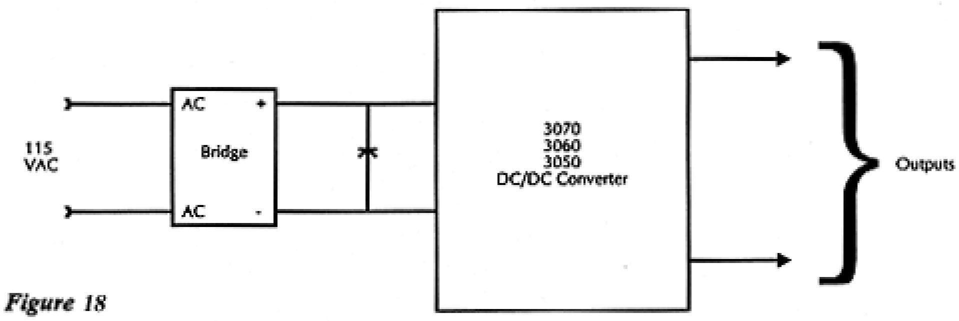

Figure 18
Typical Circuit Configuration
Tranforming a 115 VAC Input
Into DC Ouput

This configuration has excellent EMI characteristics. The high frequency emissions are controlled within the DC-DC converter itself. The low frequency conducted emissions are minimized by keeping the filter capacitance as small as possible. Since the DC-DC converter is designed to operate over a large input voltage range, it can cope with the high pulsating voltage resultant from a small capacitor.

A typical input waveform is shown in Figure 19. The small capacitor results in a large conduction angle. The large conduction angle provides a high power factor and allows a relatively fast fall off of low frequency harmonics.

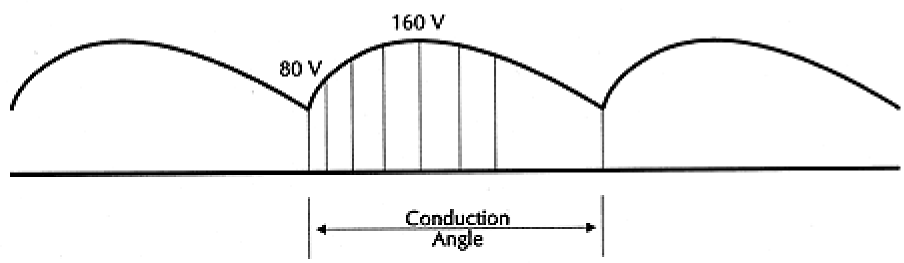

Figure 19
Converter Input Waveform

A substantial benefit of being able to operate with little or no external capacitance is the small physical dimensions of the resulting power supply.

Tables 9 through 12 show how much minimum capacitance is needed. In practice, an additional factor of safety in capacitance value may be desirable to counter the capacitance change over temperature, increase low line operating margins or reduce output ripple voltage.

The 3050/3060/3070 family of hybrid DC-DC converters typically has 60 dB of ripple rejection with 50-60 Hz inputs and 42 dB of ripple rejection with a 400 Hz input.

With the capacitor values shown, typical full wave rectified ripple component is 0.5% p-p at 50/60 Hz., and 2.5% p-p at 400 Hz. This ripple is reduced directly as capacitance is increased. For 400 Hz applications it may be desirable to use a small inductor for filtering as this may be volumetrically better than capacitors and will improve power factor.

Battery Backup Power Supplies

The requirement to operate from an AC power line with a battery backup is often encountered in critical applications. A simple configuration for battery backed up power supplies using two hybrid DC-DC converters is shown in Figure 20. Highly compact uninterruptable or battery backed up power supplies can be implemented with hybrid converters.

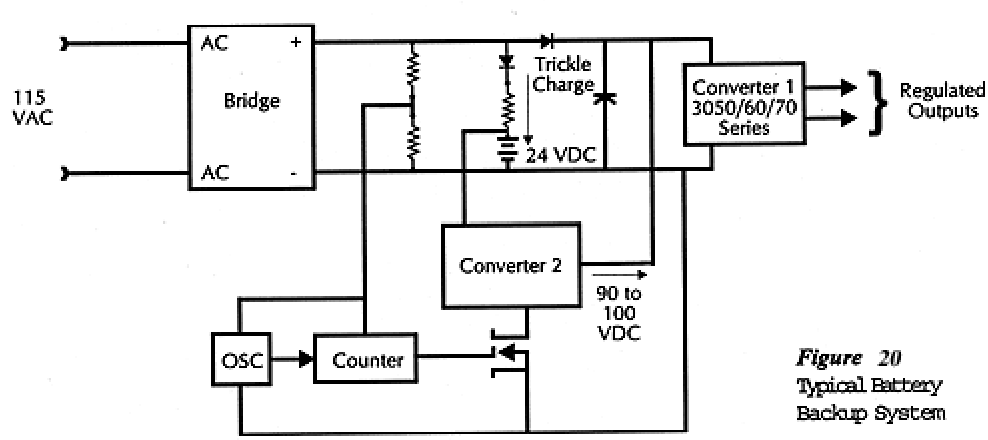

Figure 20
Typical Battery Backup System

AC power is full wave rectified and fed through a blocking diode to the principal DC-DC Converter, #1. This converter produces the desired regulated outputs.

A second diode connected to the pulsating full wave rectified voltage feeds a trickle charging resistor connected to a 20 cell Ni-Cad battery pack. The blocking diode is used to prevent unintentional back feed from the battery.

The trickle charge also supplies the no load current for DC-DC Converter # 2. Converter # 2 operates from the nominal 24 VDC battery output and delivers an output voltage in the 90 to 100 VDC range. This means that so long as AC power is present, DC-DC Converter # 2 is reverse biased and drawing only standby current. However, when the AC power source is low or not present, dropping below the output set point of DC-DC Converter #2, Converter #2 delivers the input voltage to Converter #1, drawing its power from the Ni-Cad battery.

The function of the oscillator/counter/FET switch is to disconnect DC-DC converter #2 from the battery after a preset time. This prevents the battery from discharging below an unusable potential.

Capacitor Selection

Capacitors should have a minimum voltage rating of 200 to 250 VDC for this application or as derating criteria demands. The user can use a film, multilayer ceramic, tantalum foil or a high performance aluminum electrolytic capacitor. All of these part types are available in a height that is consistent with the height of the converters.

The dissipation factors of the capacitors should be reviewed since they are operating with a high ripple voltage. A high dissipation factor can cause power dissipation. At 400 Hz it may be desirable to use more capacitance than indicated to reduce the converter's output ripple voltage.

Table 9
3070 Family (to 6.5 Watts Output)

Output With No External Capacitor	External Capacitance For Full Output
1.6 W at 50 Hz	8.7 µf/200 V
2.0 W at 60 Hz	6.5 µf/200 V
6.5 W at 400 Hz	—

Table 10
3060 Family (to 20 Watts Output)

Output With No External Capacitor	External Capacitance For Full Output
2.2 W at 50 Hz	49 µf/200 V
2.6 W at 60 Hz	30 µf/200 V
17 W at 400 Hz	3.5 µf/200 V

Table 11
3326 Family (to 40 Watts Output)

Output With No External Capacitor	External Capacitance For Full Output
5.4 W at 50 Hz	64 µf/200 V
6.5 W at 60 Hz	50 µf/200 V
44 W at 400 Hz	3.5 µf/200 V

Table 12
3051 Family (to 80 Watts Output)

Output With No External Capacitor	External Capacitance For Full Output
5.4 W at 50 Hz	125 μf/200 V
6.5 W at 60 Hz	104 μf/200 V
44 W at 400 Hz	6.8 μf/200 V

References

Hnatek, Eugene R. Design Of Solid State Power Supplies, Third Edition. Van Nostrand Reinhold, New York, 1989.

Summer, Steven E. and Zuckerman, Leonard. "Wide Input Range Multiple Output Power Supply." Proceedings of the Sixth International PCI Conference, April, 1983.