

# DC/DC Converters Meet Most Demanding Applications

Many small lightweight DC/DC converters for military, civil aviation and other applications requiring greater reliability, combine technical features such as high power density, hybrid thick film technology, hermetic package, full military temperature range, multiple input and output voltage ranges, built-in front end EMI filter and power ratings up to 120W. The devices withstand input surges and transients and meet environmental specifications for temperature extremes, shock, vibration, altitude, salt spray, fog and other key parameters. **Abhijit D. Pathak, HiRel Division, International Rectifier, San Jose, USA**



**LEFT Figure 1:**  
High-reliable DC/DC converters for avionic applications

Such DC/DC converters are produced in fully qualified facilities to MIL-PRF-38534 and are available in four screening grades such as MIL-STD-883 to satisfy a wide range of requirements. This article describes the features and technical specifications of the AHP series of DC/DC Converters in relation to requirements in targeted applications. Typical measurement data is presented. Other topics such as regulation, efficiency, ripple, synchronization, soft start, parallel operation, input and output protection; thermal, electrical stress, immunity to conducted noise and reliability considerations such as MTBF are also explained.

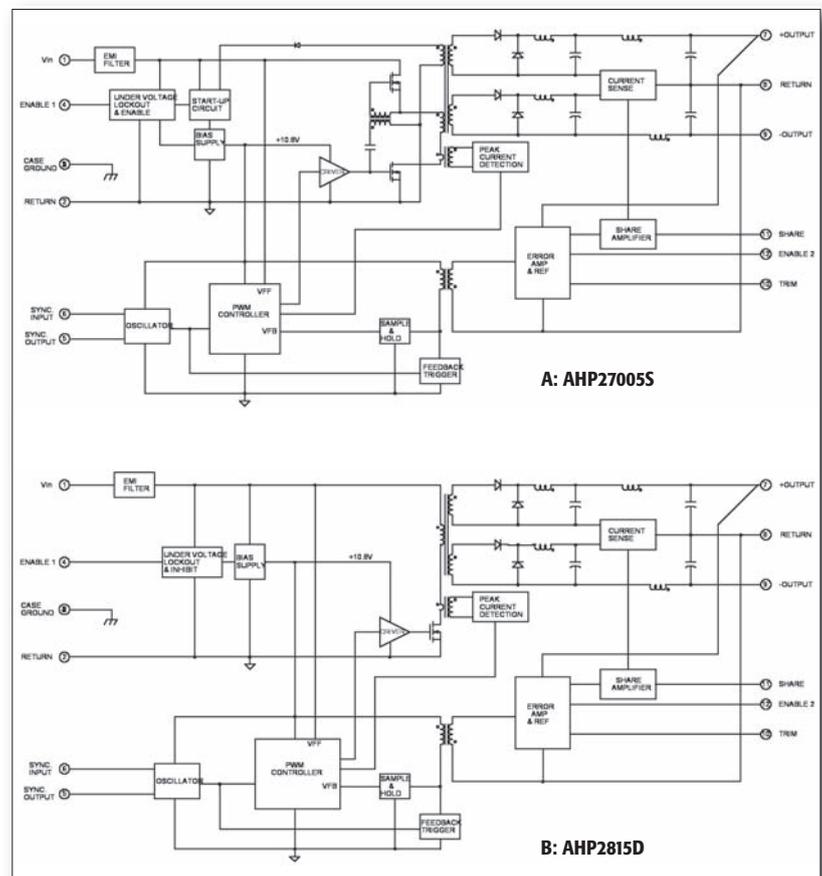
## A holistic approach

The current and future trends towards aircraft with more electric content and all-electric aircraft require a holistic approach for maintaining extremely high long term reliability, highest possible MTBF and lowest possible MTTR. With the migration to electric aircraft, there is a growing need for DC/DC converters to feed power at the right voltage and power level with all desired features and specifications to each electrical and electronic subsystem that replaces equivalent mechanical and hydraulic subsystems. The long term reliability and optimum availability and operation of such electrical and electronic subsystems

depend heavily upon the clean regulated power from such DC/DC converters. This

is due to the aircraft having standard electrical buses while every electronic subsystem throughout the aircraft characteristically may require a different voltage and current level, which the DC/DC converter provides when fed by standard electrical bus voltage. It also provides local isolation, filtering and regulation (Figure 1).

Figure 2 shows the block diagrams of two isolated DC/DC converters rated at 120W using a forward converter topology with built-in EMI filter. The AHP27005S (A) converts raw 270VDC into regulated



**Figure 2:** Block diagram of two isolated DC/DC converters (A: AHP27005S, B: AHP2815D)

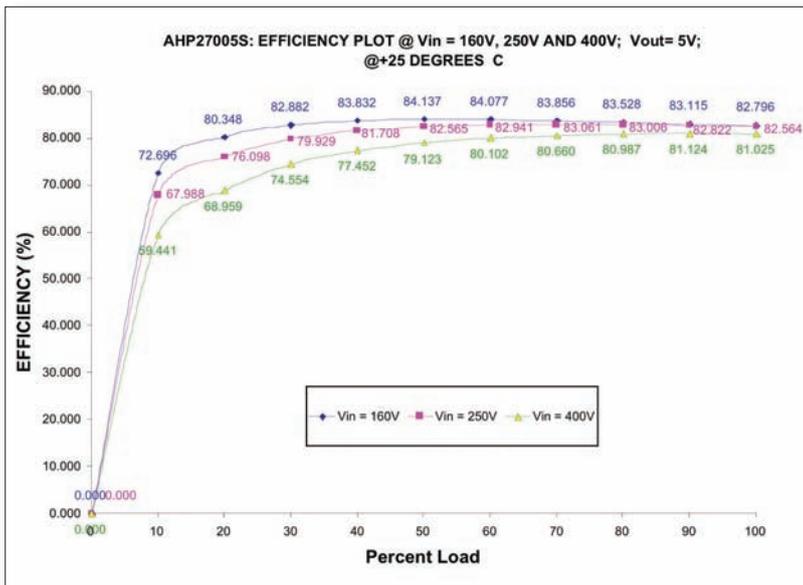


Figure 3: AHP27005S efficiency vs output load

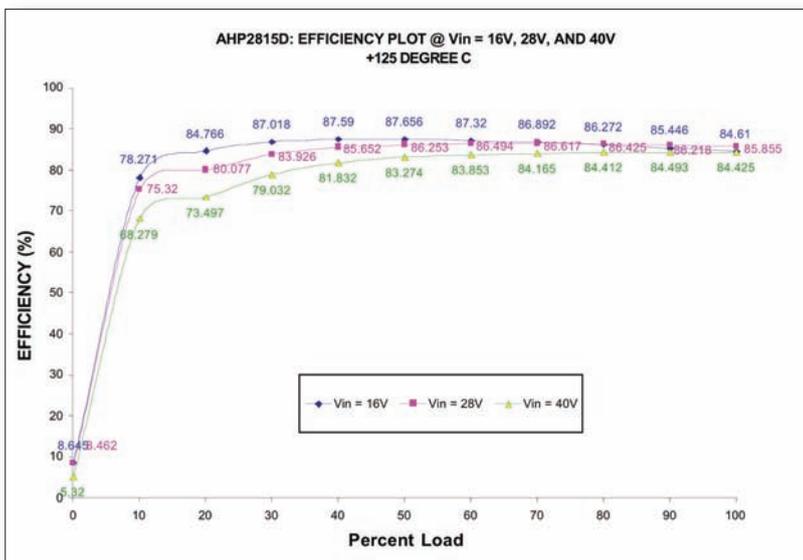


Figure 4: AHP2815D efficiency vs output load

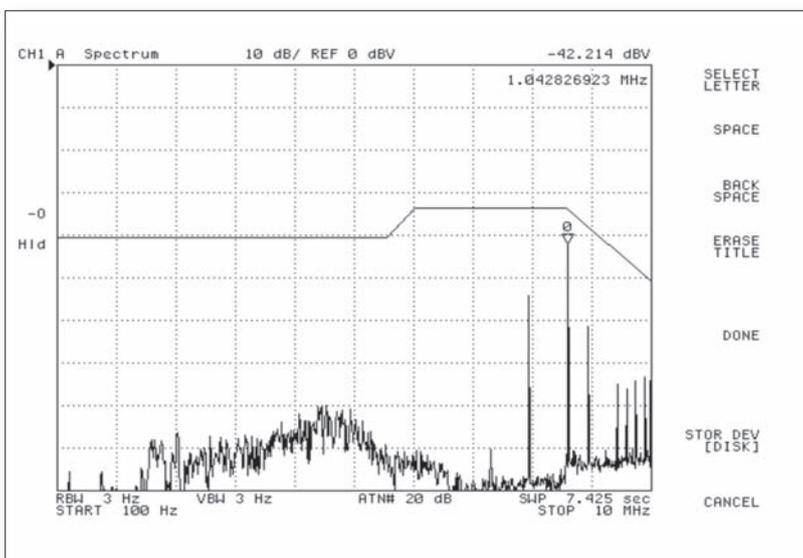


Figure 5: AHP27005S internally generated noise

5VDC. Note the use of two MOSFETs in series for withstanding higher line input voltage. The AHP2815D (B) converts 28VDC into regulated  $\pm 15$ VDC. The output regulation uses PWM techniques with controls for output regulation, over-load protection, UV detection and protection, soft start and input over-voltage protection.

The AHP series incorporates proprietary magnetic pulse feedback technology, providing optimum dynamic line and load regulation. This feedback system samples the output voltage at the pulse width modulator fixed clock frequency; nominally 550kHz. A primary and secondary referenced ENABLE circuit affords convenience and control to turn the converter ON and OFF at will, using an event or signal. The driver circuit boosts output from PWM to provide adequate di/dt to turn MOSFETs ON or OFF. A small gate drive transformer affords isolation for driving upper MOSFET in AHP270XX converters. The whole unit works in closed loop, ensuring fast dynamic response and stable performance.

**Meeting or exceeding specifications**

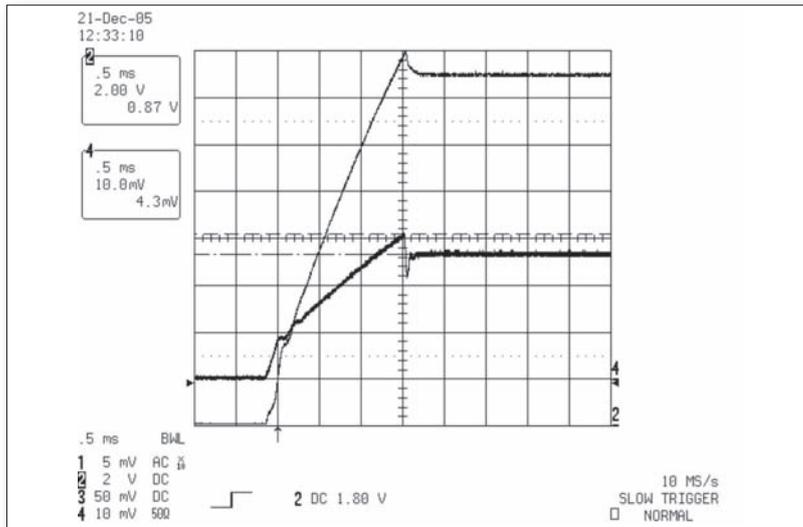
Technical specifications are the backbone of every DC/DC Converter. IR's converters are all measured at three temperatures viz -55°C, +25°C and +125°C to ensure they meet or exceed the specifications.

Very good voltage regulation under all dynamic line and load changes is a must. It is expressed in percentage versus line and/or load changes and should be  $\pm 1\%$  or better. Dynamic behavior is of utmost importance; meaning that extremely steady output voltage under fast changing load is required for all critical loads. More often than not, line input voltages do not change so abruptly; but immunity towards line transients is a must.

Another important consideration is efficiency. Higher efficiency results in less dissipation of heat in the converter, requiring a smaller heat sink and less power demand on the generator. As the number of such DC/DC converters increase, the impact of efficiency becomes all the more important. Typical efficiency curves for different input voltages and at different loads for AHP27005S are shown in Figure 3. Figure 4 shows efficiency curves of AHP2815D at +125°C.

Many sensitive electronic loads are susceptible to ripple, noise and spikes on the regulated DC bus. Ripple is specified as in mV and is weighted as a percentage of the output DC voltage. Internally generated noise must meet limits set in Figure 5 at full load.

When operating multiple series of DC/DC converters, system requirements



**Figure 6:**  
AHP27015S  
soft start  
test  
waveforms

often dictate operating them at a common frequency. These converters have both a synchronization input and output. The sync input port permits synchronization to any compatible external frequency source operating between 500kHz and 700kHz, while Sync output can provide a drive signal to drive five additional converters in synchronization. This is also useful when operating these converters in parallel to produce a higher power level at the same regulated DC bus voltage. When paralleling the converters it is important to keep in mind a few recommended set-up and operation guidelines to ensure equal current sharing amongst all paralleled converters.

Most of the electronics loads work more reliably when the DC power is supplied softly such that the voltage linearly rises to the final value in a few milliseconds. This feature is built in the AHP converters and Figure 6 shows slowly rising output voltage waveform with respect to time and resultant soft rise in input current.

It is necessary to protect each DC/DC converter's output from over-load or short circuit. This helps isolate a problem and protect the converter, load and other subsystems. Likewise, the DC/DC converter also has a protective feature to

prevent unduly loading the input bus or to be affected by any transients traveling in or out of the input bus. The AHP270XX series meet all performance requirements during normal voltage transients, abnormal steady state voltages and abnormal positive voltage transients. Operation of the devices will be interrupted during abnormal negative voltage transients, but the devices will resume normal operation once the bus voltage returns to a steady state value within range. Figure 7 shows that conducted noise waveforms are well below the limits.

Thermal and electrical stress analyses reveal adequate margins to ensure that all components in the DC to DC converter operate well below their allowable stress

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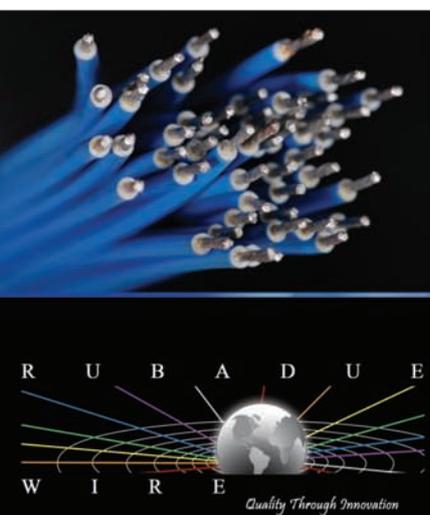
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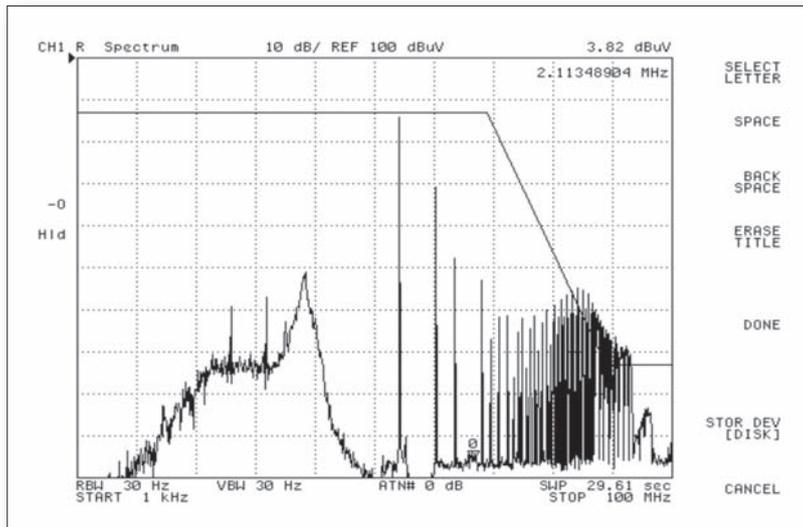
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**Figure 7: AHP27015S conducted emissions waveforms**

input, operating at 50% output power for vibration in accordance to Method 2026 of Mil-Std-883, test condition II, letter E, 14 hours per axis. The units are vibrated over a period of six total days, each axis takes two days. The maximum level is 18.7 grms.

### Conclusions

Present and future aviation, whether civil or military, will be subject to more and more adaptation of electronic subsystems replacing pneumatic, hydraulic and mechanical subsystems. Long term reliability is the primary focus of all these advances. Even though these electronic subsystems are intrinsically reliable they heavily depend upon a stable and extremely reliable DC power source. It is here that the DC/DC converters play their role.

limits. The AHP models can be qualified through 1000 hour Group C Life Test. Some models are qualified through 100 temperature cycles from -65°C to +150°C and 1000 hour life test.

The converters are hermetically packaged, utilizing copper core pins with rugged ceramic feed through to minimize resistive DC losses. The AHP270xxx converters are tested at 265V +/- 5VDC

# 30W Radiation Hardened POL Regulators

The latest introduction is the SBB series of non-isolated, radiation hardened Point-of-Load (POL) voltage regulators. The new devices are designed to maximize efficiency in space applications including satellites requiring long mission life up to 15 years or 100Krad of total ionizing dose (TID).

The SBB series delivers high efficiency of up to 89%, allowing the use of a smaller heatsink to reduce overall size and weight of the system. The new devices, suitable for designs using new digital signal processors, ASIC and FPGA technologies, feature 30W output power or output current of 14A. Standard outputs of 1.0V, 1.2V, 1.5V, 1.8V, 2.5V, and 3.3V can each be adjusted to  $\pm 10\%$  of a nominal output for precise output setting. Integrated input and output filters are also featured to ensure low noise performance for stand-alone operation without the need for external filter components.

With high efficiency performance well suited to the high power requirements of two-stage distributed power architecture design applications, the SBB Series addresses the need to reduce size and weight, as well as the increasing needs of FPGA and other digital circuitries for

increased bandwidth, data processing speed and the higher processing power requirements of digital electronics on-board spacecraft. The SBB Series was developed using proven space-level design methodology that includes discrete-based PWM controller and components with known radiation performance fully de-rated to the requirements of MIL-STD-1547.

Weighing less than 55 grams in a

compact form factor, other key features of the new devices include 4.5 to 5.5V input range, SEE LET (Heavy Ions) greater than 82 MeV.cm<sup>2</sup>/mg, under voltage lockout (UVLO), remote sense compensation, adjustable output voltage, power OK (POK) status, and remote on and off control.

**Radiation hardened POL regulators for space applications**



## SBB Series