PACIFIC® POWER SOURCE
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APPLICATION NOTE

Injecting DC Offset onto an AC Power Source Output using a Programmable DC Power Supply

Figure 1: 345AMX Linear AC Power Source

Figure 2: Adaptive Power Systems, Model DCP60-20 DC Supply

Abstract

This application note reports the results of the Adaptive Power Systems, DC Power Supply, Model DCP60-20's ability to provide a controlled level of DC offset on the output of a Pacific Power Source Programmable AC Power Source. Since DC offsets for avionics compliance testing are generally very low voltage, the lowest available voltage model DC power supply is recommended to obtain optimal resolution and accuracy of the DC offset voltage applied. The DCP series does offer a 15V voltage range model but none was available for this test so a 60V model was used instead which still provides 10mV programming resolution.

The DCP series was chosen for its high power density and is available in either 1200W or 2400W power levels. Low voltage, higher current DCP models support large DC currents as may be required for these tests. It is important that the DC power supply used can support the DC current drawn by the unit under test.

Tests were performed with a Pacific Power Source model 345AMX, linear AC power source model (Figure 1). AC source operating mode was set three phase but the offset tests were performed on phase A only with single phase offset test performed at 5.0 amps between phase A and neutral.

Introduction

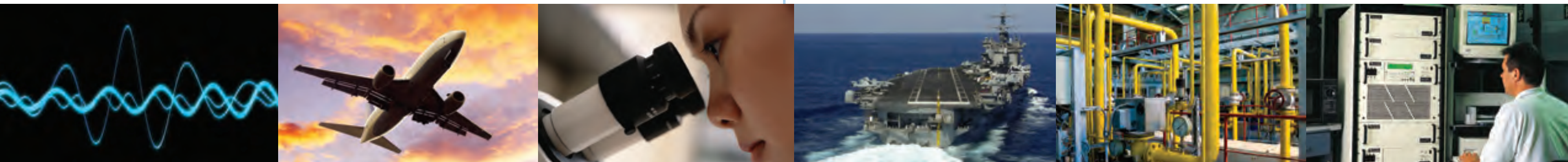
Most AC powered products are tested using an AC Power Source capable of generating the required voltage and frequency output. Under normal conditions, an AC power source does not exhibit any DC offset as DC voltage and current can significantly impact AC input transformers commonly found at the power input stage of an AC powered product.

Transformers can go into saturation when presented with a certain amount of DC voltage or current. Furthermore, the DC resistance of transformers is generally low compared to their AC impedance. This can result in significant DC currents causing overheating in the transformer.

To generate DC offset directly from an AC Power Source, the AC Source must have the ability to control and generate both an AC output and a DC offset. While there are AC Power Sources on the market that have this capability, such units can present some drawbacks from an AC Power Source output quality perspective:

- DC voltage ranges on AC Power Sources that support a DC mode are generally 0 to 200V or 0 to 400V. Programming a 100mV output on such a high voltage range is generally inaccurate. Even if the unit has 0.1% accuracy, the error would still be ±200mV on a 200Vdc range.
- AC Power Sources generally have more output noise than a typical high power DC supply as they lack the bulk output storage capacitors. On some models, the RMS level of the output noise can be higher than the required DC offset value.

The combination of a dedicated AC Power Source to produce the AC voltage and a dedicated DC supply to produce the DC offset does not suffer from these trade-offs. The tests in this report were conducted using such an arrangement. Additionally, since each of the two power sources (AC source + DC supply) used to create this AC+DC combination is optimized for its specific purpose; the resulting output can be more precise and repeatable.



DC Offset Requirements in Avionics Compliance Test Standards

To determine if the Equipment Under Test (EUT) is capable of handling specific levels of DC offset on the AC power bus, several avionics test standards require the application of a small amount of DC on the AC power line.

The AC frequency used during these tests is either 400Hz fixed or ranges from 360Hz to 800Hz (wild frequency). An overview of avionics test standards requiring these types of tests and their required DC test levels are shown in Table 1.

Pacific's UPS Test Manager test executive software may be used to automate many of these tests.

Test Standard	Power Groups	Nominal AC Voltage	DC Offset	Accuracy	Duration
RTCA / DO160					
Rev F & G	All Power Groups Sec 16.5.1.7 Figure 16-9,16-10	115Vac L-N / 200 L-L 400 Hz, 360-800 Hz	+0.2Vdc -0.2Vdc	+0.04/-0.00Vdc +0.00/-0.02Vdc	30 minutes
		230Vac L-N/ 400V L-L 400 Hz, 360-800 Hz	+0.2Vdc -0.2Vdc	+0.04/-0.00Vdc +0.00/-0.02Vdc	30 minutes
Airbus ABD0100.1.8 (A380)					
Issue E	Table A: CF Appendix 4	115Vac L-N/ 200V L-L 400 Hz	+0.3Vdc -0.3Vdc	±0.03Vdc ±0.03Vdc	30 minutes
	Table B: CF Appendix 4	26Vac, 400 Hz	+0.07Vdc -0.07Vdc	±0.01Vdc ±0.01Vdc	30 minutes
	Table C: VF Appendix 4	115Vac L-N/ 200V L-L 360-800 Hz	+0.3Vdc -0.3Vdc	±0.03Vdc ±0.03Vdc	30 minutes
Airbus ABD0100.1.8.1 (A350)					
Issue B,B1,C	SCF111 / TCF111 Figure B16, B17	115Vac L-N/ 200V L-L 400 Hz	+0.3Vdc -0.3Vdc	±0.03Vdc ±0.03Vdc	30 minutes
	SCFH111 / TCFH111 Figure B16, B18	230Vac L-N/ 400V L-L 400 Hz	+0.6Vdc -0.6Vdc	±0.06Vdc ±0.06Vdc	30 minutes
	SVF112 / TVF112 Figure B16, B17	115Vac L-N/ 200V L-L 360-800 Hz	+0.6Vdc -0.6Vdc	±0.03Vdc ±0.03Vdc	30 minutes
	SVFH112 / TVFH112 Figure B16, B18	230Vac L-N/ 400V L-L 360-800 Hz	+0.6Vdc -0.6Vdc	±0.06Vdc ±0.06Vdc	30 minutes
Airbus AMD-24 (A400M)					
Issue B & C	SCF109 / TCF109 Appendix B	115Vac L-N/ 200V L-L 400 Hz	+0.3Vdc -0.3Vdc	±0.03Vdc ±0.03Vdc	30 minutes
	SVF110 / TVF110 Appendix B	115Vac L-N/ 200V L-L 360-800 Hz	+0.3Vdc -0.3Vdc	±0.03Vdc ±0.03Vdc	30 minutes
Boeing 787B3-0147 (787)					
Rev A to C	All AC Power Groups	See Boeing standard for details			
MIL-STD 704					
Rev A to F	SAC108 / TAC108	115Vac L-N/ 200V L-L 400 Hz	A: +0.1V B:-0.1V	Not specified	30 minutes
	SVF108 / TVF108	115Vac L-N/ 200V L-L 360-800 Hz	A: +0.1V B:-0.1V	Not specified	30 minutes
Rev F			A: +0.1V B:-0.1V	Not specified	30 minutes

Table 1: Avionics Test Standards and DC Offset Test Requirement

Equipment Used

The test equipment used to perform the tests described in this test report are listed in Table 2 below.

Description	Manufacturer	Model	S/N
AC Source, 4500VA	Pacific Power Source	345AMXT	n/a
DC Supply, 60V, 20A	Adaptive Power Systems	DCP60-20	1428537
Digital Storage Oscilloscope	Rigol	DS4024	DS4A14200452
Digital Multi Meter, 6.5 digit	Rigol	DM3068	DM3O141900169

Table 2: List of Test Equipment Used

Test Setup

The injection of DC offset into the AC Power Source output requires that the DC supply be electrically in series with the AC Power Source output. Thus, the DC supply is connected between the AC Power Source and the load (EUT). For a three phase AC load test, this requires three DC supplies, one on each phase.

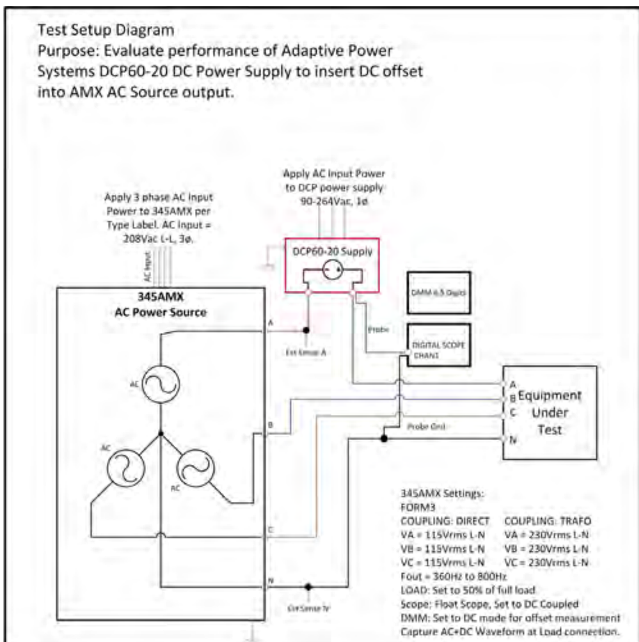


Figure 3: Test Setup for Phase A DC Offset Test

The electrical connection diagram for this application is shown in the figure 3. Measurements were taken on phase A.

For best results, distances and cable lengths between the AC source and the DC supplies should be kept as short as possible. Especially when testing at 800Hz, skin effects occurring in wiring can significantly increase impedance and impact load regulation performance.

Polarity Reversal

The setup shown here applies a positive DC offset. For negative DC offset, the DC power supply output wiring must be reversed. Since each tests runs for 30 mins or more, this reversal of wiring can be done between tests with all power off.

Non Offset Tests

Running high levels of AC current at 360, 400 or up to 800Hz puts strain on the output capacitors of the DC power supply used to generate the DC offset. For all other tests where no DC offset is required, the DC supply connection should be removed. (Bypassed).

DC Offset Measurement Setup

Measurements of DC offset under various load conditions were made on phase A. The digital storage scope was used to verify the presence of an AC output waveform.

A captured waveform is shown in Figure 4. The actual DC offset is very difficult to measure with any meaningful accuracy on a storage scope as the DC offsets are so small compared to the AC voltage present. Instead, a 6 ½ digit DMM was used in DC mode to measure the actual DC Offset.

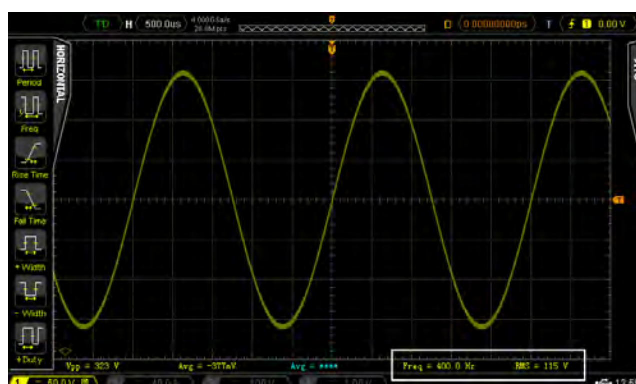


Figure 4: Captured AC+DC output at 115Vac LN +200 mVdc

Measurement Data

Data was taken at various key frequency settings and AC+DC voltage combinations based on the requirements listed in Table 1: Avionics Test Standards and DC Offset Test Requirement.

Measurement data shown in the table was made using the 6 ½ DMM only. Refer to Figure 5 for a photo of the DMM screen measuring the DC offset. The summary test data recorded for the various AC+DC combinations is shown in Table 3.

Figure 5: DMM Reading of DC Offset at 230Vac, 800Hz and 600mV offset

Conclusion

The use of a low voltage Adaptive Power Systems DC power supply that supports sufficient current to support the equipment under test, provides a cost effective and simple way to meet AC+DC test requirements. This application note illustrates single phase test mode. For three phase applications, three DC supplies will be required to apply DC offset to all phases at the same time.

For information on Adaptive Power Systems DC Power supplies, contact APS at sales@adaptivepower.com or visit the APS website. www.adaptivepower.com

Programmed Frequency	Programmed AC Voltage L-N	Programmed DC Offset	Measured DC Offset	Allowed Error	Actual Error (abs)	In Spec.
400 Hz	115 Vac	-0.200 Vdc	-0.209 Vdc	±0.020	0.009	yes
400 Hz	115 Vac	+0.200 Vdc	+0.208 Vdc	±0.020	0.008	yes
800 Hz	115 Vac	-0.300 Vdc	-0.208 Vdc	±0.020	0.008	yes
800 Hz	115 Vac	+0.300 Vdc	+0.205 Vdc	±0.020	0.005	yes
400 Hz	230 Vac	-0.600 Vdc	-0.612 Vdc	±0.060	0.012	yes
400 Hz	230 Vac	+0.600 Vdc	+0.604 Vdc	±0.060	0.004	yes
800 Hz	230 Vac	-0.600 Vdc	-0.615 Vdc	±0.060	0.015	yes
800 Hz	230 Vac	+0.600 Vdc	+0.619 Vdc	±0.060	0.019	yes

Table 3: Measured DC Offset Data Table

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