

Aircraft Electrical Power Testing

By

Bill Gatheridge, Product Manager
Yokogawa Corporation of America

Overview: RTCA Inc, (Radio Technical Commission for Aeronautics) Washington, DC, is a non-profit corporation that functions as a Federal Advisory Committee to the Federal Aviation Administration (FAA). Its recommendations serve as the basis for policy, program and regulatory decisions. Sub-committee SC-135 produces the RTCA/DO-160E document titled *Environmental Conditions and Test Procedures for Airborne Equipment*. This document defines the test conditions and procedures for testing airborne equipment and is the standard by which Boeing, Airbus and other manufacturers require avionics components and sub-systems to be tested.

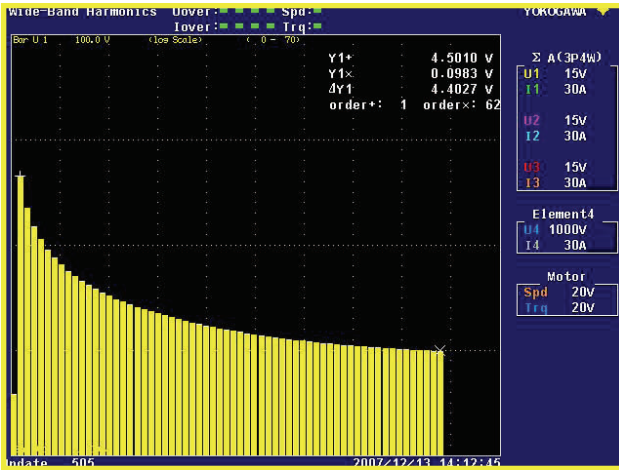
Section 16, Power Input, includes new tests to address the issues of AC Harmonic Distortion and Variable Frequency AC Power Systems. Section 16.5.1.8 defines the AC Voltage distortion test requirements. Section 16.7.1.2 defines the AC Current distortion test requirements. These requirements cover both Single Phase and Three Phase equipment. Voltage and current measurements and harmonic analysis for each phase must be performed. Aircraft electrical systems are defined in three categories. A(CF) designates Constant Frequency 400 Hz AC power system. A(NF) is the Narrow Variable Frequency AC power system with a frequency range of 360 to 650 Hz. A(WF) designates the Wide Variable Frequency AC power system with a frequency range of 360 to 800 Hz.

These tests require the measurement of the current and voltage harmonic components of magnitude and phase (optional) over the frequency band. DO160E requires harmonic analysis over 40 orders from the fundamental frequency. Requirements from Boeing and Airbus may require harmonic analysis out to 50 orders. The latest standard from Boeing, B787 Power Quality Specifications, requires harmonic analysis out to 62 orders from a fundamental frequency up to 800 Hz. Certain requirements by Boeing and Airbus may require looking at the harmonic spectrum out to 150 kHz.

Solution: The Yokogawa precision Power Analyzers provide an excellent solution for making the required Voltage and Current measurements and harmonic analysis of magnitude and phase for each harmonic order. The WT3000, PZ4000 and WT1600/Z are capable of making THD and Harmonic Analysis up to 50 orders on fundamental frequencies of 800 Hz and higher. Measurement accuracy and analysis functions meet or exceed the requirements outlined by the DO-160E test standard. Analysis capability up to 62 orders on an 800 Hz fundamental are available with Yokogawa's Model WT3000 Power Analyzer.



Yokogawa Model WT3000 Power Analyzer



Sample Harmonic Spectrum of 62 Orders

The Power Analyzer can provide complete power measurement functions on the avionic component, as required by DO-160E, such as the Voltage, Current, Real Power (W), Apparent Power (VA) Reactive Power (VAR), Power Factor and efficiency, over the operating frequency of the aircraft power system. The advantage of using the Power Analyzer is that both AC Power and Harmonic Analysis functions can be performed in one instrument. Also the Power Analyzer is designed for making high accuracy Current measurements which cannot easily be done with other types of harmonic analysis instruments.

Yokogawa can also provide precision high frequency Current Transformers with a wide band frequency response out to 150 kHz for applications requiring high current measurements.

Harmonic magnitude values for both Voltage and Current must be measured, and the Total Harmonic Distortion (THD) calculated, as well as the Individual Harmonic Content (Harmonic Distortion Factor %hdf) expressed as percentage of the fundamental. The Yokogawa Power Analyzers provide a numeric data display of each of the harmonic orders with magnitude and %hdf measurements.

Wide-Band Harmonics		Uover: <input type="checkbox"/>	Spd: <input type="checkbox"/>	YOKOGAWA			
change items		Iover: <input type="checkbox"/>	Trq: <input type="checkbox"/>				
PLL	U1	Or.	U1 [V]	hdf[%]	Or.	U1 [V]	hdf[%]
Freq	800.01 Hz	Tot.	5.7683		dc	-0.0377	-0.653
U1	5.7683 V	1	4.5022	78.051	2	2.2537	39.071
I1	0.0023 A	3	1.5034	26.063	4	1.1290	19.573
P1	-0.001 W	5	0.9042	15.675	6	0.7546	13.081
S1	0.001 VA	7	0.6476	11.227	8	0.5675	9.838
Q1	0.000 var	9	0.5052	8.758	10	0.4554	7.895
λ1	-0.92585	11	0.4147	7.190	12	0.3810	6.606
φ1	G 157.797 °	13	0.3524	6.109	14	0.3279	5.685
Uthd1	62.511 %	15	0.3067	5.317	16	0.2880	4.993
Ithd1	32.300 %	17	0.2718	4.711	18	0.2575	4.464
Pthd1	57.009 %	19	0.2446	4.240	20	0.2331	4.041
Uthf1	119.447 %	21	0.2227	3.861	22	0.2131	3.694
Ithf1	9.680 %	23	0.2043	3.542	24	0.1965	3.406
Utif1	---O F---	25	0.1895	3.285	26	0.1829	3.170
Itif1	424.862	27	0.1767	3.063	28	0.1710	2.964
		29	0.1658	2.874	30	0.1609	2.790
		31	0.1564	2.711	32	0.1521	2.636
		33	0.1482	2.569	34	0.1445	2.506
		35	0.1412	2.448	36	0.1380	2.392
		37	0.1350	2.340	38	0.1322	2.291
		39	0.1295	2.245	40	0.1270	2.202

Wide-Band Harmonics		Uover: <input type="checkbox"/>	Spd: <input type="checkbox"/>	YOKOGAWA	
change items		Iover: <input type="checkbox"/>	Trq: <input type="checkbox"/>		
Or.	U1 [V]	hdf[%]	Or.	U1 [V]	hdf[%]
Tot.	5.7683		dc	-0.0377	-0.653
41	0.1247	2.161	42	0.1225	2.124
43	0.1204	2.087	44	0.1185	2.054
45	0.1167	2.023	46	0.1150	1.994
47	0.1132	1.962	48	0.1116	1.935
49	0.1102	1.910	50	0.1088	1.886
51	0.1075	1.864	52	0.1063	1.843
53	0.1052	1.824	54	0.1041	1.805
55	0.1031	1.787	56	0.1022	1.771
57	0.1013	1.756	58	0.1004	1.741
59	0.0998	1.730	60	0.0990	1.717
61	0.0982	1.703	62	0.0977	1.694
63	---	---	64	---	---
65	---	---	66	---	---
67	---	---	68	---	---
69	---	---	70	---	---
71	---	---	72	---	---
73	---	---	74	---	---
75	---	---	76	---	---
77	---	---	78	---	---
79	---	---	80	---	---

Sample Numeric Display of the harmonic Voltage magnitudes and Individual Harmonic Content (hdf%) for each harmonic order out to 62 orders.

The below table provides a brief outline of the DO-160E requirements and the solution provided by the various Yokogawa Power Analyzers.

	Guideline	WT3000	PZ4000	WT1600/Z
Accuracy	5%	0.25% @ 400 Hz	0.4% @ 400 Hz	1.7% @ 400 Hz
Sample Rate	100 kHz or greater	100 kHz or greater	100 kHz or greater	51.2 kHz @ 400 Hz to 102.4 kHz @ 800 Hz.
Time Window	0.05 Sec or longer	0.05 Sec or longer	0.05 Sec or longer	0.05 Sec or longer
Filter	25-50 kHz	5.5 or 50 kHz	20 kHz	5.5 kHz
Window	Rectangular, Hanning, Hamming, Blackman-Harris	Rectangular	Rectangular	Rectangular
Harmonic Content	Current magnitude for 400 Hz multiple frequencies up to 150 kHz	THD & Harmonic Analysis 50 Orders up to 1 kHz Fundamental FFT Function up to 100 kHz	THD & Harmonic Analysis 50 Orders up to 1.28 kHz Fundamental FFT Function up to 2.5 MHz	THD & Harmonic Analysis 50 Orders up to 1 kHz Fundamental
Boeing 787 Power Quality Harmonic Content	THD & Harmonic Analysis of Current and Voltage magnitude up to 62 Orders at 800 Hz Fundamental	THD & Harmonic Analysis up to 62 Orders up to 800 Hz Fundamental	THD & Harmonic Analysis 50 Orders up to 1.28 kHz Fundamental FFT Function up to 2.5 MHz	THD & Harmonic Analysis 50 Orders up to 1 kHz Fundamental

Conclusion: You must choose the proper type of test instrumentation to make accurate Current, Voltage and Power measurements, and AC Harmonic Distortion analysis on aircraft electrical systems and equipment, as defined by DO-160E, Airbus ABD0100.1.8, and Boeing B787 Power Quality Specifications.

Yokogawa precision power analyzers offer a measurement solution that will meet or exceed the industry test requirements and provide the following benefits:

- **Ease of Use**
- **Measurements made Quickly, Conveniently & Accurately**
- **DC and AC Current, Voltage, Power and Harmonic measurements in one instrument**
- **Harmonic Analysis up to 62 Orders on 800 Hz fundamental to meet latest Boeing requirements**
- **Power Analyzers are covered by a 3-year warranty**
- **All service performed at factory headquarters in Newnan (Atlanta) Georgia.**
- **Full NIST Traceable Calibration provided at factory headquarters in Newnan, GA**

Yokogawa Corporation of America
 2 Dart Road, Newnan, GA 30265
 Phone 800-888-6400
 E-Mail info@us.yokogawa.com