SCOPE OF ACCREDITATION

U.S. ARMY PRIMARY STANDARDS LABORATORY

Approved: 30 April 2001 **A2LA Lab Code 118285, Certificate # 1256.01** Valid To: 31 December 2002

Measurement Parameter	Range	Best 95% (k=2) Uncertainties	Comments
DC VOLTAGE			
	100 mV	4 ppm	Josephson Array System, and voltage ratio
	1 V	0.1 ppm	
	10 V	0.04 ppm	
	10 - 100 V	4 ppm	
	100 - 1000 V	5 ppm	
DC RESISTANCE			
	0.02 - 1 mΩ	50 ppm	Direct comparison and current comparator
	1 - 10 mΩ	1.0 ppm	
	0.1 - 1 Ω	0.3 ppm	
	1 - 10 Ω	0.5 ppm	
	10 - 100 Ω	1.0 ppm	
	0.1 - 10 kΩ	1.5 ppm	
	10 - 100 kΩ	2.0 ppm	
	0.1 - 1 MΩ	4.0 ppm	
	1 - 100 MΩ	0.03 %	
	1 GΩ	0.15 %	
	10 GΩ	0.15 %	
	100 GΩ	0.3 %	
	1 TΩ	0.3 %	
INDUCTANCE			
	0.1 mH	0.12 %	Comparison with reference standards using Gen Rad RLC Digibridge
	1 mH	0.03 %	
	10 mH	0.025 %	
	100 mH	0.03 %	
	1 H	0.06 %	
	10 H	0.24 %	
CAPACITANCE			
	10 pF	8 ppm	Comparison with reference standards using Andeen-Hagerling 2500A
	100 pF	8 ppm	
	1000 pF	20 ppm	
AC RATIO			
	400 Hz and 1 kHz	0.5 ppm	Ratio techniques
RISETIME			
	> 15 ps Tr	7 ps	Comparison with standard pulse generators using a digital sampling system
VOR BEARING ANGLE			
	0 °	0.01 °	Comparison with NIST VOR standard
	0 - 360 °	0.02 °	

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AC/DC DIFFERENCE				
Voltage:	1 - 1000 V	20 Hz - 50 kHz	0.005 %	Intercomparison with thermal voltage converters, Fluke 792 and 5790, and Datron 4920
	1 - 1000 V	100 kHz	0.01 %	
	1 - 20 V	1 MHz	0.02 %	
	1 - 50 V	3 MHz	0.15 %	
	1 - 50 V	10 MHz	0.15 %	
	1 - 50 V	30 MHz	0.30 %	
	1 - 50 V	100 MHz	1.5 %	
Current:	10 mA to 1 A	10 kHz	0.010 %	
	2.5 - 10 A	10 kHz	0.015 %	
CURRENT RATIO AND PHASE				
Ratio and phase at 60 Hz	2:1, 4:1, 5:1, 10:1, 20:1	60 Hz	0.0025 % (ratio) 0.2' (phase)	Current ratio techniques using Guildline current transformer test set
RF POWER (Calibration Factor, k_b)				
Coaxial type N connector:	0.1 - 10 mW	100 kHz - 18 GHz	0.7 - 1.0 %	Power ratio comparison with standard thermistor mounts
Coaxial 3.5 mm connector:	0.1 - 10 mW	0.01 - 26.5 GHz	1.7 - 1.9 %	
Coaxial 2.92 mm (K) connector:	0.1 - 10 mW	0.01 - 40.0 GHz	2.2 - 3.5 %	
H band (WR-112) waveguide:	0.1 - 10 mW	7.0 - 10.0 GHz	2.0 %	
X band (WR-90) waveguide:	0.1 - 10 mW	8.2 - 12.4 GHz	1.5 %	
Ku band (WR-62) waveguide:	0.1 - 10 mW	12.4 - 18.0 GHz	1.3 %	
K band (WR-42) waveguide:	0.1 - 10 mW	18.0 - 26.5 GHz	1.5 %	
Ka band (WR-28) waveguide:	0.1 - 10 mW	26.5 - 40.0 GHz	1.5 %	
Q band (WR-22) waveguide:	0.1 - 4 mW	43.0 - 45.0 GHz	3.0 %	
V band (WR-15) waveguide:	0.1 - 1 mW	58.0 - 62.0 GHz	2.0 %	
W band (WR-10) waveguide:	0.1 - 3 mW	93.0 - 96.0 GHz	3.0 %	
PULSED POWER				
Coaxial with type N connector	0.1-5 mW peak power	0.01 - 18.0 GHz	0.2 dB	Power ratio comparison with std thermistor mts
RF WATTMETERS				
Terminating - Coax with type N conn	1 - 180 W	2 - 1000 MHz	3.0 %	Power ratio comparison with std thermistor mts, using an automated Brammall cascaded pwr ratio technique
- Coax with 14 mm conn	1 - 180 W	2 - 1000 MHz	3.0 %	
Thruline - Coax with type N conn	1 - 180 W	2 - 1000 MHz	3.0 %	
- Coax with 14 mm conn	1 - 180 W	2 - 1000 MHz	3.0 %	
THERMAL NOISE				
Coaxial with type N connector	5 - 40 dB ENR	0.03 - 18.0 GHz	0.2 - 0.4 dB	Ratio comparison with standard noise sources
Coaxial with 3.5 mm connector	5 - 40 dB ENR	0.03 - 26.5 GHz	0.3 - 0.7 dB	
X band (WR-90) waveguide	5 - 40 dB ENR	8.2 - 12.4 GHz	1.0 dB	

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POWER RATIO				
Coax type N, 7mm, 14 mm connector:	0 - 50 dB	300 kHz - 10 MHz	2.5 %	
Coax type N, 7 mm connector:	0 - 50 dB	0.01 - 18.0 GHz	0.07 - 0.6 dB	
Coax 3.5 mm connector:	0 - 50 dB	0.01 - 26.5 GHz	0.15 - 1.0 dB	
Coax 2.92 mm (K) connector:	0 - 50 dB	0.01 - 40.0 GHz	0.15 - 1.0 dB	
Coaxial 2.4 mm connector:	0 - 50 dB	0.01 - 40.0 GHz	0.15 - 1.0 dB	
X band (WR-90) waveguide:	0 - 50 dB	8.2 - 12.4 GHz	0.02 - 0.11 dB	Power ratio, Brammall cascaded power ratio
Ku band (WR-62) waveguide:	0 - 50 dB	12.4 - 18.0 GHz	0.02 - 0.14 dB	
K band (WR-42) waveguide:	0 - 50 dB	18.0 - 26.5 GHz	0.02 - 0.15 dB	
Ka band (WR-28) waveguide:	0 - 50 dB	26.5 - 40.0 GHz	0.05 - 0.25 dB	
K band (WR-42) waveguide:	0 - 50 dB	33.0 - 50.0 GHz	0.1 - 1.0 dB	
K band (WR-42) waveguide:	0 - 50 dB	50.0 - 75.0 GHz	0.1 - 1.0 dB	
K band (WR-42) waveguide:	0 - 50 dB	93.0 - 96.0 GHz	0.1 - 1.0 dB	
IMPEDANCE (Reflection Coefficient, S_{11})				
S_{11} magnitude:				
Coax type N connector:	0.02 - 0.6	0.01 - 18.0 GHz	0.005 - 0.020	
Coaxial 14 mm connector:	0.02 - 0.6	0.01 - 8.0 GHz	0.005 - 0.015	
Coaxial 7 mm connector:	0.02 - 0.6	0.01 - 18.0 GHz	0.005 - 0.015	
Coaxial 3.5 mm connector:	0.02 - 0.6	0.01 - 26.5 GHz	0.010 - 0.030	
Coax 2.92 mm (K) connector:	0.02 - 0.6	0.01 - 40.0 GHz	0.010 - 0.030	Reflectometer, network analyzer, 6-port
Coaxial 2.4 mm connector:	0.02 - 0.6	0.01 - 50.0 GHz	0.010 - 0.030	
X band (WR-90) waveguide:	0.02 - 0.6	8.2 - 12.4 GHz	0.006	
Ku band (WR-62) waveguide:	0.02 - 0.6	12.4 - 18.0 GHz	0.006	
K band (WR-42) waveguide:	0.02 - 0.6	18.0 - 26.5 GHz	0.01	
Ka band (WR-28) waveguide:	0.02 - 0.6	26.5 - 40.0 GHz	0.01	
S_{11} phase:				
Coaxial type N connector:	0 - 360 °	0.01 - 18.0 GHz	0.5 - 180 °	
Coaxial 7 mm connector:	0 - 360 °	0.01 - 18.0 GHz	0.5 - 180 °	
Coaxial 3.5 mm connector:	0 - 360 °	0.01 - 26.5 GHz	0.5 - 180 °	
Coaxial 2.92 mm (K) connector:	0 - 360 °	0.01 - 40.0 GHz	0.5 - 180 °	
Coaxial 2.4 mm connector:	0 - 360 °	0.01 - 50.0 GHz	0.5 - 180 °	Network analyzer, 6-port
X band (WR-90) waveguide:	0 - 360 °	8.2 - 12.4 GHz	0.6 - 180 °	
Ku band (WR-62) waveguide:	0 - 360 °	12.4 - 18.0 GHz	0.6 - 180 °	
K band (WR-42) waveguide:	0 - 360 °	18.0 - 26.5 GHz	0.6 - 180 °	
Ka band (WR-28) waveguide:	0 - 360 °	26.5 - 40.0 GHz	0.6 - 180 °	

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Measurement Parameter		Range	Best 95% (k=2) Uncertainties	Comments
ATTENUATION (S_{21})				
S_{21} magnitude:				
Coaxial type N connector:	0 - 80 dB piston	30 MHz	$0.01 + 0.001 \times \lvert S_{21} \rvert$ dB	
Coaxial type N connector:	0 - 60 dB	0.01 - 18.0 GHz	0.07 - 0.6 dB	
Coaxial 7 mm connector:	0 - 60 dB	0.01 - 18.0 GHz	0.06 - 0.5 dB	
Coaxial 3.5 mm connector:	0 - 50 dB	0.01 - 26.5 GHz	0.15 - 1.0 dB	
Coaxial 2.92 mm (K) connector:	0 - 50 dB	0.01 - 40.0 GHz	0.06 - 1.0 dB	Reflectometer, network analyzer, 6-port
Coaxial 2.4 mm connector:	0 - 50 dB	0.01 - 50.0 GHz	0.15 - 1.0 dB	
X band (WR-90) waveguide:	0 - 50 dB	8.2 - 12.4 GHz	0.04 - 0.17 dB	
Ku band (WR-62) waveguide:	0 - 50 dB	12.4 - 18.0 GHz	0.04 - 0.17 dB	
K band (WR-42) waveguide:	0 - 40 dB	18.0 - 26.5 GHz	0.04 - 0.17 dB	
Ka band (WR-28) waveguide:	0 - 40 dB	26.5 - 40.0 GHz	0.04 - 0.17 dB	
S_{21} phase:				
Coaxial type N connector:	0 - 360 °	0.01 - 18.0 GHz	0.2 - 20 °	
Coaxial 7 mm connector:	0 - 360 °	0.01 - 18.0 GHz	0.2 - 20 °	
Coaxial 3.5 mm connector:	0 - 360 °	0.01 - 26.5 GHz	0.2 - 20 °	
Coaxial 2.92 mm (K) connector:	0 - 360 °	0.01 - 40.0 GHz	0.2 - 20 °	Network analyzer, 6-port
Coaxial 2.4 mm connector:	0 - 360 °	0.01 - 50.0 GHz	0.2 - 20 °	
X band (WR-90) waveguide:	0 - 360 °	8.2 - 12.4 GHz	0.2 - 20 °	
Ku band (WR-62) waveguide:	0 - 360 °	12.4 - 18.0 GHz	0.2 - 20 °	
K band (WR-42) waveguide:	0 - 360 °	18.0 - 26.5 GHz	0.2 - 20 °	
Ka band (WR-28) waveguide:	0 - 360 °	26.5 - 40.0 GHz	0.2 - 20 °	
ELECTROMAGNETIC FIELDS				
Electromagnetic field strength	20 - 62 V/m	300 kHz - 45 GHz	2.0 dB	Anechoic chamber, TEM cell
EM power density (probes, meters)	0.1 - 1.0 mW/cm^2	300 kHz - 45 GHz	2.0 dB	Anechoic chamber, TEM cell
ANTENNA GAIN				
Pyramidal standard gain horns	10 - 25 dB	2.0 - 40.0 GHz	Device & range dependent (typically ± 2.0 dB)	Dimensional calculation
FREQUENCY				
Frequency		0.1 MHz	1×10^{-12}	Direct comparison with master oscillator using NIST-developed frequency measurement technique
		1 MHz	1×10^{-12}	
		5 MHz	1×10^{-12}	
		10 MHz	1×10^{-12}	
Frequency counters		to 110 GHz	0.1 ppm	xN comparison with master oscillators

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Measurement Parameter	Range	Best 95% (k=2) Uncertainties	Comments
DIMENSIONAL			
Gage Blocks	0.01 to 4 in 5 to 20 in	4 µin (3.3 + 1.5L) µin	Mechanical comparison
Thread and Gear Wires	4 to 80 pitch	20 µin	Measuring machine
Precision Balls	To 1 in	20 µin	Measuring machine
Angle Blocks	1' to 45°	1.0 arc second	Autocollimators, angle blocks
Optical Tooling - Theodolites and Transits	From 4 ft	1.0 arc second	Target collimator
Flatness - (e.g., Optical Flats)	Up to 5 in diameter	2 µin	Interferometer
MECHANICAL			
Mass	1 - 10 mg	0.4 µg	By comparison to Class 1 Type 2 standard weights, using precision single pan balance
	20 - 100 mg	0.7 µg	
	200 mg - 1 g	1.0 µg	
	2 - 5 g	2.5 µg	
	10 - 20 g	9.9 µg	
	30 - 100 g	14 µg	
	200 g - 1 kg	37 µg	
	2 - 5 kg	1.8 mg	
	10 kg	4.1 mg	
	20 kg	18 mg	
	0.001 lb	0.0035 mg	
	0.002 lb	0.0047 mg	
	0.005 lb	0.0061 mg	
	0.01 lb	0.010 mg	
	0.02 lb	0.012 mg	
	0.03 lb	0.015 mg	
	0.05 lb	0.051 mg	
	0.1 lb	0.055 mg	
	0.2 lb	0.055 mg	
	0.5 lb	0.075 mg	
	1 lb	0.088 mg	
	2 lb	0.27 mg	
	5 lb	0.74 mg	
	10 lb	3.3 mg	
	20 lb	13 mg	
	25 lb	25 mg	
	50 lb	36 mg	
Force (Load Cells, Proving Rings, etc.)	10 to 1,000 lb	0.03 %	Dead weight force machine
	200K to 1M lb	0.05 %	Morehouse force machine
Torque Cells	To 3,000 ft-lb	0.1 %	Torque calibration, Lebow deadweight floating system
	To 20,000 ft-lb	0.3 %	

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MECHANICAL (continued)				
Accelerometry	4 Hz - 2 kHz: 3 - 10kHz:	2 - 100 g 2 - 100 g	1.5 % 2.5 %	Comparison calibration
Static acceleration		To 72 g	0.4 - 2.5 %	Frequency counter and DMM
Rate calibration		± 500 °/sec	1.50%	Frequency counter and DMM
Pressure - Mercurial Manometer, piston gages, piston gages (medium)		To 100 in Hg	0.0003 in Hg or 0.0015 % of rdg	Schwein mercurial manometer
		0.5 - 1,000 psi 600 - 12,000 psi	0.008 % 0.010 %	Deadweight piston gage
Vacuum		20 to 5 x 10^{-3} torr	2 %	MKS
ACOUSTICAL QUANTITIES				
Microphone Sensors		20 Hz - 1 kHz	0.1 dB	Type L pressure reciprocity
		2 - 7 kHz	0.15 dB	
		8 - 12.5 kHz	0.3 dB	
		250 Hz	1.0 dB	Voltage insertion
		2 Hz - 200 kHz	0.08 dB	Electrostatic actuator
		124 - 174 dB	0.5 dB	High level
		100 Hz - 20 kHz	0.8 dB	Plane wave tube
Sound Calibrators		125 Hz - 4 kHz	0.3 dB	Comparison w/std sound calibrator
		20 Hz - 25 kHz	0.9 dB	Voltage insertion
Artificial Mastoids		1 kHz	4.5 %	Impedance head used as transfer standard
Noise Dosimeters		Mfg specs	2.0 dB	Comparison w/std Pistonphone or sound calibrator
FLUID QUANTITIES				
Calibration of Air and Gas Flow Meters		1 to 30 cfm	1 %	Bell prover (air)
		20 ccpm to 50 ltr/min	0.75 %	MKS Califlow model A100 (air and nitrogen)
		10 ccpm to 50 ltr/min	0.75 % of reading	MoBloc calibration system
Gas Mask Tester Calibration		1,000 to 10,000 particles per cc	20 % fit-factor	Aerosol measurement and comparison to CNC

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THERMODYNAMIC QUANTITIES				
Relative Humidity		10 to 90 %	0.5 %	Two-pressure chamber
Temperature				
Standard Platinum Resistance Thermometers - Fixed Point Calibrations:		-189 to 962 °C		
	Triple Point of Water:	0.01 °C	0.001 °C	
	Triple Point of Ar:	-189.3442 °C	0.002 °C	
	Triple Point of Hg:	38.8344 °C	0.002 °C	
	Melting Point of Ga:	29.7646 °C	0.002 °C	Triple points and freezing points using ac bridge
	Freeze Point of Sn:	231.928 °C	0.002 °C	
	Freeze Point of Zn:	419.527 °C	0.002 °C	
	Freeze Point of Al :	660.323 °C	0.020 °C	
Platinum Resistance Thermometers (RTDs):		-60 to 350 °C	0.005 °C	Direct comparison in baths
Thermocouples:	Type S:	0 to 1100 °C	0.75 °C	
	Type K:	0 to 1100 °C	3 °C	Direct comparison in baths
	Type J:	0 to 750 °C	3 °C	
	Type T:	0 to 350 °C	1.5 °C	
Miscellaneous Temperature Sensing Devices:		-60 to 350 °C	0.01 to 1.0 °C	
Blackbody Radiation Temperature		0 to 1200 °C	0.25 to 3.0 °C	Direct comparison
OPTICAL QUANTITIES				
Fiber Optics Power	850 nm:	10 nW to 100 μW	3.0 %	
	1310 nm:	10 nW to 100 μW	3.0 %	Detector based
	1550 nm:	10 nW to 100 μW	3.0 %	
Fiber Optics Wavelength		600 to 1700 nm	0.5 nm	Spectrum analyzer and intrinsic source
Spectral Radiance	300 to 1600 nm:	1×10^{-9} to 1×10^{-5} W cm^{-2} sr^{-1} nm^{-1}	5 %	Detector and source based
Spectral Transmission	300 to 1500 nm:	0 to 100 %	3 %	Spectrophotometer
Photometric	Illuminance:	10 to 500 fcd	2 %	Detector and source based
	Luminance:	10 to 10,000 fL	2 %	
	Color Temperature:	2000 to 3200 °K	17 °K	
Laser Energy	1064 nm:	200 nJ to 20 mJ	7 %	Detector based and using beamsplitters
Laser Power	488 nm:	100 mW to 1 W	5 %	
	514.5 nm:	100 mW to 1 W	5 %	
	1064 nm:	100 mW to 8 W	5 %	
UV Irradiance	365 nm:	600 - 2000 W/cm^2	10.0 %	Detector Based

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IONIZING RADIATION AND RADIOACTIVITY				
Alpha Sources	Small area: ^{239}Pu:	To 1 x 10^7 CPM	4.0 %	Source and detector based
	Large area: ^{238}Pu, ^{239}Pu:	To 1 x 10^6 BQ	5.0 %	
Gamma Sources	^{137}Cs, ^{60}Co:	0.05 mR/hr to 5000 R/hr	3.5 %	Detector based
X-Ray Source	20 - 250 keV:	0.5 - 500 R/hr	3.5 %	Detector based
Gamma Detectors	20 - 250 keV:	0.05 mR/hr to 800 R/hr	10.0 %	Source based