SCOPE OF ACCREDITATION TO ISO/IEC 17025:2005
ANSI/NCSL Z540-1-1994 & ANSI/NCSLI Z540.3-2006

ANRITSU COMPANY MORGAN HILL CALIBRATION SERVICES
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CALIBRATION

Valid To: April 30, 2018 Certificate Number: 2160.01

In recognition of the successful completion of the A2LA evaluation process, accreditation is granted to this laboratory to perform the following calibrations[1]:

I. Electrical – DC/Low Frequency

Parameter/Equipment	Range	CMC[2, 4] (±)	Comments
DC Voltage – Generate, Fixed Points	220 mV 2.2 V 11 V 22 V 220 V 1100 V	18 µV/V + 0.40 µV 15 µV/V + 0.70 µV 14 µV/V + 2.5 µV 14 µV/V + 4.0 µV 15 µV/V + 40 µV 17 µV/V + 0.40 mV	Fluke 5720A

Parameter/Range	Frequency	CMC[2, 4] (±)	Comments
AC Voltage – Generate			
2.2 mV	(10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz 500 kHz to 1 MHz	0.065 % + 4.5 µV 0.031 % + 4.5 µV 0.021 % + 4.5 µV 0.047 % + 4.5 µV 0.095 % + 7.0 µV 0.12 % + 13 µV 0.18 % + 25 µV 0.35 % + 25 µV	Fluke 5720A

Parameter/Range	Frequency	CMC[2, 4] (±)	Comments
AC Voltage – Generate (cont)			
22 mV	(10 to 20) Hz	0.065 % + 5.0 µV	Fluke 5720A
	(20 to 40) Hz	0.031 % + 5.0 µV	
	40 Hz to 20 kHz	0.021 % + 5.0 µV	
	(20 to 50) kHz	0.047 % + 5.0 µV	
	(50 to 100) kHz	0.095 % + 7.0 µV	
	(100 to 300) kHz	0.12 % + 12 µV	
	(300 to 500) kHz	0.18 % + 25 µV	
	500 kHz to 1 MHz	0.35 % + 25 µV	
220 mV	(10 to 20) Hz	0.065 % + 13 µV	
	(20 to 40) Hz	0.031 % + 8.0 µV	
	40 Hz to 20 kHz	0.021 % + 8.0 µV	
	(20 to 50) kHz	0.042 % + 8.0 µV	
	(50 to 100) kHz	0.095 % + 25 µV	
	(100 to 300) kHz	0.12 % + 25 µV	
	(300 to 500) kHz	0.18 % + 35 µV	
	500 kHz to 1 MHz	0.35 % + 80 µV	
2.2 V	(10 to 20) Hz	0.06 % + 80 µV	
	(20 to 40) Hz	0.026 % + 25 µV	
	40 Hz to 20 kHz	0.018 % + 6.0 µV	
	(20 to 50) kHz	0.022 % + 16 µV	
	(50 to 100) kHz	0.035 % + 70 µV	
	(100 to 300) kHz	0.053 % + 0.13 mV	
	(300 to 500) kHz	0.12 % + 0.35 mV	
	500 kHz to 1 MHz	0.23 % + 0.85 mV	
22 V	(10 to 20) Hz	0.06 % + 0.80 mV	
	(20 to 40) Hz	0.026 % + 0.25 mV	
	40 Hz to 20 kHz	0.018 % + 60 µV	
	(20 to 50) kHz	0.022 % + 0.16 mV	
	(50 to 100) kHz	0.035 % + 0.35 mV	
	(100 to 300) kHz	0.06 % + 1.5 mV	
	(300 to 500) kHz	0.14 % + 4.3 mV	
	500 kHz to 1 MHz	0.28 % + 8.5 mV	
220 V	(10 to 20) Hz	0.06 % + 8.0 mV	
	(20 to 40) Hz	0.026 % + 2.5 mV	
	40 Hz to 20 kHz	0.018 % + 0.80 mV	
	(20 to 50) kHz	0.032 % + 3.5 mV	
	(50 to 100) kHz	0.06 % + 8.0 mV	
	(100 to 300) kHz	0.16 % + 90 mV	
	(300 to 500) kHz	0.48 % + 90 mV	
	500 kHz to 1 MHz	1.2 % + 0.19 V	
1100 V	(15 to 50) Hz	0.05 % + 16 mV	Up to 250 V
	50 Hz to 1 kHz	0.018 % + 3.5 mV	

Parameter/Equipment	Range	CMC[2, 5] (±)	Comments
DC Resistance – Generate, Fixed Points	0 Ω 1 Ω 1.9 Ω 10 Ω 19 Ω 100 Ω 190 Ω 1 kΩ 1.9 kΩ 10 kΩ 19 kΩ 100 kΩ 190 kΩ 1 MΩ 1.9 MΩ 10 MΩ 19 MΩ 100 MΩ	0.014 % 0.02 % 0.02 % 0.013 % 0.013 % 0.011 % 0.011 % 19 μΩ/Ω 19 μΩ/Ω 19 μΩ/Ω 19 μΩ/Ω 0.012 % 0.012 % 0.012 % 0.013 % 0.014 % 0.015 % 0.02 %	Fluke 5720A

II. Electrical – RF/Microwave

Parameter/Range	Frequency	CMC[2] (±)	Comments
S Parameters – Magnitude and Phase for S_{11}, S_{12}, S_{21}, S_{22}[3]			Vector network analyzers, passive microwave components
Reflection S_{11}/S_{22} – Measure			
(0.0001 to 1.0) lin	10 MHz to 40 GHz	(0.004 to 0.017) lin	VNA: MS464XA, 37XXX and 360 with calibration/verification kits 3663, 3653, 3666, 3650-1, 3667, 3651-1, 3668, 3652-1, 36585K, 36585V, 3657, 3669
(0.0001 to 0.01) lin (0.01 to 0.1) lin (0.1 to 1) lin		(90 to 18) deg (2.6 to 1.8) deg (0.65 to 0.95) deg	
(0.0001 to 1.0) lin	(40 to 70) GHz	(0.0026 to 0.0058) lin	
(0.0001 to 0.01) lin (0.01 to 0.1) lin (0.1 to 1) lin		(90 to 16) deg (16 to 4.0) deg (4.0 to 1.4) deg	

Parameter/Range	Frequency	CMC[2] (±)	Comments
S Parameters – Magnitude and Phase for S_{11}, S_{12}, S_{21}, S_{22}[3]			Vector network analyzers, passive microwave components
Transmission S_{12}/S_{21} – Measure			
(0 to 20) dB	10 MHz to 40 GHz	(0.029 to 0.056) dB (0.20 to 0.38) deg	MS 462X with calibration/verification kits 3663R, 3753R, 3666R, 3750R, 3667R, 3751R
(20 to 40) dB		(0.029 to 0.056) dB (0.20 to 0.37) deg	
(40 to 60) dB		(0.034to 0.061) dB (0.23 to 0.41) deg	
(60 to 80) dB		(0.042 to 0.062) dB (0.28 to 0.42) deg	
(0 to 20) dB	(40 to 70) GHz	(0.033 to 0.094) dB (0.22 to 0.63) deg	
(20 to 40) dB		(0.033 to 0.094) dB (0.22 to 0.63) deg	
(40 to 60) dB		(0.038 to 0.099) dB (0.26 to 0.66) deg	
(60 to 80) dB		(0.043 to 0.11) dB (0.29 to 0.72) deg	

Parameter/Range	Frequency	CMC[2, 5] (±)	Comments
50 Ω Airline Characteristic Impedance	(2 to 18) GHz (18 to 70) GHz	1.0 mΩ/Ω 2.0 mΩ/Ω	Coaxial airlines: 18A50, 18N50, 18NF50, 19K50, 19KF50, 3657, 3680K, LRL-GPC-7
Power Sensors –	10 MHz to 40 GHz Calibration Factor:		Power sensors:
Type N Connector	At 10 MHz At 50 MHz to 18 GHz	1.8 % 0.56 % to 0.92 %	MA24XXX A/B/D, 10 MHz to 18 GHz
Type K Connector	At 10 MHz At 50 MHz to 40 GHz	1.8 % 1.4 % to 3.6 %	MA24XXX A/B/D, 10 MHz to 40 GHz
Power Level – Absolute and Relative[6]: Type N and Type K Connector			
(20 to -100) dBm:	10 MHz to 40 GHz:		Direct power measurement (for type N and type K connector), MA 247XA/B with ML 2437/8A and ML 2530; Agilent 8487A and PSA *M* = mismatch
0 dBm	(10 to 50) MHz (50 to 150) MHz (0.15 to 2) GHz (2 to 12) GHz (12 to 18) GHz (18 to 32) GHz (32 to 40) GHz	(0.090 to 0.080) dB + *M* (0.080 to 0.080) dB + *M* (0.080 to 0.080) dB + *M* (0.080 to 0.080) dB + *M* (0.080 to 0.090) dB + *M* (0.090 to 0.11) dB + *M* (0.11 to 0.12) dB + *M*	
(20 to -60) dBm (Except 0 dBm)	(10 to 50) MHz (50 to 150) MHz (0.15 to 2) GHz (2 to 12) GHz (12 to 18) GHz (18 to 32) GHz (32 to 40) GHz	(0.13 to 0.12) dB + *M* (0.12 to 0.12) dB + *M* (0.12 to 0.12) dB + *M* (0.12 to 0.12) dB + *M* (0.12 to 0.13) dB + *M* (0.13 to 0.17) dB + *M* (0.17 to 0.17) dB + *M*	

Parameter/Range	Frequency	CMC[2, 5] (±)	Comments
Power Level – Absolute and Relative[6]: Type N and Type K Connector –			
20 dBm to -100 dBm:	10 MHz to 40 GHz:		Direct power measurement (for type N and type K connector), MA 247XA/B with ML 2437/8A and ML 2530; Agilent 8487A and PSA *M* = mismatch
(-60 to -85) dBm	(10 to 50) MHz	(0.13 to 0.13) dB + *M*	
	(50 to 150) MHz	(0.13 to 0.13) dB + *M*	
	(0.15 to 2) GHz	(0.13 to 0.13) dB + *M*	
	(2 to 12) GHz	(0.13 to 0.13) dB + *M*	
	(12 to 18) GHz	(0.13 to 0.14) dB + *M*	
	(18 to 32) GHz	(0.14 to 0.17) dB + *M*	
	(32 to 40) GHz	(0.17 to 0.18) dB + *M*	
(-85 to -95) dBm	(10 to 50) MHz	(0.17 to 0.17) dB + *M*	
	(50 to 150) MHz	(0.17 to 0.17) dB + *M*	
	(0.15 to 2) GHz	(0.17 to 0.16) dB + *M*	
	(2 to 12) GHz	(0.16 to 0.17) dB + *M*	
	(12 to 18) GHz	(0.17 to 0.17) dB + *M*	
	(18 to 32) GHz	(0.17 to 0.20) dB + *M*	
	(32 to 40) GHz	(0.20 to 0.21) dB + *M*	
(-95 to -100) dBm	(10 to 50) MHz	(0.85 to 0.85) dB + *M*	
	(50 to 150) MHz	(0.85 to 0.85) dB + *M*	
	(0.15 to 2) GHz	(0.85 to 0.85) dB + *M*	
	(2 to 12) GHz	(0.85 to 0.85) dB + *M*	
	(12 to 18) GHz	(0.85 to 0.86) dB + *M*	
	(18 to 32) GHz	(0.86 to 0.86) dB + *M*	
	(32 to 40) GHz	(0.86 to 0.87) dB + *M*	
Frequency Modulation – Measure			
Rate: 20 Hz to 10 kHz, ≤40 kHz peak	(0.25 to 10) MHz	2.3 % + 1 digit	8902 measuring receiver
Rate: 50 Hz to 100 kHz, ≤400 kHz peak	(0.25 to 10) MHz	1.2 % + 1 digit	
Rate: 20 Hz to 200 kHz, ≤400 kHz peak	(10 to 1300) MHz	5.8 % + 1 digit	

Parameter/Range	Frequency	CMC[2, 5] (±)	Comments
Amplitude Modulation – Measure			
Rate: 50 Hz to 10 kHz, 5 % to 99 %	(0.15 to 10) MHz	2.4 % + 1 digit	8902 measuring receiver
Rate: 20 Hz to 10 kHz, 5 % to 99 %		3.5 % + 1 digit	
Rate: 50 Hz to 50 kHz, 5 % to 99 %	(10 to 1300) MHz	1.2 % + 1 digit	
Rate: 20 Hz to 100 kHz, 5 % to 99 %		3.5 % + 1 digit	
Attenuation – Coaxial Type N			
0 dB	(10 to 1300) MHz	0.026 dB + *M*	8902 measuring receiver *M* = mismatch
10 dB		0.026 dB + *M*	
20 dB		0.034 dB + *M*	
30 dB		0.045 dB + *M*	
40 dB		0.055 dB + *M*	
50 dB		0.065 dB + *M*	
60 dB		0.074 dB + *M*	
70 dB		0.088 dB + *M*	
80 dB		0.096 dB + *M*	
90 dB		0.098 dB + *M*	
100 dB		0.11 dB + *M*	
110 dB		0.15 dB + *M*	
0 dB	(1300 to 2000) MHz	0.035 dB + *M*	
10 dB		0.035 dB + *M*	
20 dB		0.053 dB + *M*	
30 dB		0.074 dB + *M*	
40 dB		0.096 dB + *M*	
50 dB		0.13 dB + *M*	
60 dB		0.15 dB + *M*	
70 dB		0.17 dB + *M*	
80 dB		0.19 dB + *M*	
90 dB		0.23 dB + *M*	
100 dB		0.25 dB + *M*	
110 dB		0.27 dB + *M*	
Noise Figure Measurement –			
(0 to 10) dB	10 MHz to 70 GHz	0.19 dB	MS464X VNA

Parameter/Equipment	Range	CMC[2] (±)	Comments
Phase Noise- Measure Offset Frequency (1 to 10) Hz (10 to 100) Hz (100 to 1) kHz 1 kHz to 40 MHz (40 to 100) MHz	10 MHz to 7 GHz	 4 dB 4 dB 3 dB 2 dB (3 dB for wide capture range mode) 3 dB	E5052x

III. Mechanical

Parameter/Equipment	Range	CMC[2] (±)	Comments
Torque	(1 to 10) in·lbf (2 to 20) in·lbf (2.5 to 25) in·lbf (4 to 40) in·lbf (10 to 100) in·lbf (25 to 250) in·lbf	2.2 % 3.8 % 0.99 % 3.3 % 0.86 % 6.4 %	Mountz torque analyzer

IV. Time & Frequency

Parameter/Equipment	Range	CMC[2] (±)	Comments
Frequency – Measuring Equipment	10 MHz	1.5×10^{-12} Hz/Hz	GPS disciplined oscillator, fixed point, aging rate
Frequency Accuracy – Measure	10 MHz to 70 GHz	$1.5 \times 10^{-12} f$	Frequency counter f = frequency

[1] This laboratory offers commercial and on-site calibration services.

[2] Calibration and Measurement Capability Uncertainty (CMC) is the smallest uncertainty of measurement

that a laboratory can achieve within its scope of accreditation when performing more or less routine calibrations of nearly ideal measurement standards or nearly ideal measuring equipment. CMCs represent expanded uncertainties expressed at approximately the 95 % level of confidence, usually using a coverage factor of $k = 2$. The actual measurement uncertainty of a specific calibration performed by the laboratory may be greater than the CMC due to the behavior of the customer's device and to influences from the circumstances of the specific calibration.

[3] Field calibration service is available for this calibration and this laboratory meets A2LA *R104 – General Requirements: Accreditation of Field Testing and Field Calibration Laboratories* for these calibrations. Please note the actual measurement uncertainties achievable on a customer's site can normally be expected to be larger than the CMC found on the A2LA Scope. Allowance must be made for aspects such as the environment at the place of calibration and for other possible adverse effects such as those caused by transportation of the calibration equipment. The usual allowance for the actual uncertainty introduced by the item being calibrated, (e.g. resolution) must also be considered and this, on its own, could result in the actual measurement uncertainty achievable on a customer's site being larger than the CMC.

[4] The measurands stated are generated using the indicated instrument (see Comments). This capability is suitable for the calibration of the devices intended to measure the measurand in the ranges indicated. CMCs are expressed as either a specific value that covers the full range or as a fraction of the reading plus a fixed floor specification.

[5] Unless otherwise noted, percentage refers to percent of reading.

[6] Enlisted values represent absolute power level uncertainty; relative power level uncertainty does not include 1 mW reference and associated mismatch uncertainty of the enlisted values.

Accredited Laboratory

A2LA has accredited

ANRITSU COMPANY MORGAN HILL CALIBRATION SERVICES

Morgan Hill, CA

for technical competence in the field of

Calibration

This laboratory is accredited in accordance with the recognized International Standard ISO/IEC 17025:2005 *General requirements for the competence of testing and calibration laboratories*. This laboratory also meets the requirements of ANSI/NCSLI Z540-1-1994 and the requirements of ANSI/NCSLI Z540.3-2006 and any additional program requirements in the field of calibration. This accreditation demonstrates technical competence for a defined scope and the operation of a laboratory quality management system (*refer to joint ISO-ILAC-IAF Communiqué dated 8 January 2009*).

Presented this 1st day of June 2016.

Senior Director of Quality and Communications
For the Accreditation Council
Certificate Number 2160.01
Valid to April 30, 2018

For the calibrations to which this accreditation applies, please refer to the laboratory's Calibration Scope of Accreditation.