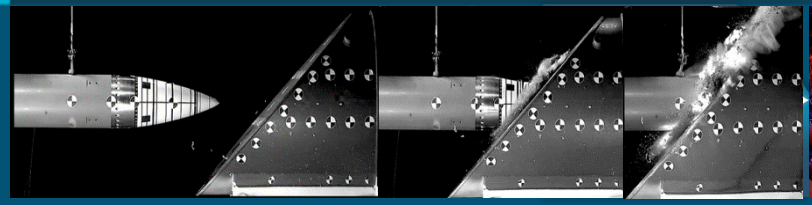
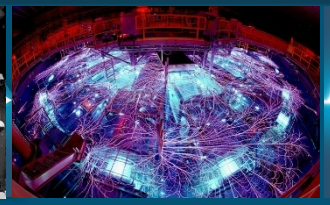
SAND2022-11234C

Sandia National Laboratories

Metrology Software User Experience (UX) Design





PRESENTED BY

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U.S. DEPARTMENT OF ENERGY | NNSA

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Overview

- What is UX?
- Why Concentrate on UX?
- AC Lab UX-Centered Software Improvements
- Examples of UX-Centered Design in Metrology Software
- Conclusion

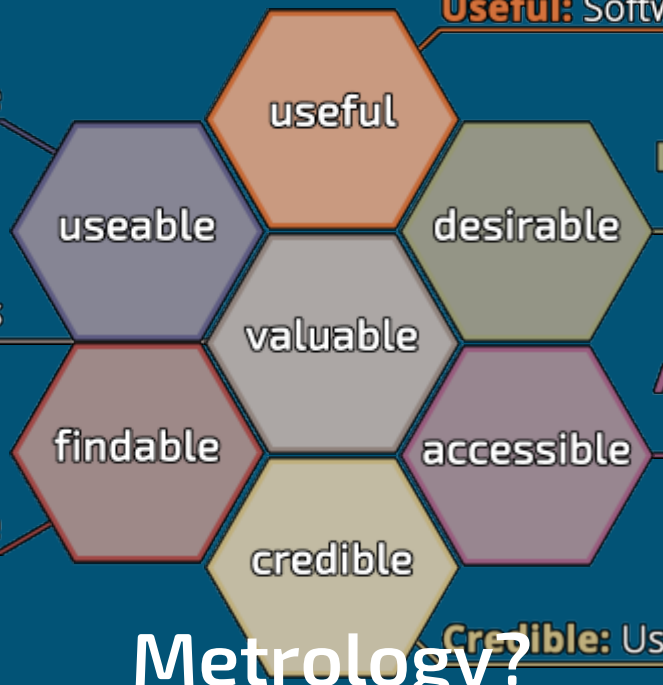
What is User Experience (UX)?

Different types of software focus on certain factors more than others.

UX is a User-Centered Design Process

- “Design is a funny word. Some people think design means how it looks. But of course if you dig deeper, it’s really how it works.” – Steve Jobs
- UX is not just a User Interface (UI).
- UX focuses on having a deep understanding of users, what they need, what they value, their abilities, and also their limitations. - Usability.gov

User Experience Honeycomb



Useful: Software must fulfill a need

Usable: Software must be easy to use

Desirable: Software must feature graphics and design elements that appeal to appreciation

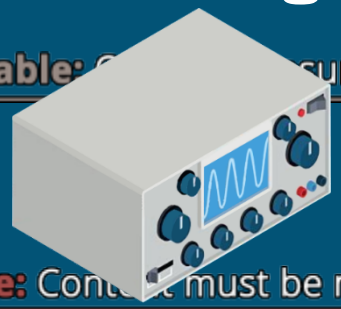
Valuable: Content must be a measure of other core factors

Accessible: Software can be used by people of all abilities and

Findable: Content must be navigable and locatable

Credible: Users must trust the software

Banking



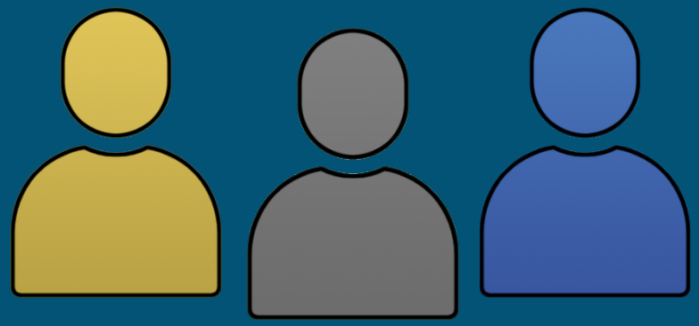
Social Media

Metrology?

Why Concentrate on UX?

Return of Investment (ROI) of Good UX Design

ROI for good UX design is not so straightforward for metrology software.
ROI for good UX design is typically straightforward in commercial software.



Good UX will draw more users to the product.
The end-users need to purchase a license for the product.
Users who have a positive experience are more likely to continue using the product and purchase goods and services.
More users means even more ROI.

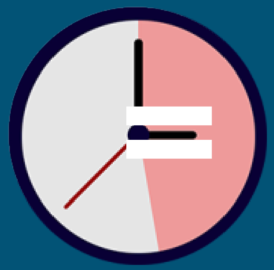
Quantitative ROI for Metrology Software UX

Good UX decreases calibration time
Good UX decreases training time
Good UX increases usability

Calibration Time
Training Time
Usability

Throughput
Productivity
Errors

Decreased calibration time increases throughput
Decreased training time increases productivity
Increased usability decreases errors



Qualitative ROI for Metrology Software UX

Good UX design can increase confidence in metrology software and calibration results.

Good UX design can improve or expand calibration capabilities.

Quality UX design is expected by the next generation of metrologists and scientists.

Gen Z

Millennial

Gen X

Baby Boomer

Considerations for UX Design

UX centered design is not necessary or ideal for all metrology software.

- Low-use or single-use software
- Research software
- Software with short running time

UX increases software development time, initial investment, and complexity.

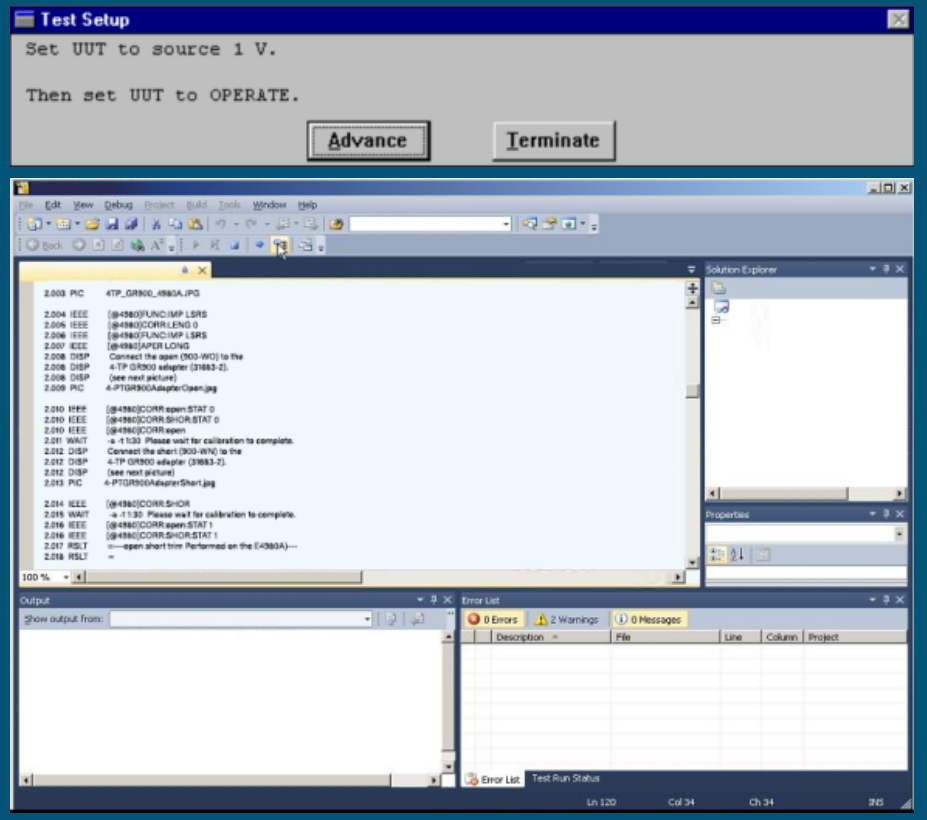
It is absolutely necessary to have clear and well-defined software requirements before designing software.

The increased complexity of UX can make minor changes significantly more difficult to implement.

AC Lab UX-Centered Software Improvements

AC Lab Legacy Calibration Software

Which calibration is running?



Which test point is being measured?

Which instruments are being used?

What is the program doing?

Can the program go back a step?

How is equipment set up?

AC Lab UX Centered Software Improvements

Goal: Improve or redesign legacy calibration software throughout the AC Lab. Focus on UX and benchmark ROI for improvements.

Strategy: Target high-use Major Measurement System software packages. Gauge improvement success and carry forward lessons learned to next lab UX software improvement.

Chose LabVIEW as the Integrated Development Environment

- Well established
- Excellent instrument communication and support
- Robust Graphical User Interface (GUI) capabilities

*Certain commercial equipment, instruments, software, or materials are identified in this presentation in order to adequately describe the experimental procedure. Such identification does not imply recommendation or endorsement by the authors, Sandia National Laboratories, nor does it imply that the materials or equipment identified are the only or best available for the purpose.

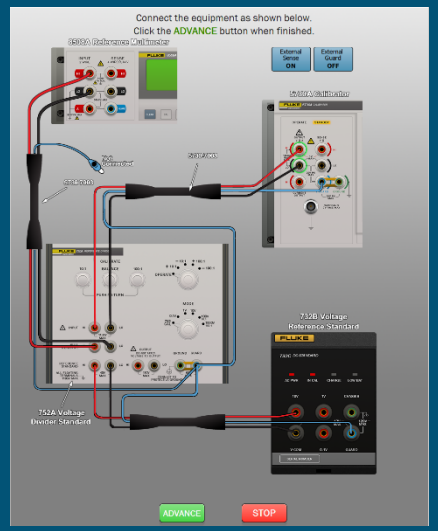
Examples of UX-Centered Design in Metrology Software

Advanced UX Software Features

Software can load standards used for calibrations; checks calibration expiration dates; load certified values, corrections, uncertainties; and configures network settings.

findable

accessible



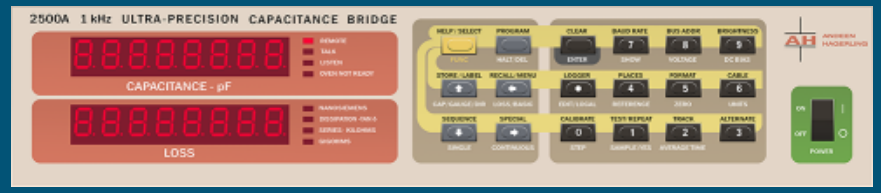
Software shows detailed connection diagrams for every step of calibrations.

Software shows animated user prompts to effectively communicate calibration steps and progress.

Real-Time Instrument Interfaces

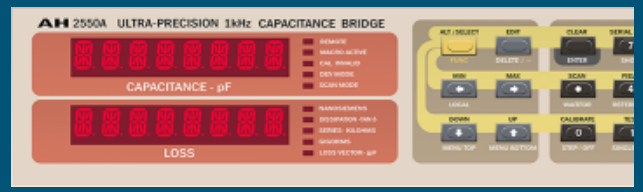
Features real-time instrument user interfaces to show which instruments are being used and what they are measuring.

Different model instruments, same program.

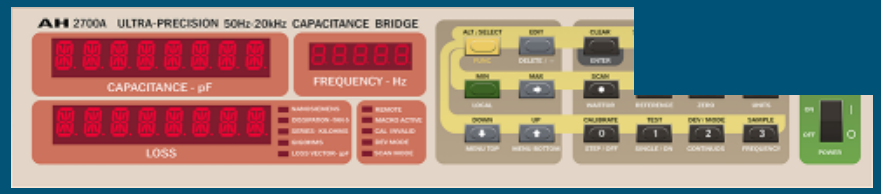


Andeen Hagerling 2500A Capacitance Bridge

User Interface



Andeen Hagerling 2550A Capacitance Bridge



Andeen Hagerling 2700A Capacitance Bridge

Actual Instrument

Using Multiple Instruments

User interfaces show the current instruments being used. These instruments can be hidden or displayed based on monitor size and user preference. This allows for a minimal or robust program display.

User interfaces can be tabbed through to see the different measurement parameters and results. The current measurement information is also displayed in real time.

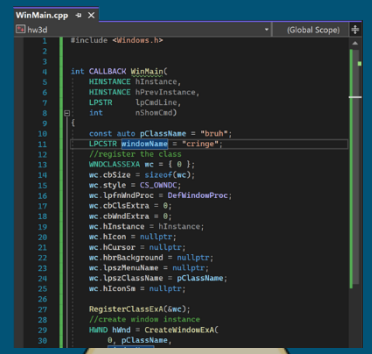
Real-Time System Status

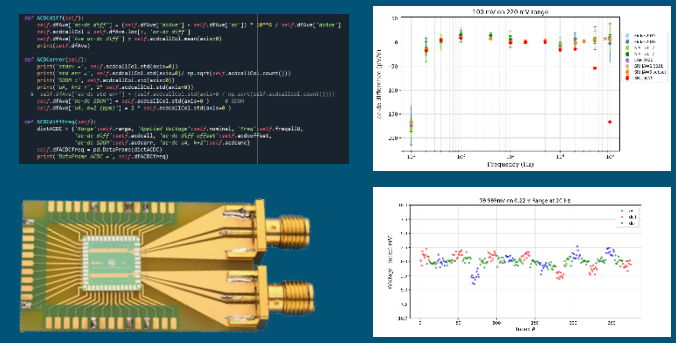
Detailed schematics and user interfaces allow for real-time system status. System complexity benefits greatly from robust UI.

Leveraging Software Synergy

Josephson Arbitrary Waveform Synthesizer (JAWS)

LabVIEW + Python =





AC-DC Difference

useful

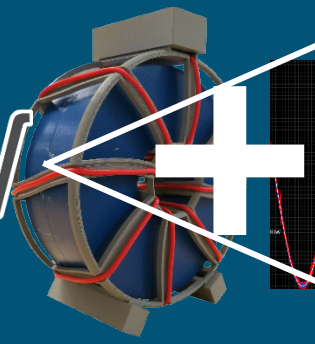
useable

credible

Machined Rogowski Coils (MRC)

SolidWorks

LabVIEW + MATLAB = Custom UI Graphics



Photoshop

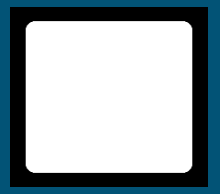
Wayne Kerr Calibrations

LabVIEW +

Visual Studio C++ Dynamically-Linked Libraries (.dll)

Programming Interface (API)

+



Transparency Bitmap

=

Transparent Windows

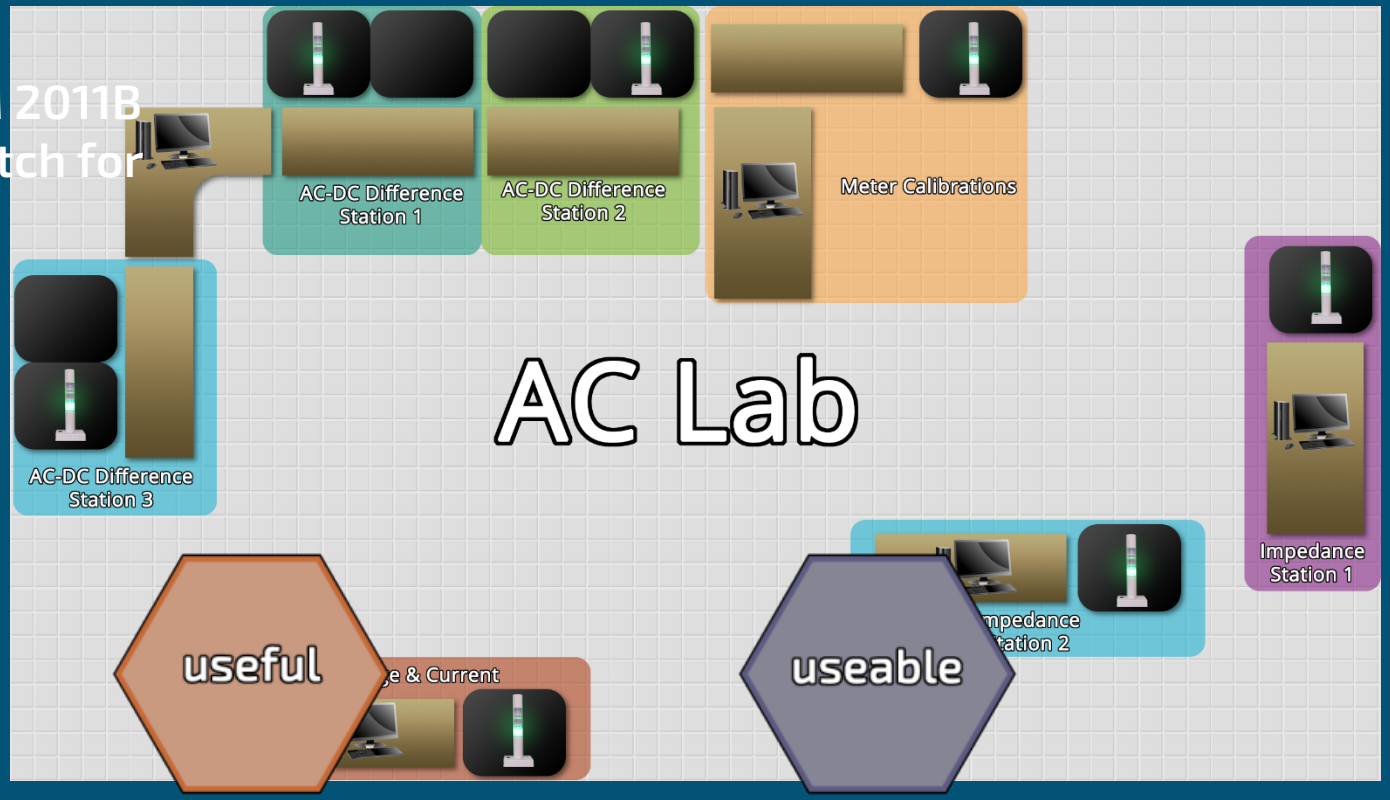
Software Physical Interaction

Normal Operation Action Needed High Voltage

Implemented Tri-Color indicator lights for visual and audible indications of system status and safety signaling.

Greatly reduced time between steps or calibrations and improved lab's situational awareness!

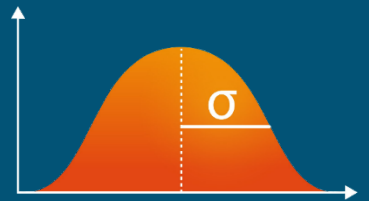
Implemented SunJEM 2011B Automatic Range Switch for the 792A.



Uncertainty, Test Uncertainty Ratio (TUR), and Guardbanding

For tolerance testing calibrations, the software calculates time-of-test uncertainty and determines the TUR. If a TUR is <4:1, the software will guardband the limit. No TURs <1.5:1 are allowed.

Standard uncertainty



Statistical uncertainty

u_{b1}

u_{a1}

Time-of-Test Uncertainty

$$U_c = \sqrt{+u_b{}^2 + u_a{}^2} \times k$$

U_c = expanded uncertainty

u_b = standard uncertainty

u_a = statistical uncertainty

$k = 2$ (coverage factor)

U_c

$$TUR = \frac{limit}{U_c}$$

credible

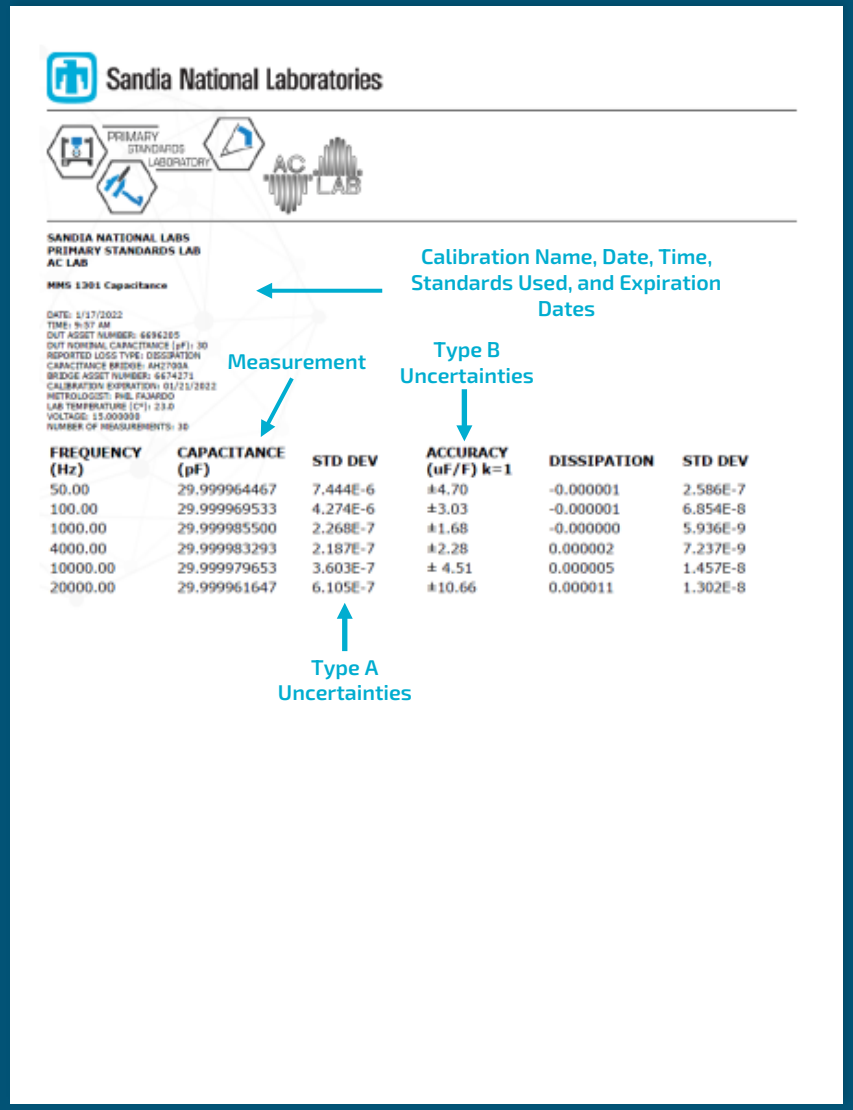
findable

Standardized Calibration Reports

Software provides metrologists and customers with easy-to-read calibration reports.

credible

findable



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AC LAB

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AC LAB

MMS 1301 Capacitance

DATE: 1/17/2022
TIME: 9:57 AM
DUT ASSET NUMBER: 6696265
DUT NOMINAL CAPACITANCE (pF): 30
REPORTED LOSS TYPE: DISSIPATION
CAPACITANCE BRIDGE: AH2700A
BRIDGE ASSET NUMBER: 6674271
CALIBRATION EXPIRATION: 01/21/2022
METROLOGIST: PHIL FAJARDO
LAB TEMPERATURE (C°): 23.0
VOLTAGE: 15.000000
NUMBER OF MEASUREMENTS: 30

Calibration Name, Date, Time, Standards Used, and Expiration Dates

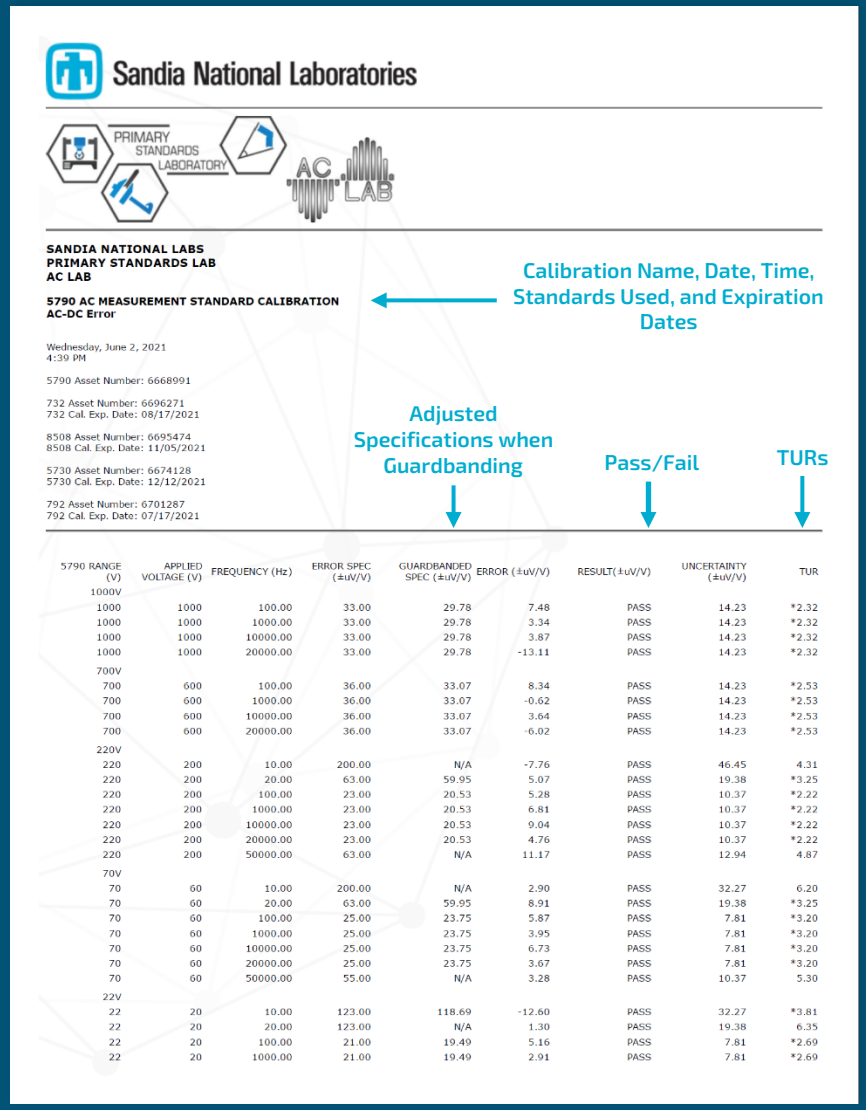
Measurement

Type B Uncertainties

FREQUENCY (Hz)	CAPACITANCE (pF)	STD DEV	ACCURACY (uF/F) k=1	DISSIPATION	STD DEV
50.00	29.999964467	7.444E-6	±4.70	-0.000001	2.586E-7
100.00	29.999969533	4.274E-6	±3.03	-0.000001	6.854E-8
1000.00	29.999985500	2.268E-7	±1.68	-0.000000	5.936E-9
4000.00	29.999983293	2.187E-7	±2.28	0.000002	7.237E-9
10000.00	29.999979653	3.603E-7	± 4.51	0.000005	1.457E-8
20000.00	29.999961647	6.105E-7	±10.66	0.000011	1.302E-8

Type A Uncertainties

Uncertainty Analysis Report



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AC LAB

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PRIMARY STANDARDS LAB
AC LAB

5790 AC MEASUREMENT STANDARD CALIBRATION
AC-DC Error

Calibration Name, Date, Time, Standards Used, and Expiration Dates

Wednesday, June 2, 2021
4:39 PM

5790 Asset Number: 6668991

732 Asset Number: 6696271
732 Cal. Exp. Date: 08/17/2021

8508 Asset Number: 6695474
8508 Cal. Exp. Date: 11/05/2021

5730 Asset Number: 6674128
5730 Cal. Exp. Date: 12/12/2021

792 Asset Number: 6701287
792 Cal. Exp. Date: 07/17/2021

Adjusted Specifications when Guardbanding

Pass/Fail

TURs

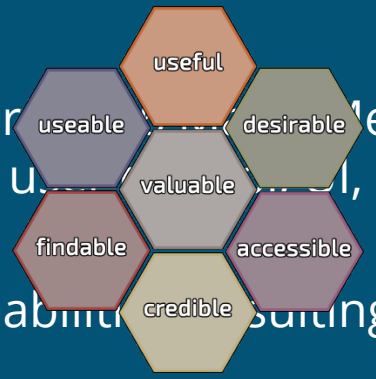
5790 RANGE (V)	APPLIED VOLTAGE (V)	FREQUENCY (Hz)	ERROR SPEC (±uV/V)	GUARDBANDED SPEC (±uV/V)	ERROR (±uV/V)	RESULT(±uV/V)	UNCERTAINTY (±uV/V)	TUR
1000V								
1000	1000	100.00	33.00	29.78	7.48	PASS	14.23	*2.32
1000	1000	1000.00	33.00	29.78	3.34	PASS	14.23	*2.32
1000	1000	10000.00	33.00	29.78	3.87	PASS	14.23	*2.32
1000	1000	20000.00	33.00	29.78	-13.11	PASS	14.23	*2.32
700V								
700	600	100.00	36.00	33.07	8.34	PASS	14.23	*2.53
700	600	1000.00	36.00	33.07	-0.62	PASS	14.23	*2.53
700	600	10000.00	36.00	33.07	3.64	PASS	14.23	*2.53
700	600	20000.00	36.00	33.07	-6.02	PASS	14.23	*2.53
220V								
220	200	10.00	200.00	N/A	-7.76	PASS	46.45	4.31
220	200	20.00	63.00	59.95	5.07	PASS	19.38	*3.25
220	200	100.00	23.00	20.53	5.28	PASS	10.37	*2.22
220	200	1000.00	23.00	20.53	6.81	PASS	10.37	*2.22
220	200	10000.00	23.00	20.53	9.04	PASS	10.37	*2.22
220	200	20000.00	23.00	20.53	4.76	PASS	10.37	*2.22
220	200	50000.00	63.00	N/A	11.17	PASS	12.94	4.87
70V								
70	60	10.00	200.00	N/A	2.90	PASS	32.27	6.20
70	60	20.00	63.00	59.95	8.91	PASS	19.38	*3.25
70	60	100.00	25.00	23.75	5.87	PASS	7.81	*3.20
70	60	1000.00	25.00	23.75	3.95	PASS	7.81	*3.20
70	60	10000.00	25.00	23.75	6.73	PASS	7.81	*3.20
70	60	20000.00	25.00	23.75	3.67	PASS	7.81	*3.20
70	60	50000.00	55.00	N/A	3.28	PASS	10.37	5.30
22V								
22	20	10.00	123.00	118.69	-12.60	PASS	32.27	*3.81
22	20	20.00	123.00	N/A	1.30	PASS	19.38	6.35
22	20	100.00	21.00	19.49	5.16	PASS	7.81	*2.69
22	20	1000.00	21.00	19.49	2.91	PASS	7.81	*2.69

Tolerance Testing Report

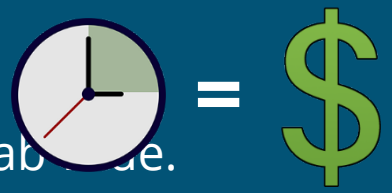
Conclusion

Conclusion

- AC Lab completely redesigned softwar… easurement Systems (2017–2022)
  - Improved useability, throughput, u… I, etc.
- Added numerous new calibration capabilit… sulting in two new Major Measurement Systems.
- Reduced turnaround time.
- Standardized calibration reports AC lab… de.
- Improved lab situational awareness and safety.
- Increased software development ti… nd complexity.



- What is UX?
- UX Benefits



- UX Examples

Questions