PSL's Approach to Specifications

Our Approach

- **PSL does four types of PSL certification/calibration**
  - "NIST-trace Certification"
    - "NIST" is the United States National Institute of Standards and Technology, which maintains the ultimate references in the United States for measurements. A PSL "NIST-trace Certification" is a document that certifies that a competent PSL calibration engineer has calibrated a measurement, made by an instrument-under-test, through an unbroken chain of certified measurement standards to a Standard at the United States National Institute of Standards and Technology or another National Measurement Institute. Here is an example: http://www.powersensorsltd.com/CalibCerts/P3001143.pdf
  - "Intrinsic Reference calibration"
    - For some measurements, PSL uses an Intrinsic Reference calibration method. For example, to calibrate 0.000° phase angle measurements between channels of an individual instrument, PSL applies the same signal to both channels simultaneously.
  - "Relative calibration"
    - For a few measurements, such as micro-synchrophasor angle measurements, there are no reference standards that reach the level of precision available in PSL instruments. If the useful measurement is always a relative measurement (for example, micro-synchrophasor angles are always measured as the relative difference between two instruments), PSL may designate a single physical instrument as the "gold" standard, and calibrate all other instruments relative to this instrument. (As a practical matter, PSL transfers the "gold" standard into two "silver" standards, which are actually used for these calibrations, and which, through periodic checks with each other and with the gold standard provide a level of confidence against drift and other errors.)
  - "Standards-based certification"
    - Some Standards, such as the ANSI Class 0.2 and IEC Class 0,2 S Revenue Metering Accuracy Standards, have hundreds of tests under a wide variety of specified input parameters. PSL performs all of these tests using NIST-trace methods, and records both the resulting errors and the PASS/FAIL results according to the Standard's requirements. Other Standards, such as the IEC 61000-4-30 Power Quality Measurement Method Standard, have specific measurement *methods*, and, in some cases, limited accuracy and measurement range requirements. For this type of Standard, PSL calibration engineers independently construct test waveforms that are specifically designed to detect errors in the measurement methods

Power Sensors Ltd. 980 Atlantic Ave, Alameda CA 94501, USA
Tel ***++1-510-522-4400*** Fax ***++1-510-522-4455*** www.PowerSensorsLtd.com

in an instrument. Measurement ranges are verified, and any accuracy requirements are tested using NIST-trace methods.

- **Range**
  - The maximum signal that can be measured without introducing distortion and/or degrading accuracy. PSL designs typically include an extra 10% beyond the specified range. Range is a straightforward specification for DC signals, but for channels designed for measuring AC it is typically specified as a maximum RMS value with a maximum Crest Factor (the two numbers, multiplied together, give the instantaneous maximum or peak value), or it may be simply specified as ±(units)pk. (For signals that are AC, distorted, and have widely varying values, such as current, there is often confusion about the “name” of a range, and caution in interpretation is recommended.)
- **Resolution**
  - This is the smallest useful short-term change-in-value for a typical measurement, in PSL’s engineering judgement. The judgement includes such factors as the number of bits of resolution of an underlying set of measurements, the number of those measurements that have been algorithmically combined, the algorithm used, the channel noise (which is often a function of frequency, so may be changed by the algorithm), and the resolution of the digital representations in the algorithms. The phrase “short-term” indicates that the engineering judgement includes consideration of practical applications – for grid frequency measurements, for example, short-term might be about 1 second, but for lightning-strike impulse measurements short-term might be about 1 microsecond.
  - NOTE: A single measurement channel may have multiple ranges, and multiple resolutions.
  - As an example, PQube 3 mains voltage channels include all of the following, simultaneously:
    - Waveform measurements at 512 samples-per-cycle, with a range of approximately ±1,000V, and a resolution of ±15 bits, or approximately 30 millivolts. These measurements are preceded by both analog anti-alias filters, and 64x oversampling digital anti-alias filters.
    - RMS measurements based on all 512 samples, with a resolution of approximately 2 millivolts, or 2 PPMfs (parts-per-million, full-scale).
    - Impulse waveform measurements at 4,000,000 samples-per-second, with a range of approximately ±6,000V and a resolution of ±11 bits, or approximately 3 volts.
    - 2kHz-150kHz emissions measurements at 1,024,000 samples-per-second, with a range of ±60V and a resolution of ±12 bits; in this case, the useful resolution is limited by the digital representation of values in the FFT algorithm, and the analog noise floor dominated by the 4500:1 10MHz voltage divider on the channel input.

Power Sensors Ltd. 980 Atlantic Ave, Alameda CA 94501, USA
Tel ***++1-510-522-4400*** Fax ***++1-510-522-4455*** www.PowerSensorsLtd.com

- **Accuracy**
    - Accuracy – Typical
        - This is the usual, useful accuracy that, in PSL's engineering judgement, can be reasonably expected from most instruments under typical conditions of use examining typical signals. It is an engineering judgement, based on all information available to PSL. It is always a tighter limit that the "Accuracy – Factory Pass/Fail" limit.
    - Accuracy – Factory Pass/Fail
        - This is the accuracy limit that PSL's automated calibration equipment uses to either accept or reject a measurement. It is always a tighter limit than the "Accuracy – Specification" limit. Where applicable, this limit appears on every measurement on every PSL NIST-trace Certificate, and excludes the error in the reference instrument used for a particular certification.
    - Accuracy – Specification
        - This is the accuracy, at specified rated conditions, that PSL guarantees is traceable through an unbroken chain of certified measurement standards to the references maintained at the United States National Institute of Standards and Technology or another National Measurement Institute. It is always the loosest limit specified by PSL, and accounts for factors such as drift over time and, where applicable, the uncertainty in the reference instrument.
    - Indicative
        - Measurements specified by PSL as "Indicative" are, in PSL's engineering judgement, useful measurements, but PSL does not specify any accuracy on these measurements because PSL does not have the technical capabilities, in PSL's engineering judgement, of verifying their accuracy to a degree that would be acceptable to PSL. Examples of "Indicative" measurements provided by PSL instruments include barometric pressure, mechanical acceleration, and the like.
    - Reference error
        - Almost all accuracies certified by PSL are dependent on the accuracy and resolution of either a Reference Instrument or Transfer Standard. In general, PSL specifies its accuracies as though the Reference Instrument or Transfer Standard had zero error. In some cases, a measurement on a PSL NIST-trace Certificate may also specify a Reference Instrument Uncertainty. Depending on the application, it may make sense to add that Reference Instrument Uncertainty to the "Accuracy – Specification" limit.

Power Sensors Ltd. 980 Atlantic Ave, Alameda CA 94501, USA
Tel ***++1-510-522-4400*** Fax ***++1-510-522-4455*** www.PowerSensorsLtd.com