Test&Measurement

Are you able to proof the power efficiency of your application?

High frequency Power calibration requirements

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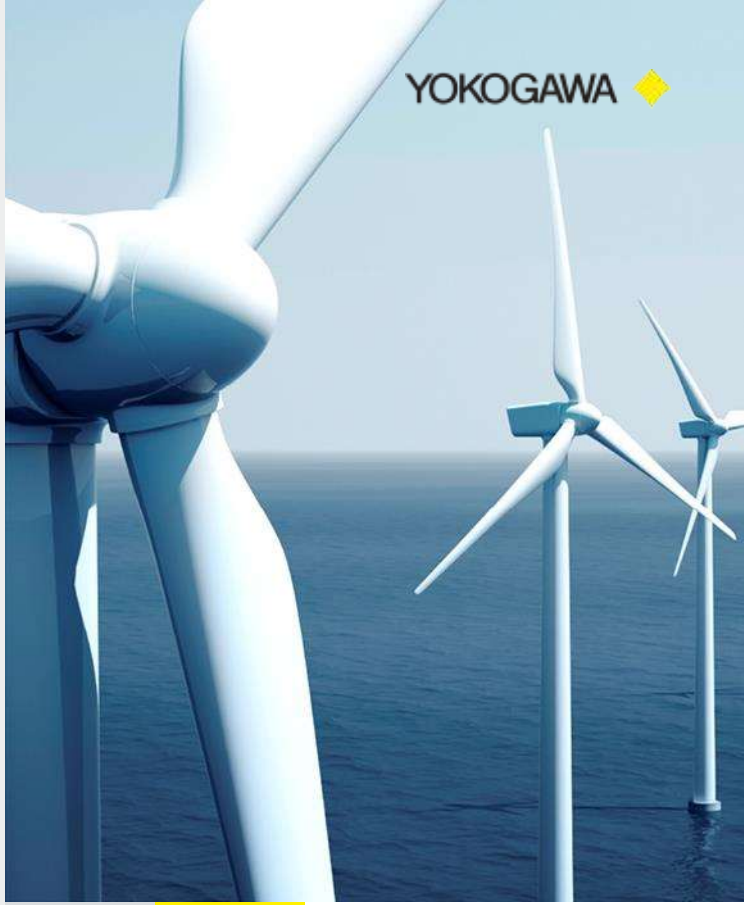
Power and Energy Measurement Specialist



Definition of Measurement

Any measurement of an object can be judged by the following meta-measurement criteria values:

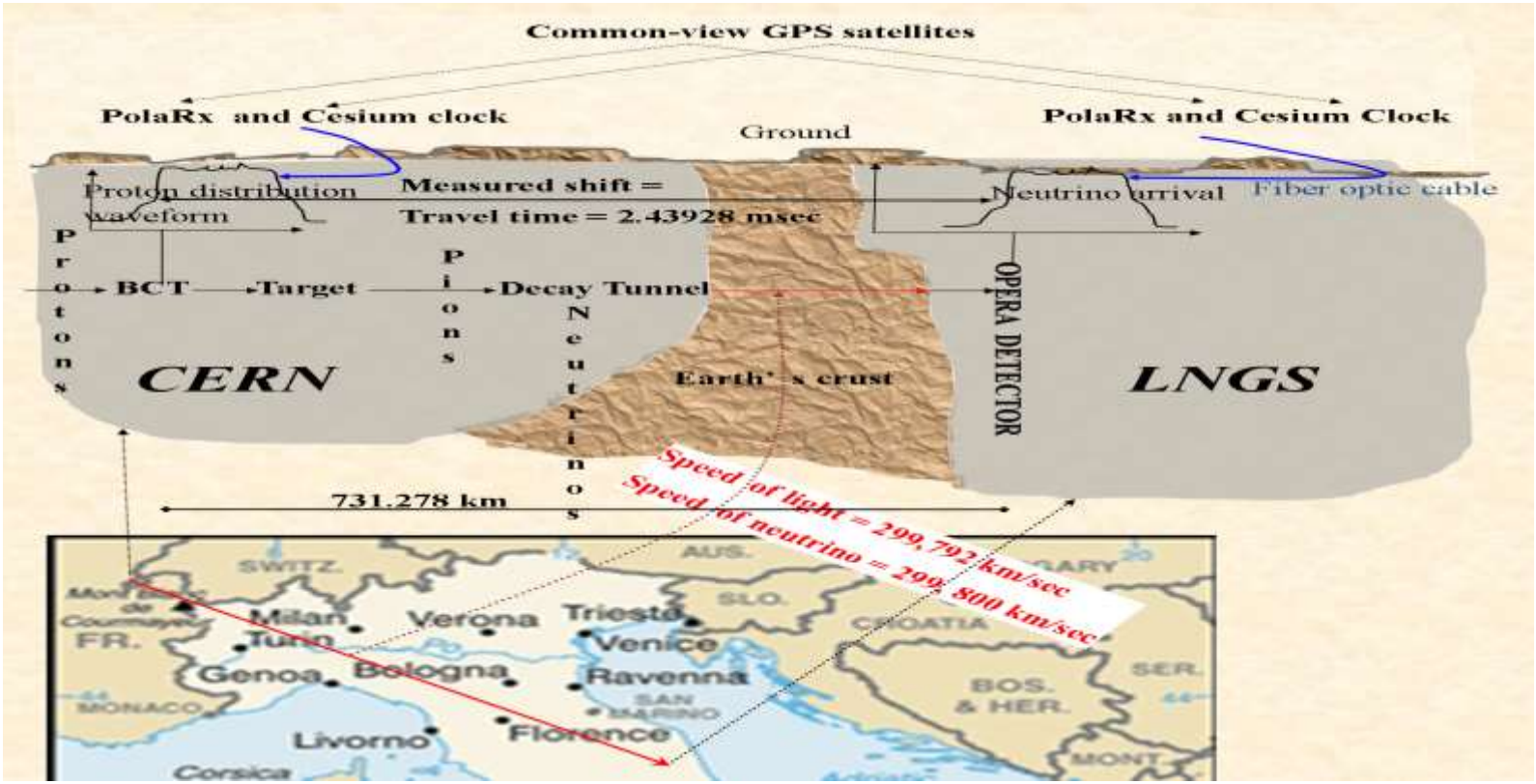
- ✓ **level of measurement (which includes magnitude)**
- ✓ **dimensions (units)**
- ✓ **uncertainty.**

Source: Wikipedia

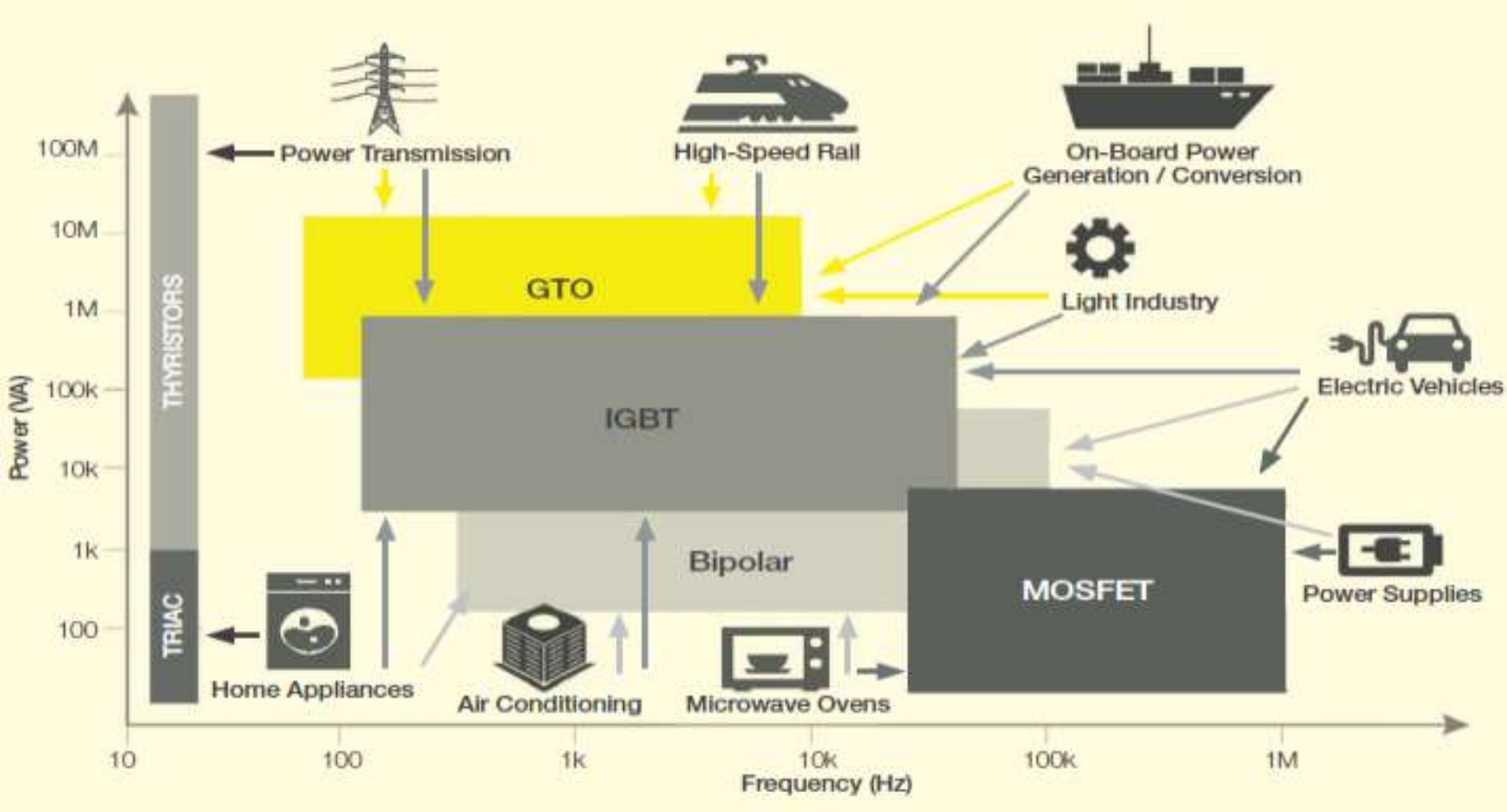
Why calibration

The Opera project

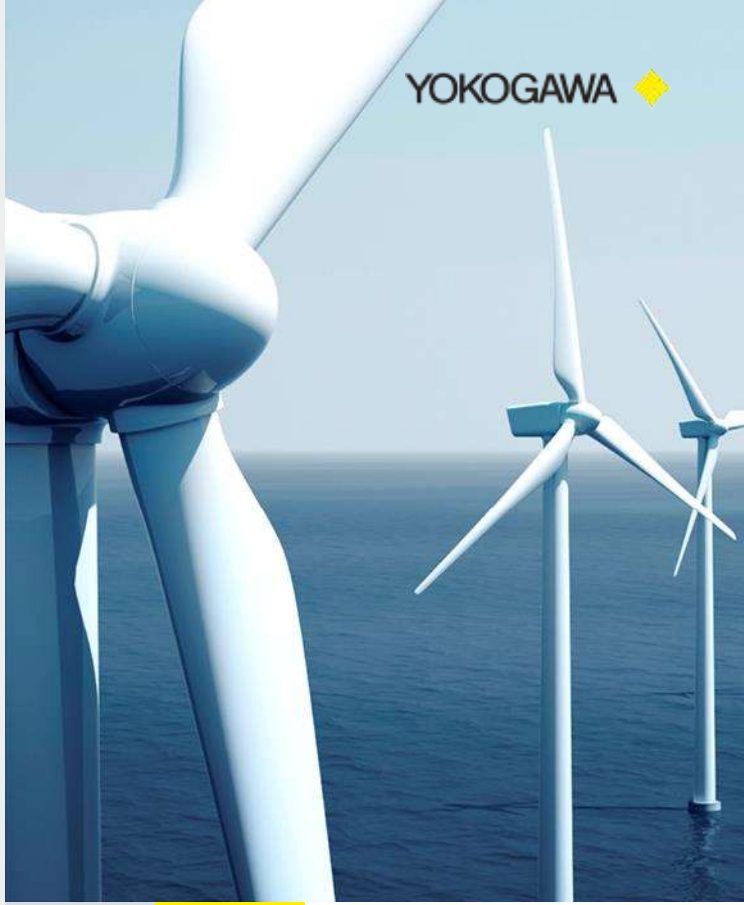
- The Data That Threatened to Break Physics Faster-than-light neutrino (2011)



Frequencies in different applications



Home and office appliances

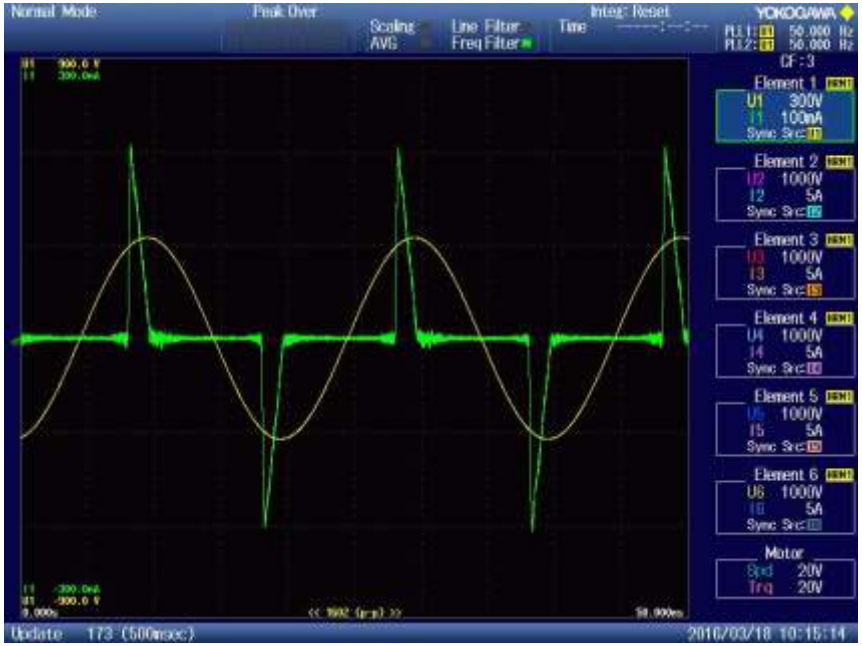


Home and office appliances

50Hz only?

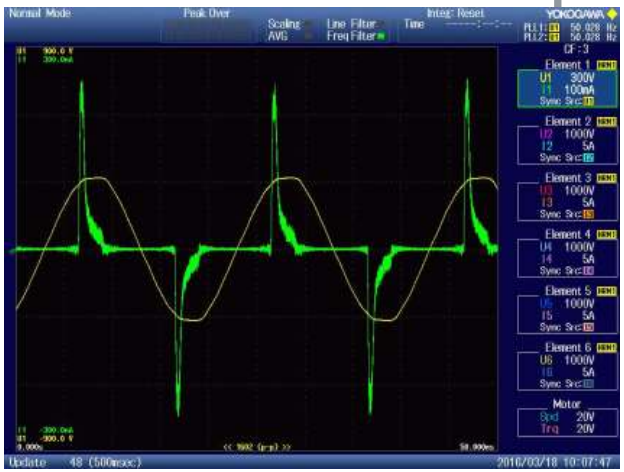
Home and office appliances

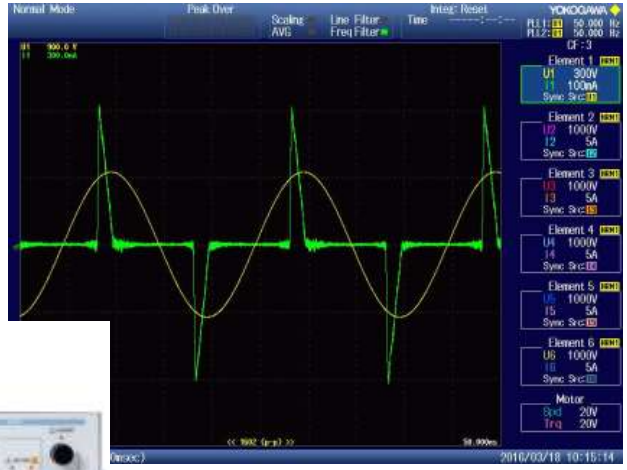
When using a stabilized power supply



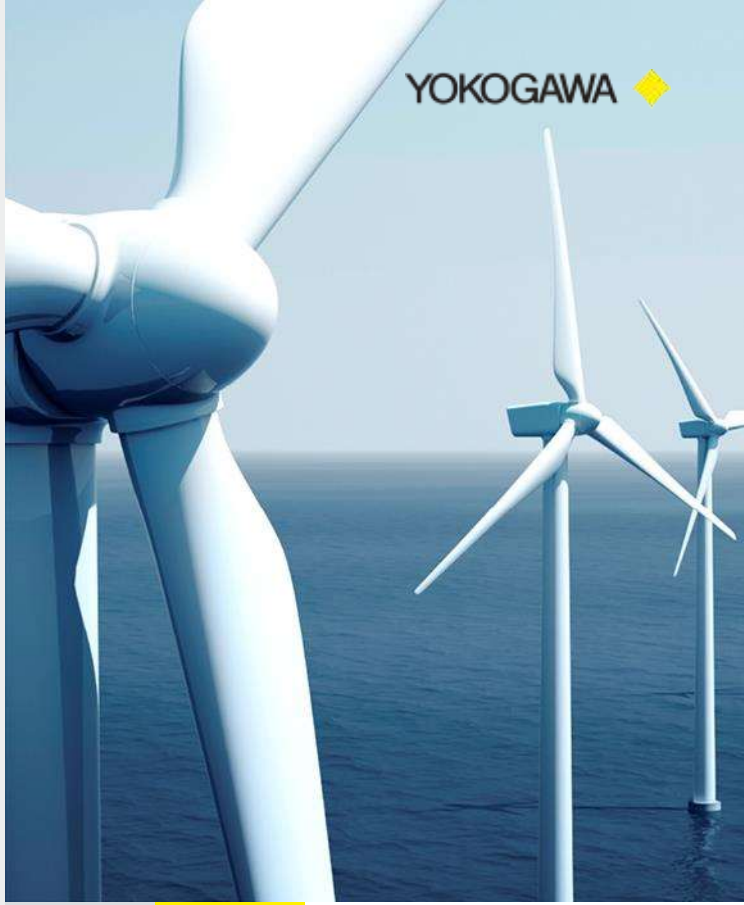
Home and office appliances

Power calibration frequency range





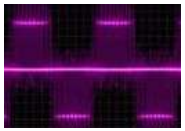
Inverter applications



Inverter applications

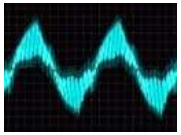
Traction

Voltage



Square wave
±0.05% requires 400 x f_{sw}

Current



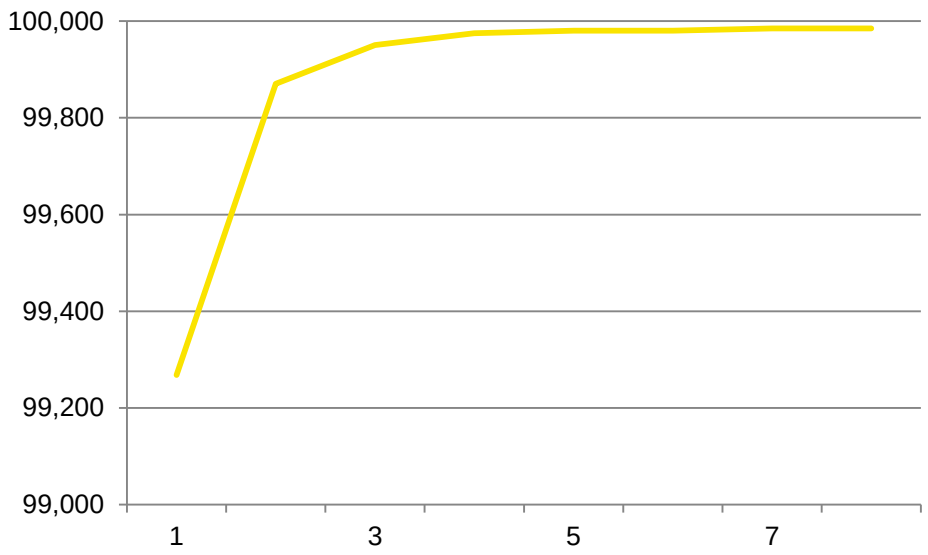
Triangular impact
±0.05% requires 5 x f_{sw}

Power calibration frequency range

5 x or more f_{sw}
depending on the required accuracy

How many harmonics orders to include in a triangular wave

Harmonic order	% of total signal
1	99.268 [%]
3	99.870 [%]
5	99.950 [%]
7	99.975 [%]
9	99.980 [%]
11	99.980 [%]
13	99.985 [%]
15	99.985 [%]



Inverter applications

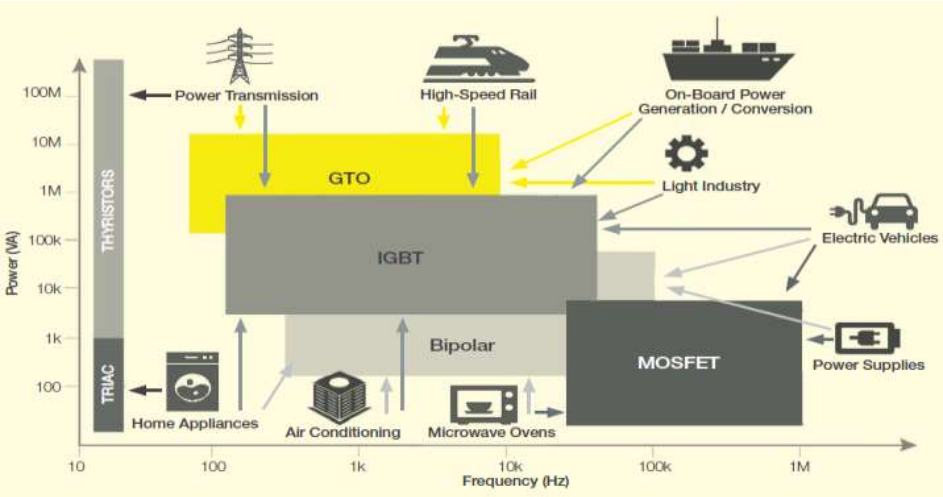
Renewable energy

- For renewable energy the used switching frequencies are between 2 10kHz. To reduce harmonic injection into the grid.

- The requirement for the frequency response depends on the quality of the output signals of the inverter
- Ideally these should be sinusoidal

Switching Frequencies

Switching technique	Switching frequency
IGBT	2 kHz – 20kHz
SiC Mosfet	10kHz – 50kHz
GaN	50kHz – xMHz



Inverter applications

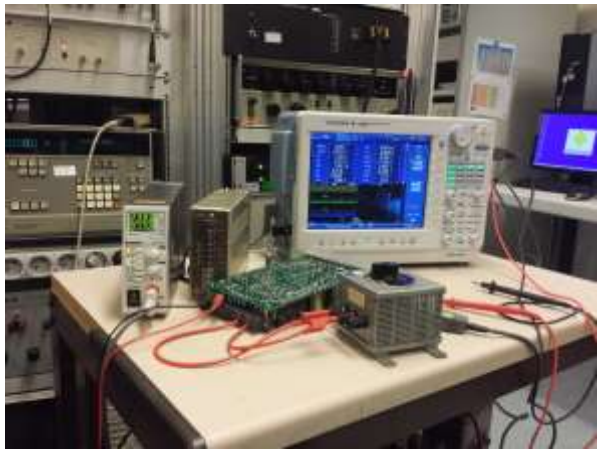
DC

- **As soon as there is a ripple on it phase becomes important.**

  On DC busses in inverters or DC input into inverters often contain a significant AC component

High frequency fundamental applications

- Wireless charging low power applications (phones, tablets etc.) 100 kHz – 300 kHz
- Wireless charging electrical vehicles standardized US and Japan at 200 kW approx. 80 A at 85 kHz
- Inductive cooking
- Industrial inductive ovens
- Electronic components
- Audio



Transformer in DC-DC converter

- 40 kHz fundamental

Accreditation

Calibration Laboratories

Laboratories that are accredited to ISO 17025, have demonstrated that they are technically competent and able to produce precise and accurate calibration measurements

ISO 17025

norm

General requirements for the competence of testing and calibration laboratories (ISO/IEC 17025:2005,IDT)

Yokogawa accreditation Logo from: (Dutch Accreditation Council)

Capabilities Calibration Laboratories

Before Calibration
Check the CMC i.e. Scope of the Calibration Laboratories

What should be checked:

- If they can calibrate the required measurement points
- If the uncertainty is good enough to calibrate your instrument

Annex to ISO/IEC 17025:2005 declaration of accreditation for registration number: **K 164**

of **Yokogawa Europe B.V.**
Yokogawa European Standards Laboratory

This annex is valid from: **24-06-2015** to **01-07-2019** Replaces annex dated: **NA**

HCS code	Measured quantity, Range	Frequency	CMC[1]	Remarks
LF 4 2	AC Current Ratio			
	Current transformer - ratio	53 Hz	$(3.7 \cdot 10^{-5} - 5 \cdot 10^{-5}) \cdot I_n/I_{out}$	Measure Primary: 100 A to 1200 A Secondary:100 mA to 5 A
	Current transformer - phase	53 Hz	2.5 m$^{\theta}$	Measure Primary: 100 A to 1200 A Secondary:100 mA to 5 A
LF 5 1	Power			
	100 µW – 30 kW	DC	$(1.4 \cdot 10^{-5} - 4 \cdot 10^{-4}) \cdot$ W	Generate / Measure 100 mV – 1 kV 1 mA – 30 A
	1 mW – 12 kW	53 Hz	$(4 \cdot 10^{-5} - 1.0 \cdot 10^{-3}) \cdot$ W/VA	Generate / Measure 0.1 –8 V 10 mA – 1200 A cos(φ) = 1
				10–200 V

Calibration for power with Distorted waveforms

Yokogawa method to get traceability for distorted waveforms:

Calibration of:

- **Gain (Voltage, Current) DC and AC up to higher frequencies for each range**
- **Linearity of Voltage, Current (DC and AC)**

- **Power at power factor 1 up to higher frequencies for each range (gives amplitude response)**
- **Linearity of Power (DC and AC)**
- **Power at power factor 0 (inductive and capacitive) up to higher frequencies. (gives phase response)**

- **Harmonic Analysis Function (PLL synchronization circuit) (Voltage, Current and Power)**
- **Time base for frequency measurement**

This includes up to 170 calibration points for one element.

Questions?

Yokogawa European Standards Laboratory