With the right oscilloscope and the tips outlined in this poster, learn how to better ensure the reliability, stability, compliance, and safety of your switch-mode power supply (SMPS) design.

**Power Quality**
- **Power Quality Issues**
  - To determine the effect of the insertion of a power supply, voltage and current parameters must be measured directly on the input power line.
  - Power quality measurements include:
    - True, Apparent or Reactive Power
    - Power Factor/Crest Factor
    - Pre-compliance Testing to EN/IEC/ANSI 3-2 Standards
    - Total Harmonic Distortion (THD)

**Output Analysis**
- Ripple is the periodic AC component on the top of the DC voltage output.
- Ripple frequency is related to:
  - Line frequency: ~60 Hz in countries with 60 Hz power
  - ~50 Hz in countries with 50 Hz power
  - Typically > 100 kHz

**Probing Considerations**
Loading and skew between probes introduce error and distortion in power measurements.
**Tip:** Eliminate skew between current and voltage probes. Since power is the product of voltage and current accurate measurements are made with time-aligned voltage and current waveforms. Tektronix oscilloscopes with the TekVPI interface simplify setup with automated displays.
**Tip:** Remove voltage offset by using the built-in DC offset adjustment controls on differential probes. Additionally run the oscilloscope self-calibration routine as often as necessary to ensure accurate voltage measurements.
**Tip:** A TekVPI current probe has a Degauss/AutoZero button on the probe body. Depressing the AutoZero button will remove any DC offset error present in the measurement system as a result of any residual magnetic field.

**Tektronix 4 and 5 Series MSO**
- 200 MHz – 1.5 GHz (4 Series)
- 350 MHz – 2 GHz (5 Series)
- Up to 6 analog and 84 digital channels
- Comprehensive probing solutions
  - Differential probes to make floating measurements
  - IsoVu™ isolated probes with high bandwidth for accurate characterization of fast edges
  - Power rail probes for low noise and high DC offset specifically for power integrity measurements
  - 12 bit ADC vertical resolution
  - Repeatable, automated power measurement software — key to ensuring designs are reliable, safe and compliant.

Learn more about Tektronix power measurement and analysis solutions at:
www.tektronix.com/power-efficiency

**Magnetics Analysis**
- **Inductors**
  - Used in power supplies as a filter or energy storage device
  - Where:
    - \( L \) is the inductance
    - \( V \) is the voltage across the inductor
    - \( f \) is the current through the inductor
    - \( dr/dt \) is the rate of change in a signal, the slew rate
- **Transformers**
  - Magnetic coupling
  - Multiple winding inductor or transformer used for stepping voltages up or down with the same net power level
  - Two types of magnetic losses are associated with magnetic materials:
    - Core Loss: Composed of hysteresis loss and eddy current loss. The hysteresis loss is a function of the frequency of operation and the AC flux swing
    - Copper Loss: Due to the resistance of the copper winding wire.

**Switching Loss Measurements**
- Transistors dissipate very little power in either the On or Off states, achieving high efficiency with low heat dissipation
- Transistor switch circuits often dissipate the most energy during transitions because circuit parasitics prevent the devices from switching instantaneously
- For the most part, the switching device determines the overall efficiency of an SMPS

**Overcoming Common Mode Voltage**
- Many power supply topologies require measurements of small differential voltages in the presence of high common mode voltages. For example, VSSS and VDS on the high side of a half-bridge switching stage often move up and down 100s or 1000s of volts relative to ground.
- IsoVu™ isolated Measurement Systems offer extremely high common mode rejection.

**Switching Loss Overview**
- **Turn-on Loss**
  - Energy losses when the switching device changes from its non-conducting state to its conducting state
- **Conduction Loss**
  - Losses in the switching device when it is conducting
- **Turn-off Loss**
  - Energy losses when the switching device changes from its conducting state to its non-conducting state.