

Using an Oscilloscope and Power Electronics

1. Introduction to the Switched Mode Power Supply (SMPS) Prototype

- The goal: Building a functional prototype that converts 230V AC to 5V DC.
 - Successful testing: The system outputs approximately 5V without issues.
 - Reminder: Working with oscilloscopes requires knowledge of their operation to avoid mistakes that could damage the equipment.
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2. Overview of the Oscilloscope

- **Purpose:** Visualizes voltage/current values over time, crucial for observing waveforms in power electronics and data communication.
 - **Basic Operation:** The oscilloscope helps diagnose issues in circuits by showing real-time signals, crucial for building and repairing electronics.
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3. Choosing the Right Oscilloscope

- **Channels:** More channels allow simultaneous observation of multiple signals. A 4-channel scope is ideal for most applications.
 - **Bandwidth:** The scope's ability to handle higher frequencies without significant signal degradation. Rule of thumb: Choose a scope with a bandwidth 5 times greater than the signal's frequency.
 - **Sampling Rate:** The number of measurements taken per second. 2GSa/s is sufficient for most applications, even with multiple channels active.
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4. Probes: Types and Usage

- **Passive Probes:** Easy to use and come with scaling factors of x1 or x10.
 - **Scaling Factor:**
 - x1: No voltage reduction but lower bandwidth due to higher capacitance.

- **x10:** Reduces the voltage signal by a factor of 10 but maintains higher bandwidth and performance.
 - **Impedance:** Not discussed in-depth, but important for high-quality measurements.
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5. Triggering the Oscilloscope

- **Triggering:** Essential for stabilizing periodic signals on the oscilloscope display.
 - The trigger ensures that the signal is captured at the same point every time, like at the rising or falling edge.
 - **Common Mistake:** Incorrect triggering leads to unstable or non-stationary waveforms.
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6. Voltage Division

- **Vertical Voltage Division:** Determines the signal amplitude on the oscilloscope screen.
 - Misadjustment can lead to incorrect signal amplitude readings.
 - Example: If your project works with 5V logic, ensure the oscilloscope scaling is set properly to reflect this.
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7. Time Division and Frequency

- **Horizontal Time Division:** Controls the time per division on the oscilloscope.
 - Helps calculate the frequency of signals.
 - Example: With a time division of 10 μ s per division, the signal frequency is approximately 33 kHz.
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8. Advanced Measurement Features

- **Measurement Functions:** Modern digital oscilloscopes come with built-in measurement features to directly measure parameters like frequency, rise time, etc.
 - **Cursor Function:** Allows you to manually measure specific characteristics of a waveform, such as rise time by selecting voltage points.
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9. AC and DC Coupling

- **AC Coupling:** Allows only AC signals to pass, removing any DC offset for clearer waveforms.
 - Example: Measuring the ripple on the output of a boost converter without interference from DC offset.
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10. Single Mode Capturing

- **Single Mode:** Useful for capturing transient events like capacitor charging.
 - The oscilloscope triggers only once the signal reaches a specific threshold, allowing you to capture a single event.
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11. Current Measurement

- **Current Measurement Methods:**
 - **Current Shunt:** Measures current by sensing the voltage drop across a known resistance.
 - **Current Clamp:** Easier to use and set up for non-invasive current measurements.
 - **Recommendation:** A current clamp is recommended for simple and effective current measurements.
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12. Safe Mains Voltage Measurement

- **Warning:** Mains voltage (230V AC) can be hazardous. Always use proper safety precautions when measuring mains voltage with an oscilloscope.
 - **Scaling Factor:** A 10:1 scaling factor reduces the 230V AC to a safer 23V, within the oscilloscope's safe input range.
 - **Common Mistake:** Incorrectly grounding the oscilloscope by connecting the alligator clip to the PE (Protective Earth) wire can trip circuit breakers or damage the scope.
 - **Solution:** Use a differential probe for safe mains voltage measurement.
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13. Differential Probe

- **Purpose:** A differential probe isolates the input and output, preventing potential damage when measuring high-voltage signals, such as mains voltage.
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14. Advanced Functions: Math & FFT

- **Math Function:** Useful for analyzing complex signals, such as calculating the power in a circuit.
 - **FFT (Fast Fourier Transform):** Converts time-domain signals to the frequency domain, useful for analyzing frequency components in power electronics.
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15. Conclusion and Final Tips

- Oscilloscopes are powerful tools but require proper understanding and precautions.
 - With knowledge of triggering, scaling factors, and measurement techniques, you can safely and effectively use an oscilloscope for various electronic projects.
 - Always ensure proper grounding, especially when working with high-voltage signals like mains electricity.
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This concludes the basics of using an oscilloscope and the key techniques for safe and effective measurements in power electronics.