Power Factor Correction (PFC) and Its Importance in Modern Power Supplies

1. Introduction to Power Factor and Current Consumption

- **Current Consumption Comparison**:
  - **Heat Gun**: Draws current in phase with mains voltage, sinusoidal current waveform.
  - **LED Strip**: Draws current only briefly at the peak of the mains voltage, creating a distorted current waveform.
- **Problem**: The LED strip, with its AC to DC power supply, draws a lot of **apparent power** due to the abnormal current waveform, while the real power it requires is relatively low. This is inefficient and stresses the power grid.

2. Understanding Power Types

- **Real Power**: The actual power consumed by devices (e.g., lighting up LEDs).
- **Apparent Power**: The total power drawn from the grid (including both real and reactive power).
- **Reactive Power**: Useless power that oscillates between the grid and the device. Causes more current to flow than necessary, leading to inefficiencies and requiring thicker wires.
- **Goal**: Minimize reactive power and make apparent power equal to real power for efficiency.

3. What Causes Reactive Power?

- **Phase Shifts**: Reactive power is generated when current does not follow the same phase as the mains voltage. Two common causes:
  - **Capacitive Power Supplies** (e.g., LED lights)
  - **Motors** (inductive load)
- **Fixing Reactive Power**: Adding inductance to capacitors and vice versa can reduce phase shift and thus reactive power, leading to a power factor closer to 1 (ideal scenario).

4. Types of Power Factor Correction Circuits

- **Passive Power Factor Correction (PFC)**:
  - Uses inductance and capacitance to reduce phase shifts.

    - Simple, effective, and inexpensive but not as efficient for high-power applications.
- **Active Power Factor Correction (PFC)**:
    - More advanced; uses a boost converter to convert AC to DC and smooth the current draw to match the mains voltage shape.
    - Provides a higher power factor by reducing current harmonics and minimizing reactive power.

5. Testing Active PFC

- **Experiment Setup**:
    - Tested a common power supply with noticeable current pulses.
    - Used an active PFC circuit to smooth out the current waveform.
    - Without PFC: The current waveform was irregular, leading to low power factor and high reactive power.
    - With PFC: The current waveform became sinusoidal, eliminating most of the current harmonics and improving the power factor.
- **Results**: With the active PFC installed, the power supply's input current followed the mains voltage more closely, reducing reactive power and increasing the power factor.

6. How Active PFC Works

- **Boost Converter Mechanism**:
    - Converts varying AC input voltage to a stable, higher DC voltage.
    - Regulates the current flow by adjusting the duty cycle of the MOSFET switches based on input voltage.
    - Results in a smoother current waveform, reducing harmonic distortion and improving efficiency.

7. Practical Benefits and Future Regulations

- **Efficiency Improvements**: Active PFC reduces reactive power and harmonics, making devices more efficient.
- **Regulations**: Many regulations are already in place to limit current harmonics. Active PFCs are becoming mandatory for new appliances.

- **Recommendation**: When purchasing power supplies, consider models with built-in active PFC for better efficiency and grid stability.

8. Conclusion

- **Importance of Power Factor Correction**: PFC circuits, especially active PFC, are critical for reducing inefficiencies and improving the stability of the electrical grid. They help in managing reactive power and ensuring that power supplies draw only the necessary current, which will become even more essential as power grid demands increase.

Key Takeaways:

- **Power Factor (PF)** is crucial for understanding how efficiently power is used in devices. A **PF of 1** means all the power is being used effectively.
- **Reactive power** is a problem caused by devices that create phase shifts, wasting energy and stressing the power grid.
- **PFC circuits** help mitigate this problem, either passively or actively, to improve efficiency.
- **Active PFC circuits** are necessary for modern devices, and as regulations become stricter, these circuits will likely become mandatory in the near future.