Switching Mode Power Supplies

Inverters, UPS, and the Hysteresis Curve

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Inverters and Uninterruptible Power Supplies

An inverter is a switching power supply that converts DC into AC.

The DC is usually a 12- volt battery which is converted to 120 volt 60 Hz sine wave.

A popular version of inverter is the uninterruptible power supply (UPS). It is commonly used to ensure continuous operation of computers and other devices during a power failure.

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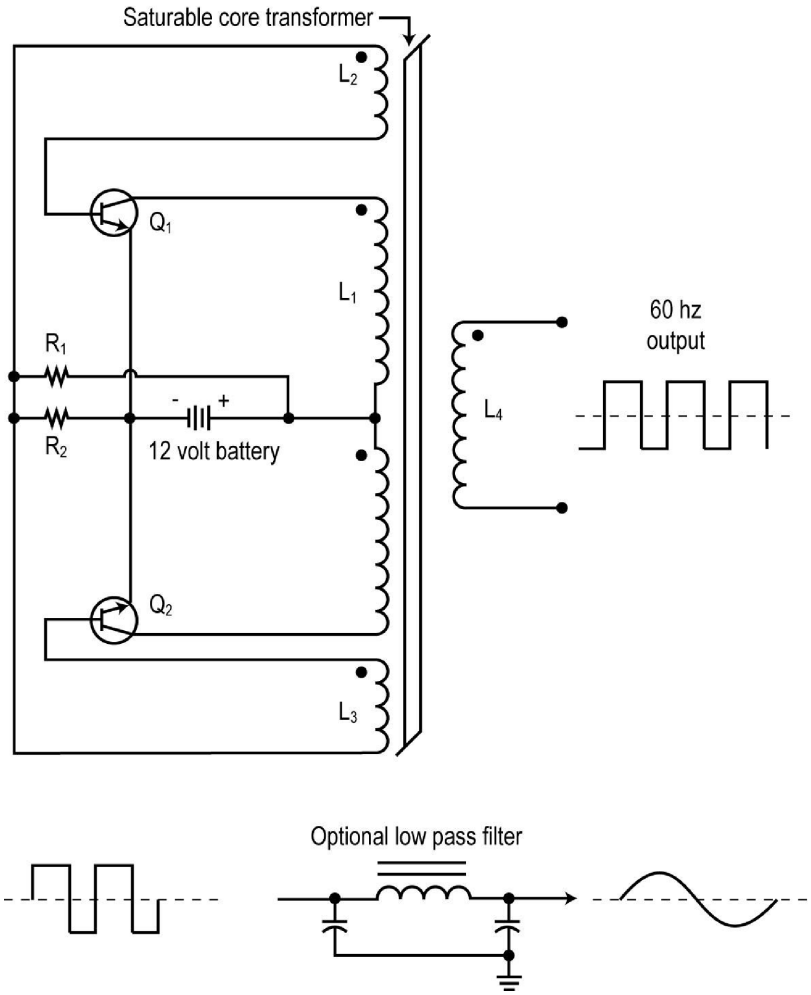
Inverter Operation

This inverter circuit is a push-pull switching oscillator. Q_1 and Q_2 alternately conduct connecting and disconnecting the primary winding L_1 of the transformer to the 12 volt battery. Secondary windings L_2 and L_3 provide positive feedback to Q_1 and Q_2 to initiate and sustain oscillation.



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Inverter Operation (continued)

The frequency of oscillation is a function of the transformer characteristics:

f = $(V \times 10^8)(4 \times N \times B_{sat} \times A)$

V = DC input voltage

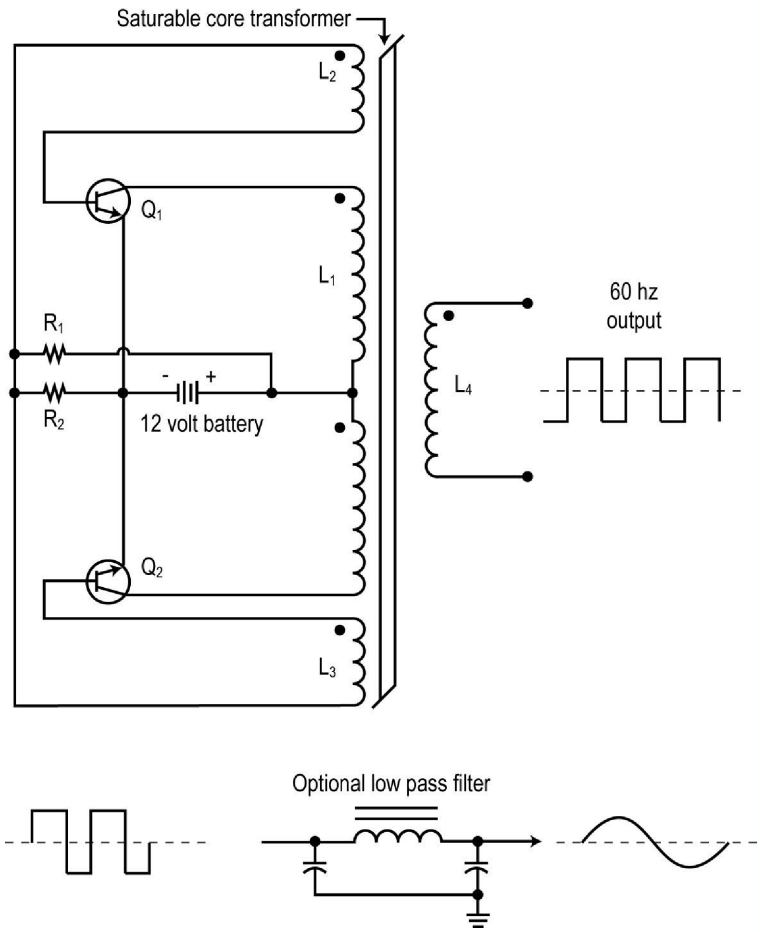
N = number of turns on half the primary

B_{sat} = saturation flux density of core

A = cross sectional area of the core

An AC square wave is developed across the secondary winding L_4. Some loads operate satisfactorily with square wave but others do not.

A low pass filter is often used to convert the output square wave into a sine wave.



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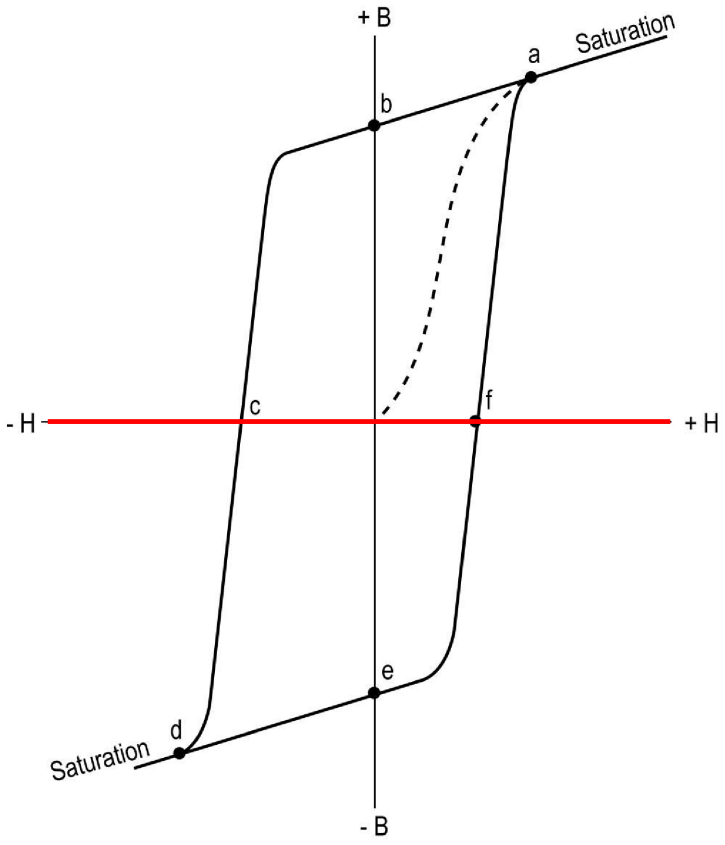
Hysteresis Curve

A plotted hysteresis curve describes the operation of the transformer and shows the operating characteristics of the inverter circuit.

The horizontal axis (H) is the magnetizing force. It is proportional to the number of turns on the primary (N) and the current in the primary (I).
H = NI



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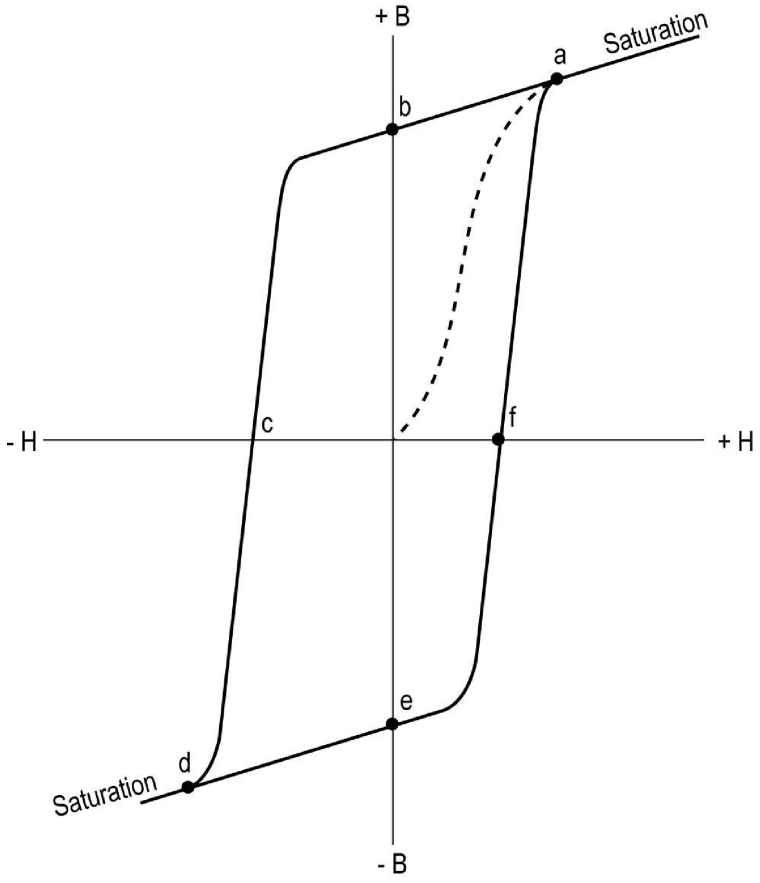
Hysteresis Curve (continued)

As the magnetizing force increases, the flux density (B) is expressed as the number of magnetic flux lines per unit area. B increases as H increases until saturation of the core occurs. Saturation is defined as the point where an increase in H no longer causes an increase in B. The core retains some magnetism even if the magnetizing force is removed. A magnetic field of the opposite polarity will demagnetize the core. This is the nature of hysteresis.



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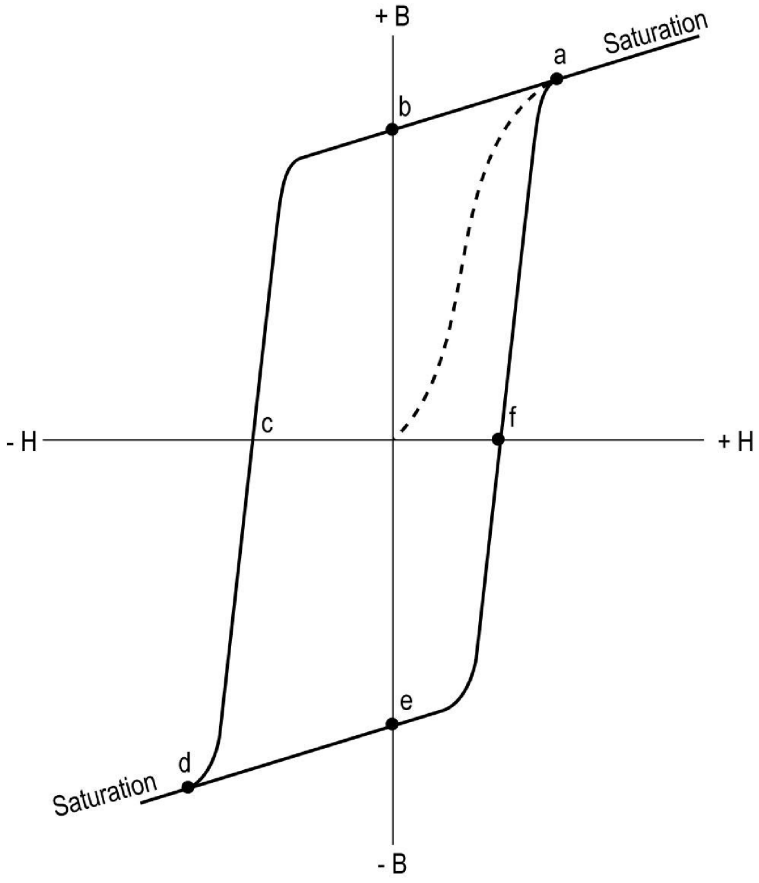
Hysteresis Curve (continued)

The core material of a transformer is easily saturated by the magnetic field developed by the primary. As H increases from zero, B increases until saturation at point a occurs. If H is decreased to zero, B decreases but the core retains some of the magnetism at point b.



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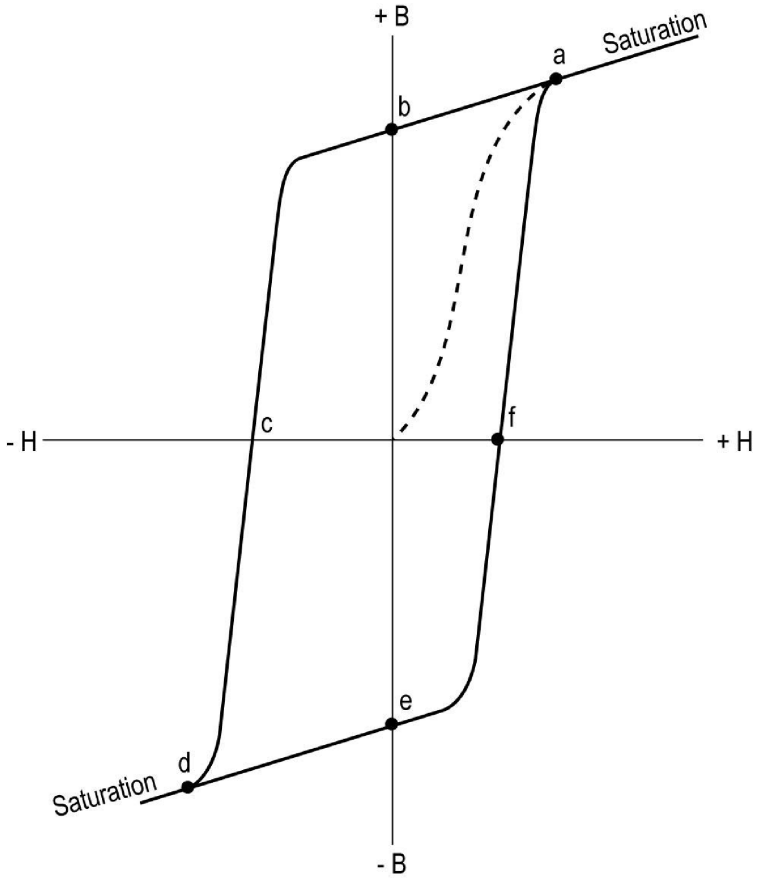
Hysteresis Curve (continued)

If the magnetizing force is reversed (-H), the core will be demagnetized and then remagnetized in the opposite direction. The core saturates in the opposite direction at point d. Decreasing H and reversing its direction increases B in the original direction again producing saturation at point a. As long as H is changing, B changes causing a voltage to be induced into the transformer windings. When B no longer changes, due to saturation, induced voltage ceases.



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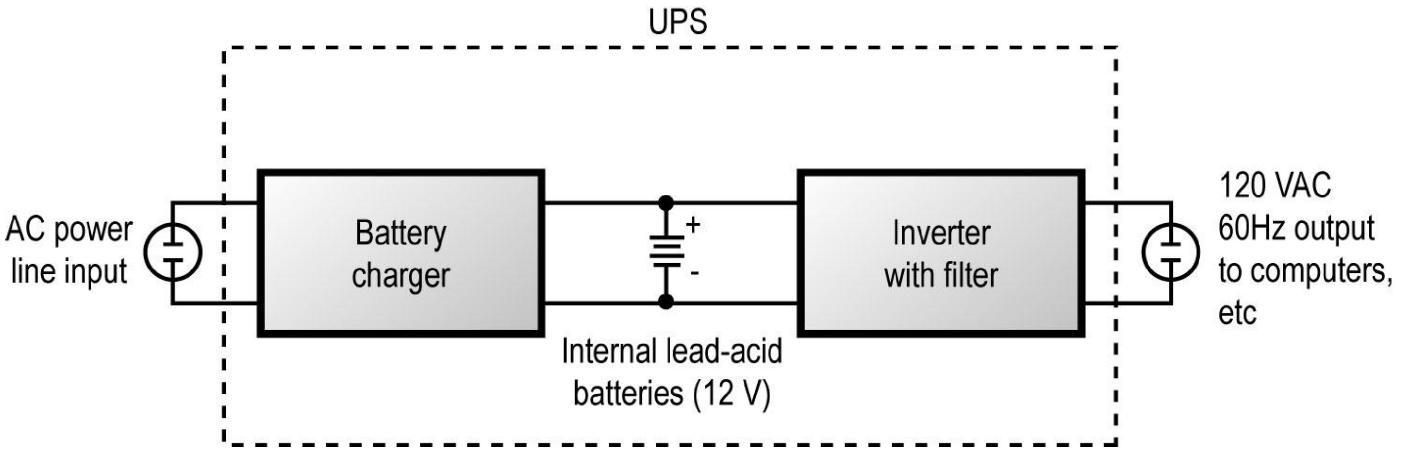
Uninterruptible Power Supply

An uninterruptible power supply (UPS) is used to power personal computers and network servers in order to maintain operation during any power failure. Units are available for operation from a fraction of an hour to many hours depending upon the size and capacity of the batteries.



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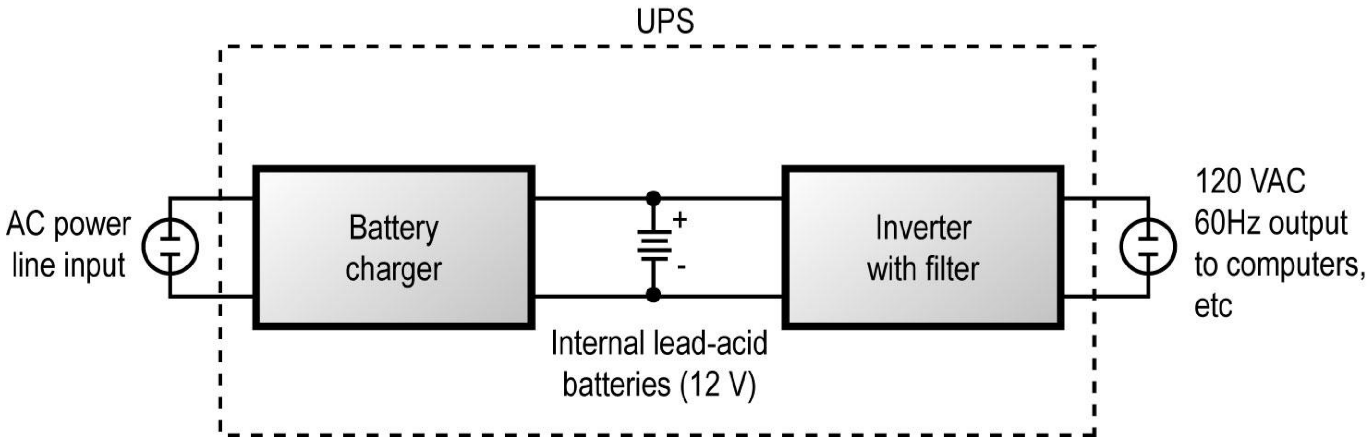
UPS Operation

A battery (usually lead-acid, 12 volts) operates the inverter which produces 120 VAC at 60Hz. A microcomputer and/or other loads are plugged into the inverter. A battery charger, operated from a 60 Hz AC line, keeps the battery charged prior to a power outage. The loads are not exposed to the AC line voltage directly so they are protected from any voltage variations including noise and pulses. A variation of UPS powers the computer directly from the AC power line until a power failure occurs at which time MOSFET switches connect the inverter to the computer.



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