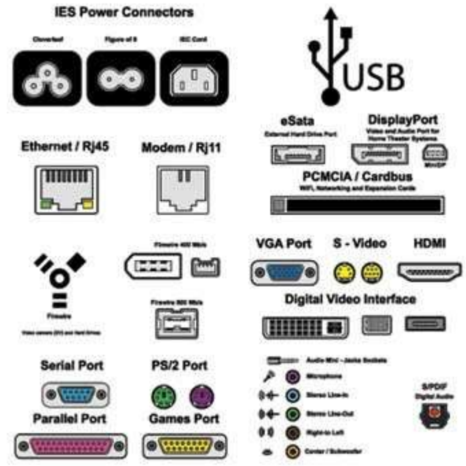

Let us now discuss a few important types of ports –

Serial Port

Used for external modems and older computer mouse

Two versions: 9 pin, 25 pin model

Data travels at 115 kilobits per second

Parallel Port

Used for scanners and printers

Also called printer port

25 pin model

IEEE 1284-compliant Centronics port

PS/2 Port

Used for old computer keyboard and mouse

Also called mouse port

Most of the old computers provide two PS/2 port, each for the mouse and keyboard

IEEE 1284-compliant Centronics port

Universal Serial Bus (or USB) Port

It can connect all kinds of external USB devices such as external hard disk, printer, scanner, mouse, keyboard, etc.

It was introduced in 1997.

Most of the computers provide two USB ports as minimum.

Data travels at 12 megabits per seconds.

USB compliant devices can get power from a USB port.

VGA Port

Connects monitor to a computer's video card.

It has 15 holes.

Similar to the serial port connector. However, serial port connector has pins, VGA port has holes.

Power Connector

Three-pronged plug.

Connects to the computer's power cable that plugs into a power bar or wall socket.

Firewire Port

Transfers large amount of data at very fast speed.

Connects camcorders and video equipment to the computer.

Data travels at 400 to 800 megabits per seconds.

Invented by Apple.

It has three variants: 4-Pin FireWire 400 connector, 6-Pin FireWire 400 connector, and 9-Pin FireWire 800 connector.

Modem Port

Connects a PC's modem to the telephone network.

Ethernet Port

Connects to a network and high-speed Internet.

Connects the network cable to a computer.

This port resides on an Ethernet Card.

Data travels at 10 megabits to 1000 megabits per seconds depending upon the network bandwidth.

Game Port

Connect a joystick to a PC

Now replaced by USB

Digital Video Interface, DVI port

Connects Flat panel LCD monitor to the computer's high-end video graphic cards.

Very popular among video card manufacturers.

Sockets

Sockets connect the microphone and speakers to the sound card of the computer.

KT1002 Power supply units, uninterruptible power supplies, and identifying power supplies

Unregulated

An unregulated power supply is the most rudimentary type, consisting of a transformer, rectifier, and low-pass filter. These power supplies typically exhibit a lot of ripple voltage (i.e. rapidly-varying instability) and other AC "noise" superimposed on the DC power. If the input voltage varies, the output voltage will vary by a proportional amount. The advantage of an unregulated supply is that it's cheap, simple, and efficient.

Linear regulated

A linear regulated supply is simply a "brute force" (unregulated) power supply followed by a transistor circuit operating in its "active," or "linear" mode, hence the name linear regulator. (Obvious in retrospect, isn't it?) A typical linear regulator is designed to output a fixed voltage for a wide range of input voltages, and it simply drops any excess input voltage to allow a maximum output voltage to the load. This excess voltage drop results in significant power dissipation in the form of heat. If the input voltage gets too low, the transistor circuit will lose regulation, meaning that it will fail to keep the voltage steady. It can only drop excess voltage, not make up for a deficiency in voltage from the brute force section of the circuit. Therefore, you have to keep the input voltage at least 1 to 3 volts higher than the desired output, depending on the regulator type. This means the power equivalent of at least 1 to 3 volts multiplied by the full load current will be dissipated by the regulator circuit, generating a lot of heat. This makes linear regulated power supplies rather inefficient. Also, to get rid of all that heat they have to use large heat sinks which make them large, heavy, and expensive.

Switching

A switching regulated power supply ("switcher") is an effort to realize the advantages of both brute force and linear regulated designs (small, efficient, and cheap, but also "clean," stable output voltage). Switching power supplies work on the principle of rectifying the incoming AC power line voltage into DC, re-converting it into high-frequency square-wave AC through transistors operated as on/off switches, stepping that AC voltage up or down by using a lightweight transformer, then rectifying the transformer's AC output into DC and filtering for final output. Voltage regulation is achieved by altering the "duty cycle" of the DC-to-AC inversion on the transformer's primary side. In addition to lighter weight because of a smaller transformer core, switchers have another tremendous advantage over the prior two designs: this type of power supply can be made so totally independent of the input voltage that it can work on any electric power system in the world; these are called "universal" power supplies. The downside of switchers is that they are more complex, and due to their operation they tend to generate a lot of high-frequency AC "noise" on the power line. Most switchers also have significant ripple voltage on their outputs. With the cheaper types, this noise and ripple can be as bad as for unregulated power supply; such low-end switchers aren't worthless, because they still provide a stable average output voltage, and there's the "universal" input capability. Expensive switchers are ripple-free and have noise nearly as low as for some a linear type; these switchers tend to be as expensive as linear supplies. The reason to use an expensive switcher instead of a good linear is if you need universal power system compatibility or high efficiency. High efficiency, light weight, and small size are the reasons switching power supplies are almost universally used for powering digital computer circuitry.

Ripple regulated

A ripple-regulated power supply is an alternative to the linear regulated design scheme: a "brute force" power supply (transformer, rectifier, filter) constitutes the "front end" of the circuit, but a transistor operated strictly in it's on/off (saturation/cutoff) modes transfers DC power to a large capacitor as needed to maintain the output voltage between a high and a low setpoint. As in switchers, the transistor in a ripple regulator never passes current while in its "active," or "linear," mode for any substantial length of time, meaning that very little energy will be wasted in the form of heat. However, the biggest drawback to this regulatory scheme is the necessary presence of some ripple voltage on the output, as the DC voltage varies between the two voltage control setpoints. Also, this ripple voltage varies in frequency depending on load current, which makes the final filtering of the DC power more difficult. Ripple regulator circuits tend to be quite a bit simpler than switcher circuitry, and they need not handle the high power line voltages that switcher transistors must handle, making them safer to work on.

All power supplies are required by UL (formerly known as Underwriters Laboratories) to include a sticker with power ratings on it. If you're unable to locate a sticker on your power supply, the identification may be on the side that is not visible

KT1003 Conversion of voltage, overcurrent protection, input supply voltage, DC voltage regulation, input under-voltage, and Energy Star designation

What are AC-DC Converters

Electric power is transported on wires either as a direct current (DC) flowing in one direction at a non-oscillating constant voltage, or as an alternating current (AC) flowing backwards and forwards due to an oscillating voltage. AC is the dominant method of transporting power because it offers several advantages over DC, including lower distribution costs and simple way of converting between voltage levels thanks to the invention of the transformer.

AC power that is sent at high voltage over long distances and then converted down to a lower voltage is a more efficient and safer source of power in homes. Depending on the location, high voltage can range from 4kV (kilo-volts) up to 765kV. As a reminder, AC mains in homes range from 110V to 250V, depending on which part of the world you live it. In the U.S., the typical AC main line is 120V.

AC-DC Converters steer an alternating current, as its voltage also alternates, into reactive impedance elements, such as inductors (L) and capacitors (C), where it is stored and integrated. This process separates the power associated with the positive and negative potentials.

Filters are used to smooth out the energy stored, resulting in creation of a DC source for other circuits. This circuit can take many forms but always comprises of the same essential elements, and may have one or more stages of conversion.

The AC-DC converters depicted in figure 1 is called a 'forward converter", which is a higher efficiency than a slightly simpler architecture; a 'flyback converter'.

Although not discuss in detail, a flyback converter differs from a forward converter in that its operation depends upon energy stored in the airgap of the transformer in the circuit. Apart from this difference, they can utilize the same essential blocks.

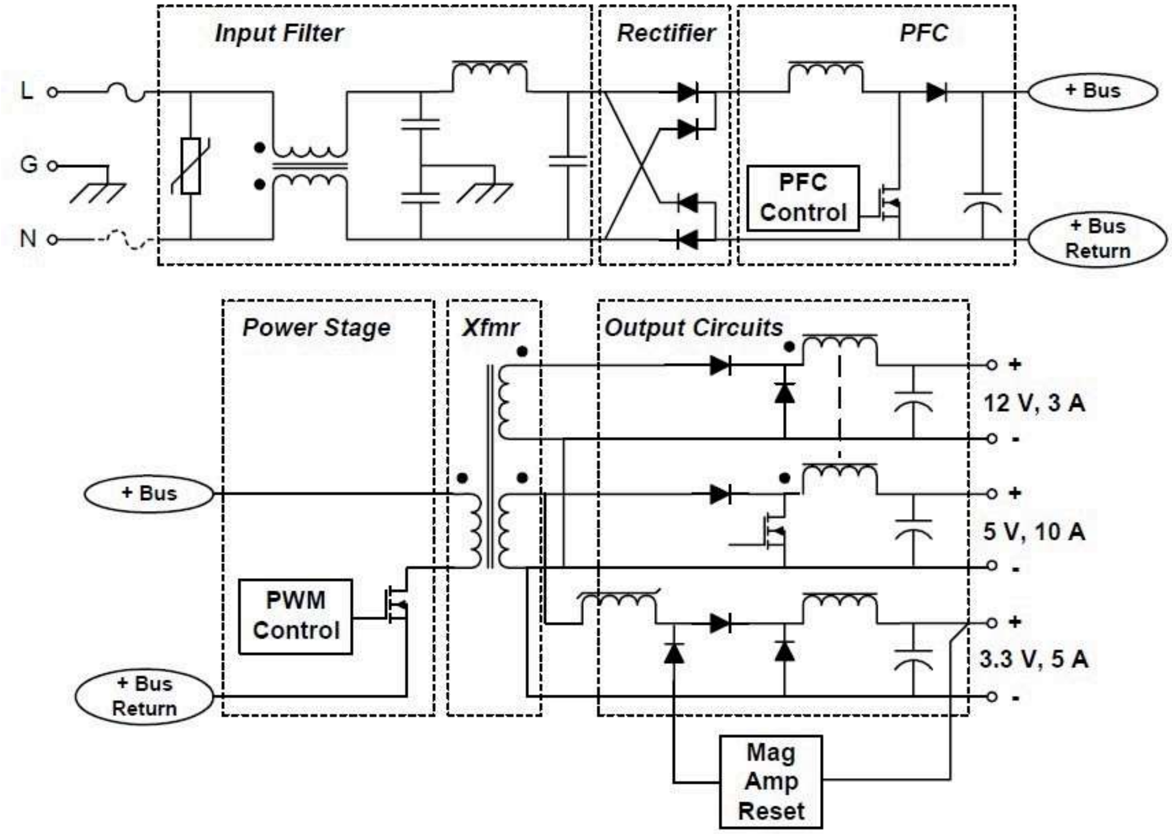

Figure 1: Functional Block Diagram of a Forward Converter AC/DC Power Supply

Input Filtering Block

An input filter is important as it prevents noise produced in the power supply switching elements from getting back onto the mains power supply. It also prevents noise that may be on the mains power supply getting into subsequent circuits. The filter passes through 50/60Hz mains frequency, and attenuates higher frequency noise and harmonics that might be present.

As with other parts of AC-DC converters, reactive elements like capacitors and inductors perform the important role of frequency – selective suppression. Capacitors do not pass DC, and can be used in series (as DC blocking 'high pass filter' elements), or parallel (to shunt high frequencies to ground preventing them from getting through to the converter).

The input filtering block will also typically include a voltage dependent resistor, or varistor to prevent high voltage spikes on the electrical power grid from damaging the power supply. This is the rectangular box with the diagonal line through it on the input in Figure 1. The most common type of varistor is a metal-oxide varistor (MOV). Any voltage over the devices 'clamping voltage' causes the MOV to become conductive, shunting the high voltage spike and suppressing the surge.

Rectification

The simplest AC-DC converters comprise of a transformer following the input filtering, which then passes onto a rectifier to produce DC. In this case, rectification occurs after the transformer because transformers do not pass DC. However, many AC/DC converters use more sophisticated, multi-stage conversion topologies as depicted in figure 1 due to advantages of smaller transformer requirements and lower noise referred back to the mains power supply.

Rectifiers are implemented using semiconductor devices that conditionally conduct current in one direction only, like diodes. More sophisticated semiconductor rectifiers include thyristors. Silicon controlled rectifiers (SCR) and triode for alternating current (TRIAC) are analogous to a relay in that a small amount of voltage can control the flow of a larger voltage and current.

The way these work is they only conduct when a controlling 'gate' is triggered by an input signal. By switching the device on or off at the right time as the AC waveform flows – current is steered to create a DC separation. There are many circuits for doing this, with signals tapped off the AC waveform used as control signals that set the phase quadrants thyristors are on or off. This is commutation, and can be either natural (in the case of a simple diode) or forced, as in the case of devices that are more sophisticated.

High efficiency power supplies can use active devices like MOSFETs as switches in such circuits. The reason for using topologies that are more complex is usually for efficiency improvement, to lower noise or to act as a power control.

Diodes have an intrinsic voltage drop across them when they conduct. This causes power to be dissipated in them, but other active elements may have much lower drop and therefore lower power loss. SCR and TRIAC circuits are particularly common in low cost power control circuits like the light dimmer example below – used to directly steer and control current delivered to the load as the input mains alternates.

Note that these implementations are not galvanic when they do not have a transformer in the circuit – only useful in circuits that are appropriate like direct mains connected light control. They are also used in high power industrial and military power supplies where simplicity and robustness is essential

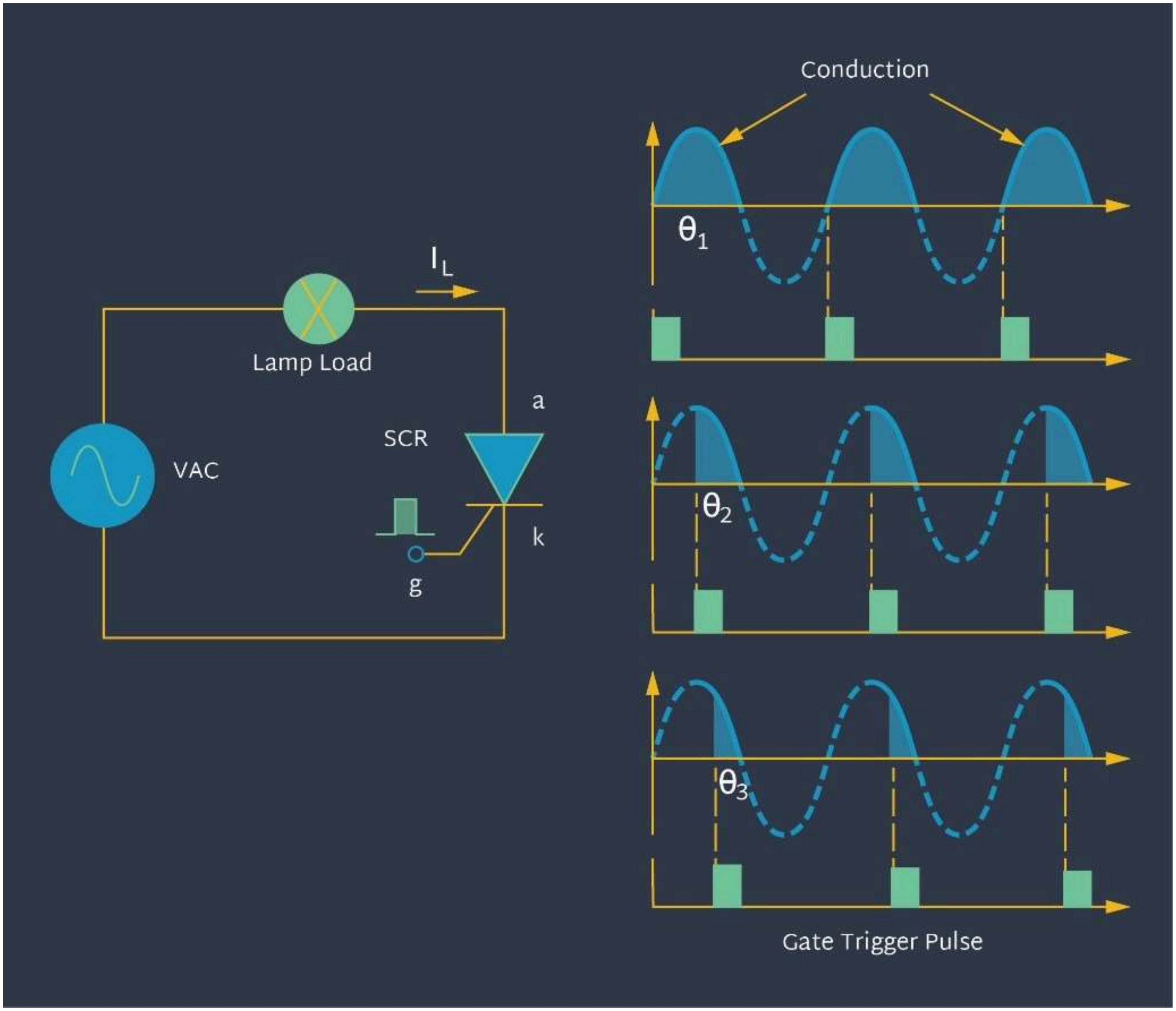

Figure 2: SCR Based Conversion

Power Factor Correction (PFC)

This is the most complicated aspect of a converter to understand. PFC is an essential element in improving the efficiency of a converter by correcting the relative phase of current being drawn to voltage waveform to maintain the optimum power factor. It reduces the 'reactive load' characteristics that the converter may otherwise present to the mains power supply.

This is essential for maintaining high quality, efficient electrical networks and electrical supply companies can even impose special reactive current tariffs on customers that have poor power factors. Passive or active PFC refers to whether active elements or passive elements being used to correct the phase relationships.

Semiconductor PFC can refer to special purpose ICs with integrated controllers tailored to actively monitor and adjust the PFC circuit, reducing the component count and simplifying the overall design while obtaining higher performance. They can incorporate other functions like over/under voltage protection, over current protection, soft start, and fault detection/response.

The converter depicted in figure 1 is a single stage PFC converter. The capacitor in this section is used to store the unbalanced energy between the pulsating input power and relatively constant output power of the stage. See the "Reactive Energy Storage" section for more details on this. Two stage PFC converters are commonly used as they don't have to handle as wide a voltage range across the storage capacitor you get in universal power supplies, which has a detrimental effect on conversion efficiency. They can also offer better trade-offs in the capacitor size, and this can help reduce cost.

An AC-DC Converters Power Stage

The power stage controls the power delivered from the primary to the secondary side through the transformer. It comprises of an active switching device that switches at a high frequency that can be in the hundreds of kHz. The switch ON/OFF state is controlled by a pulse width modulation (PWM) input that changes depending upon the amount of power that needs to be dynamically delivered to the load.

This information is obtained by a feedback path from the secondary side that may be communicated by a number of techniques that accommodate for the converter's isolation requirements. The higher frequency switching results in a smaller transformer requirement, reducing size and cost.

Transformer

A transformer is comprised of wires wound on a common core that couple into each other by electromagnetic induction. This is important when connecting to high voltage (mains) sources – referred to as 'off-line' conversion as the inductive coupling disconnects the mains from the subsequent circuit, a much safer scenario than direct connection.

Coupling by an electromagnetic field, rather than a direct copper circuit, called 'galvanic isolation' restricts the maximum energy that can cause electric shock or dangerous sparking discharge to the stored energy in the transformers magnetic field flux lines. The ability (related to size and materials) of the transformer to store energy is an important consideration in converter design as it dictates how well the transformer can provide the energy to maintain the desired voltage potential under changing load conditions.

Figure 1 has a block called 'Mag Amp Reset' associated with demagnetizing the transformer due to a magnetization current inherent in the architecture. Without this, the remanence of the core material would saturate it in a few cycles of the power stage PWM. Although too complex to cover in this tutorial, this additional circuit can be very confusing when reviewing converter circuit diagrams, and it is useful to know why it is required.

There are a number of techniques to perform demagnetization, the simplest being when the power stage switch is off a demagnetizing current is fed back diode through a separate auxiliary winding. This circuit restricts the maximum PWM duty cycle to 50%, but more complex methods can be used to enable higher duty cycles.

Transformers or other galvanic isolation methods (like optocouplers) are frequently used to communicate information signals between primary and secondary sides. This is needed to facilitate more intricate control of the conversion process – enabling a primary side situated control circuit to respond to the state of the secondary side load and dynamically change how it steers current to get lower noise and higher efficiency.

AC-DC Converters Output Circuit

As mentioned in the filtering section, electric fields in passive reactive (storage) elements like capacitors and inductors store energy. When used after the charge steering rectification, they act as a reservoir of energy during the alternating input power cycle. This is a vital element in a convertor as this energy storage acts as a source – enabling a constant output voltage under varying load conditions.

Active elements sense the voltage presented to the load and/or the current flowing into the load, and in a negative feedback control loop, use this information to adjust the energy pumped into these storage elements to maintain a constant output voltage level. This pumping process uses active elements to switch on and off the current flowing into the storage elements, referred to under the broad concept of regulation.

Regulation

We need a constant voltage presented to a load circuit, irrespective of the dynamic impedance of the load. Without this, over or under voltage conditions may occur, leading to spurious circuit behavior or even circuit damage. This is particular true with low voltage digital electronics where supply voltages must be tightly constrained within a window of a few percent of a nominal value. Reactive elements do not have any in-built control of this. The way an AC/DC converter achieves a tightly controlled window of output voltage is by conditionally controlling the energy stored in the low impedance reactive store source.

The voltage output will change over time as power drains from these elements and may also have variance caused by the non-ideal characteristics of the devices – like series resistance or parasitic capacitance. Some kind of dynamic control to recharge this source is required. This is called regulation. Loads like microprocessors change the power they demand as they perform different operations, and this exacerbates the need to have an active dynamic regulation.

Regulation control is a feedback circuit that controls the switching elements. In this case the switching element is on the primary side of the converter. For a switch to be efficient it has to be either hard ON (lowest impedance possible) or hard OFF (highest impedance possible) – as in between states lead to power traveling through the switch being dissipated and wasted. Semiconductor switches like MOSFETS are non-ideal and exhibit some impedance, they dissipate energy and this lowers conversion efficiency.

There are only really two ways to control a switch , by varying the duty cycle a switch is on or off, called Pulse Width Modulation (PWM) or controlling the frequency of being ON or OFF. Non-Resonant Mode converters employ hard switching techniques, but Resonant Mode convertors employs a more intelligent soft-switching technique.

Soft switching means switching on or off the alternating current waveforms at zero voltage or zero current points, eliminating switching losses and leading to very high efficiency architectures. Techniques like synchronous rectification replace the rectification diodes with active switching elements like MOSFETS. Controlling the switching synchronized to the input AC waveform enables the MOSFET to conduct with a very low ON resistance and less voltage drop at the right time – leading to higher efficiency when compared to diode rectification.

How does the regulation circuit know when to switch? There are two principle methods of control mode: voltage control and current control. Regulators utilize one or a combination of both methods to regulate the voltage presented to the load circuit.

Voltage Control Mode

The regulation circuit senses output voltage, compares it to a reference voltage to create an error function. The error signal modifies the switching ratio to bring the output closer to the desired level. This is the simplest method of control.

Current Control Mode

Both output voltage and inductor current sensed and the combination used to control the duty cycle. This inner 'current sensing loop' enables faster response time to load change, but is more complex than voltage control mode.

Further complicating the regulation element, over and above the method of control, the way a converter acts as a commutation cycle is called a continuous or discontinuous mode of operation. A continuous mode of operation is one where the inductor current never falls to zero (if the converter topology has one).

This is a lower output ripple and therefore lower noise mode of operation, but as the inductor is always conducting, it is always dissipating some energy in its non-ideal series conduction losses. In discontinuous mode, the inductor current is allowed to go to zero, causing the load to obtain energy from the storage capacitors. This is a higher efficiency mode of operation but does potentially have more ripple and poorer regulation control.

Types of AC-DC Converters

As touched on briefly, there are several converter types relating to their topology, including flyback and buck- flyback architectures. These are common topologies as they incorporate transformers, have low component count and can be low cost relative to other options.

Flyback converters are typically a buck-boost AC-DC converters (step-up/step down) with the inductor replaced with a transformer. The stored energy inside the transformer is used to commutate the secondary through an active or passive rectification circuit. The most common type of flyback converter utilizes discontinuous mode (DCM) – with current flowing in the transformer getting to zero – as this typically has the simplest control loop and lowest cost. Continuous current mode (CCM) flyback convertors are required for higher power levels but result in higher transformer winding losses due to continuous conducting.

Many power supplies switch between modes depending upon the load level. Quasi resonant (QR) and valley switching/variable frequency variations on the flyback topology are more complex circuits that optimize when and how switching occurs to improve efficiency. QR flyback achieve this by recycling energy of non-ideal leakage inductances, and valley switching reduces spikes caused by overshoot. They are typically used in low power applications.

Internal Assessment Criteria and Weight

• IAC1001 An understanding of ports, cables, and connectors and the effect of voltage are demonstrated

(Weight 2%)

Previous Next