CONTENTS

ILLUSTRATIONS

POWER SUPPLY MODULE THEORY

The Power Supply Module supplies power to all other boards in the terminal. Without the Power Supply Module, the terminal cannot run. The board provides the following voltages:

- o +12 Volts
- o -12 Volts
- o +5 Volts

If the + 5 volt supply rises to a value of + 6.25 volts (+ or - 0.50 volts), or if any of the current limits are exceeded, circuitry on the board senses this and shuts the power supply down.

The Power Supply Module consists of the following functional blocks:

- o AC Power
- o EMI Filtering
- o Line Select
- o Rectifier and Filter
- o Kick Start
- o Pulse Width Modulator (PWM)
- o Base Drive & Main Switching Transistor
- o Primary Snubber
- o Housekeeping & Primary Current Limit
- o Main Transformer
- o Control Loop Sense and Drive
- o +12 and -12 Volt Outputs
- o + and -12 Volt Current Limit
- o Over Voltage Protect
- o +5 Volt Output
- o +5 Volt Current Limit

Each of these blocks is discussed briefly in the first part of this section, and discussed more thoroughly in the latter part.

OVERVIEW

The Power Supply Module is based on a discontinuous mode fly-back, high-efficiency, switching-type design. This type of supply provides the advantages of lower weight, smaller volume, and reduction in size over conventional supplies. The principle of a switching supply is shown in Figure P2-1.

Figure P2-1. A Switching Supply.

A switching supply uses a Pulse Width Modulator (PWM) to produce a signal with a given pulse width. The pulse width is varied by the PWM, to keep the supplies in regulation as line voltage and load fluctuates. The PWM is shown on Figure P2-1 as a controlled switch.

The transformer is switched on and off at a fixed rate (in this case, at 25 KHz). During the on time, energy is stored in the primary coil of the transformer. During the off time, this energy is released to the secondary, where a capacitor and diode are connected. During the off time of the secondary, the capacitor supplies the output voltage. The diode provides isolation of the two windings.

SIMPLIFIED BLOCK DESCRIPTIONS

The following text gives a short, simplified description of each of the blocks shown in Figure P2-2. The more detailed descriptions of the circuit blocks follow the simplified descriptions.

Figure P2-2. Power Supply Detailed Block Diagram.

AC Power. AC power acts as an input to the power supply (the AC Power Block).

EMI Filter. The EMI Filter block eliminates high frequency noise created by the switching of the power supply. This filter prevents such noise from flowing back into the AC lines.

Rectifier and Filter and Line Select. The Rectifier and Filter block rectifies the AC voltage to a high voltage DC signal (between 200 and 400 volts). The setting of the Line Select switches tells the Rectifier which of two methods to use to accomplish this.

Kick Start. The Kick Start is used to start the Pulse Width Modulator (PWM) when the power supply is first turned on.

Pulse Width Modulator (PWM). The PWM supplies a 25 KHz pulse used by the Base Drive block.

Housekeeping, Base Drive, and Primary Snubber. Using the pulse supplied by the PWM, these blocks act together to chop the high voltage DC and deliver it to the primary coil of the Main Transformer.

Main Transformer. The Main Transformer transfers energy from the high voltage, line connected dc side, to the low voltage secondary side.

Voltages
The secondary transformer outputs are rectified to form the output voltages of the supply.

Over Voltage and Current Limit. These blocks sense if a voltage has risen excessively high, or if the current limit of the supply is exceeded, and breaks the control loop back to the PWM. This causes the supply to shut down.

Control Loop Sense and Drive. This block forms a feedback loop back to the PWM. The loop senses load and line variations, and adjusts the PWM pulse-width to keep the supplies in regulation. If current flow in the loop is broken, the supply shuts down.

DETAILED BLOCK DESCRIPTIONS

During the following discussion, refer to the Power Supply Module schematic, along with the block diagram. The block diagram shows how each block relates to one another, while the schematics are used when describing how each block functions.

AC Power

The AC Power section consists of the AC plug, a fuse, and the power switch.

AC power comes into the supply via a power cord connected to the AC plug. The power supply is protected by a 4 A fuse and turned on by the power switch. The fuse is mounted on the power supply circuit board, and is not an externally accessible part.

EMI Filtering

The EMI filtering section is used to keep high frequency (Khz range and up) noise created by the switching of the supply from getting back onto the AC line. The filtering of this section does not affect the 60 Hz input signal, which is delivered to the Rectifier and Filter block. The EMI Filtering block consists of a thermal resistor, two series capacitors and an inductor, and two power resistors.

The inductor is a common-mode rejection transformer. This transformer has its two coils connected to opposites sides of the AC line, hence current is flowing in equal and opposite directions, creating a net flux of zero. When a high frequency signal enters this transformer, it meets a high opposing inductance. The signal then takes the alternate path (through the capacitors) to ground.

A thermistor limits surge current to the two main 100 uf capacitors (in the Rectifier and Filter block) when power to the supply is first turned on. The thermistor then heats up, which lowers its resistance, while the supply is operating. The thermistor normally runs hot during operation of the supply.

Two inductors, working with an energy storing capacitor, isolate the high frequency switching noise that is generated by the converter. This prevents such noise from going back into the AC line.

Line Select

The Line Select block consists of two switches. The setting of these switches depends on which AC input (115 or 230 volts) the supply is operating from.

CAUTION

> The line select switches must both be set to the same setting. Failure to do this could result in damage to the power supply or the monitor.

One switch selects the AC input for the power supply, the other selects the input for the Display Module's deguass coil and its power supply. The setting of the line select switch determines if the diode bridge in the Rectifier and Filter block acts as a voltage doubler or a full-wave bridge (see the next block description).

Rectifier and Filter

The Rectifier and Filter block changes the AC input signal to a high voltage DC signal (200 to 360 volts) for use by the Primary Snubber, Main Transformer, and Kick Start blocks. The main components of the Rectifier and Filter block are: a diode array, a warning light, the two 220 uf capacitors, and two zener diodes. To better understands how this circuit works, assume that all capacitors with a value less than 1 uF are open circuits (these capacitors are for high frequency filtering and appear as an open circuit to 60 Hz).

The setting of the AC line-select switch determines how the AC input is rectified into DC. With the switch set to the 115 V position, the switch acts as a short circuit, and a voltage doubler circuit is created (see Figure P2-3). The voltage across the 220 uf capacitors is approximately 300 volts.

Figure P2-3. Rectifier and Filter Block When Used as a Voltage Doubler.

When the switch is set to the 230 Volt position, the switch acts as an open circuit. The circuit then acts as a full-wave bridge (see Figure P2-4), and voltage across the capacitors is approximately 300 volts. Therefore, in either configuration, the same voltage is developed across the capacitors.

Figure P2-4. Rectifier and Filter Block as a Full-Wave Bridge.

The two capacitors each have a 150 Kohm resistor and a 200 volt zener diode in parallel. The resistors set the discharge time of the capacitor after the power is turned off (discharge time is less than five minutes). The zener diode is a surge suppression device that helps to absorb any transients that occur on the AC line. These diodes conduct at 200 volts, preventing the capacitors from overcharging (maximum charge is 200 volts, or 400 volts across the two capacitors).

A warning light in this block shows that dangerous voltages exist in the supply. This light flashes when the power supply is on, and continues flashing after the supply is unplugged until the capacitors discharge to a safe level.

Kick Start

The Kick Start circuitry is initialized when the power supply is first turned on and is used to start the Pulse Width Modulator operating. Input voltage to this block is the +300 volts (approximate) from the Rectifier and Filter Block. The components of this block that are used for the Kick Start are: two resistors, a capacitor, a 16 volt zener diode, a signal diode, and an SCR. After the housekeeping supply comes up (which maintains the PWM after it starts switching), the Kick Start circuitry resets -- so it will be ready to start the PWM at the next power-up. The components used to reset the Kick Start are a 12 volt zener diode, two resistors, and a transistor.

When the supply is first turned on, the 16V zener diode prevents gate current from flowing in the SCR, while the 20K resistor allows leakage current to flow to the return. This allows the capacitor to charge up to the 16V zener voltage, at which point the zener conducts, injecting current into the SCR gate and turning it on. The capacitor then begins discharging into the PWM and base drive circuitry, furnishing a 16 volt supply for start-up.

After this occurs, the reset circuitry in this block resets the Kick Start. The 12 volt zener is turned on, causing the transistor to turn on. This, in turn, discharges the capacitor connected to the SCR. The SCR is then reset and ready to start the PWM the next time the power supply is turned on.

The signal diode prevents the reverse voltage from causing breakdown of the cathode-gate junction, after reset.

Pulse Width Modulator (PWM)

The PWM provides regulation of the supply voltages by controlling the width of its 25 KHz output pulse. This is a function of the feedback signal received from the Control Loop Sense and Drive block.

After the Kick Start block has furnished a supply voltage to the PWM, it begins switching.

Pin 2 (Vz) produces an output voltage of approximately 8.4 volts dc. This voltage is fed back to an RC network connected to Pin 5. This RC network sets the 25 Khz switching rate of the PWM by placing a semi-sawtooth wave on Pin 5 (this waveform is shown in Figure P2-5).

Figure P2-5. RT, CT Input of the PWM.

The width of the pulse is set by the voltage on Pin 4, which is predominately controlled by an op-amp inside the PWM chip. In this particular case, the op-amp has a gain of about .75, and acts as an input port for the Control Loop Sense and Drive block.

The output of the PWM is a 25 Khz pulse on Pin 7 that has a minimum voltage of 0.1 volts and a maximum voltage of 0.7 volts. This pulse drives the base drive block. The Base Drive block then switches the main transformer, via the main switching transistor.

The feedback signal enters Pin 3, which controls the PWM in combination with the voltage on Pin 4.

Primary current limit is sensed on Pin 6. If the primary current reaches a level sufficent to raise this pin 0.52 volts, the PWM shuts down (stopping the output pulse).

Maintenance Test

This circuit limits the width of the PWM pulse when power is applied to the supply. This block consists of a transistor that is used to manually control the pulse width during testing/maintenance. This circuit allows you to manually control the voltage on Pin 2 of the test connector (using a special test fixture).

Base Drive and Main Switching Transistor

This block chops the primary voltage (+300 volts dc), via the main switching transistor, which interrupts the current in the primary winding (Pins 7 and 8) of the main transformer. This is accomplished by alternating a switching transistor between on and off states. The main components of this block are: three transistors, two resistors and diodes, a current source capacitor, and a proportional base drive transformer (T220). The transistors are labeled by functions as follows: main switching transistor (Q331), base drive transistor (Q332), and the charging transistor (Q231).

The output pulse of the PWM is fed directly to the base of the base drive transistor, where it is used to turn on and off the switching transistor. When the base drive transistor is on, the switching transistor is off, and vice versa.

The following discussion is depicted in Figure P2-6. When the base drive transistor is on, the currnt source capacitor (C235) is discharged through CR232; and the charging transistor is held off by the reverse bias provided by this diode. The current is limited by R334 through the control winding of the base drive transformer.

When the base drive transistor is turned off, the energy stored in the core of the transformer is released into the base of the switching transistor, turning it on. As current begins to flow through the switching transisitor, it is fed back to the base (via transformer action) as a fixed ratio of collector current, ensuring adequate base drive under all conditions. During this 'on' time of the switchng transistor, the charging transistor turns on and charges the current source capacitor (to the Housekeeping Supply voltage).

When the PWM turns on the base driver, the energy stored in the charging capacitor is used to turn off the switching transistor through the control winding of the switching transformer. The two diodes in the base circuit of the switching transistor act as a maximum current limiter for that transistor.

This cycle is repeated for each pulse from the PWM.

Figure P2-6. Base Drive Circuit and Current Source Capacitor.

Primary Snubber

The Primary Snubber consists of two diodes, a capacitor, and a high wattage resistor.

When the primary switching transistor (in the Base Drive block) is starting to turn off, a voltage spike of up to 800 volts or more occurs. This is the result of energy stored in primary leakage inductances.

The snubber acts to steer current through the capacitor and diodes back into the primary (+300 volts) supply, preventing the high current from going through the switching transistor. After the transistor has completed turning off, the resistor rapidly discharges the capacitor, dissipating about 4 watts of power through the resistor.

Housekeeping and Primary Current Limit

Resistor, R325, acts as a primary current sense resistor, whose output is fed to Pin 6 of the PWM. When this voltage level reaches 0.52 V (nominal) the output of the PWM is inhibited, turning on the base drive transistor.

CR137 and C336 form a housekeeping supply which provides power for the primary side control circuitry (while the converter is running).

Main Transformer

The Main Transformer provides power from the primary to the secondary in order to develop the individual voltage supplies.

The Main Transformer is configured in a fly-back type of configuration. During the on time of the primary (as determined by the switching transistor), energy is stored in the primary coil. During the off time of the primary, this energy is released into the secondary coils. The energy released is filtered to become the individual voltage sources. A more thorough discussion of this process is covered at the beginning of this section.

Control Loop Sense and Drive

This block of circuitry forms a loop from the secondary windings of the transformer back to the PWM. When this loop is closed, the PWM is allowed to function. The loop senses the load on the supplies, and feeds back to the PWM, telling it to widen or narrow the PWM pulse width. When this loop is opened, such as when an overvoltage protect block opens it, the power supply shuts down. The primary components of this block are the opto-isolator, control regulator, capacitor, and a series of resistors.

As the +5 volt supply is initialized (when the power supply is first turned on) the REF pin of the Control Regulator approaches +2.5 volts. When the REF pin reaches +2.5 volts, the Control Regulator turns on and begins to shunt excess drive current from opto-isolator. Current through the opto-isolator (which is held at a fixed value) feeds back to the PWM and maintains the PWM pulse-width. The current through the opto-isolator is modulated by the control regulator and varies with the load on the supplies. The opto-isolator current then adjusts PWM pulse-width accordingly to maintain regulation.

The cathode of the Control Regulator can be brought to ground by an over current or voltage condition on the supplies. This stops current through the opto-isolator, breaking the control loop, and the power supply shuts down.

+12 and -12 Volts

When the secondary of the transformer is on, the diodes conduct and the capacitor charges. The output of the secondary is +12 and -12 volts, which is delivered as the output voltages. When the secondary is off, the diodes are reversed biased, preventing discharge of the capacitor back into the transformer. The charge of the capacitor carries the supply through until the secondary is again turned on.

+12 and -12 Volt Current Limit

This block senses whether the current limit of the + or - 12 volt supplies is being exceeded. If so, this block causes the power supply to shut down (by breaking the loop formed in the Control Loop Sense and Drive block). This block consists of two transistors, resistors, and a diode.

If current through one of the + or - 12 volt capacitors is sensed by the resistor, one of the two transistors begins conducting (depending on which supply was sensed). This shunts drive current away from the opto-isolator and shuts down the supply.

Over-Voltage Protector

This block allows an over voltage (a runaway voltage) on the +5 volt supply to shut down the power supply. The main components of this block are a Silicon Controller Rectifier (SCR), zener diode, capacitor, and resistors.

If the + 5 volt supply rises above +5.6 volts, the zener diode turns on and begins conducting. When the zener has sourced enough current to raise it another 0.6 volts, the SCR turns on. This, in turn, pulls the cathode of the control regulator (in the Control Loop Sense and Drive block) to ground, no current goes through the opto-isolator, the control loop is broken, and the supply shuts down.

+5 Volt Output

The +5 volt supply basically operates the same way as the + and - 12 volt supplies. The capacitor charges during the on time of the secondary winding, and then supplies the output voltage when the transformer is off. The diodes provide isolation when the secondary has turned off. The remaining components in this block (capacitors, inductor, and a resistor) are used to filter out any noise created by the switching of the supply. Since this voltage is used for all of the TTL devices in the terminal, it is important that the supply be free of high frequency noise.

+5 Volt Current Limit

This block senses whether the +5 Volt supply has exceeded the current limit. If this happens, this block causes the supply to shut down. The main components of this block are two transistors, a zener diode, and a sense resistor.

The +12 volt supply is used to set the zener diode at +10 volts. This provides a constant voltage for this circuit to use. Current flows down through the 10 Kohm resistor and turns on Q257. The voltage at the base of Q352 is set by the 330 ohm resistor. The current sense resistor is connected between the two emitters of the transistors. When the current through this resistor gets large enough, it raises the emitter of Q257 to a higher voltage. When this voltage plus the collector-emitter voltage of Q257 equals approximately +0.65 volts, Q352 turns on. This shuts down the opto-isolator (no current flows), the control loop is broken, and the supply shuts down.