SECTION 1

INTRODUCTION
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This book focuses on three rather broad and inter-related topics: *power management*, *thermal management*, and *hardware monitoring*. We will discuss them in terms of the various design and application issues associated with each and show how modern ICs allow cost effective and efficient solutions.

Power management broadly refers to the generation and control of regulated voltages required to operate an electronic system. It encompasses much more than just power supply design. Today's systems require that power supply design be integrated with the system design in order to maintain high efficiency. In addition, distributed power supply systems require localized regulators at the PC board level, thereby requiring the design engineer to master at least the basics of switching and linear regulators.

Integrated circuit components such as switching regulators, linear regulators, switched capacitor voltage converters, and voltage references are typical elements of power management. Battery charging is also an important portion of power management.

Closely related to power management is *thermal management*. In addition to traditional applications of temperature sensors in industrial process control, today's systems require accurate control of monitoring and control of temperature, airflow, etc.

Today's computers require that hardware as well as software operate properly, in spite of the many things that can cause a complex high performance system to crash or lock up. The purpose of *hardware monitoring* is to monitor the critical items in a computing system and take corrective action should problems occur.

Microprocessor supply voltage and temperature are two critical parameters. If the supply voltage drops below a specified minimum level, further operations should be halted until the voltage returns to acceptable levels. In some cases, it is desirable to reset the microprocessor under "brownout" conditions. It is also common practice to reset the microprocessor on power-up or power-down. Switching to a battery backup may be required if the supply voltage is low. Under low voltage conditions it may also be desirable to inhibit the microprocessor from writing to external CMOS memory by inhibiting the Chip Enable signal to the memory.

A summary of the concepts of power management, thermal management, and hardware monitoring is shown in Figure 1.1.

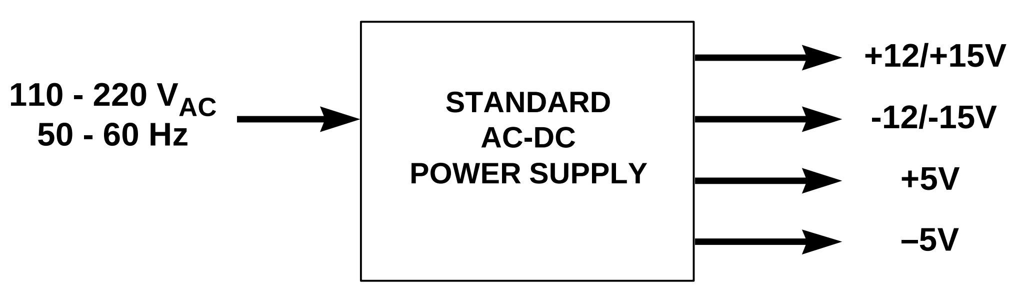
POWER MANAGEMENT, THERMAL MANAGEMENT AND HARDWARE MONITORING OVERVIEW

- **Power Management**
  - **Switching Supplies**
  - **Switched Capacitor Voltage Converters**
  - **Battery Chargers**
  - **Linear Low Dropout Regulators**
  - **Voltage References**
- **Thermal Management**
  - **Temperature Sensing**
  - **Temperature Control**
- **Hardware Monitoring**
  - **µP Supervision**
  - **Supply Voltages**
  - **Temperature**

Figure 1.1

In order to understand power management better, we will consider a few typical applications. Consider the traditional desktop PC power supply shown in Figure 1.2. This approach suffers from a number of disadvantages including inefficiency (all the voltages are on all the time - which is probably not necessary), multiple high-current distribution busses, etc.

CLASSICAL POWER SUPPLY SYSTEM e.g. TRADITIONAL DESKTOP PCs



Major Disadvantages of the Traditional PS System Include:

- **Inefficiency : Output Voltages Are Always Turned On**
- **Cable Lengths**
- **Inductance**

Figure 1.2

The trend in today's systems is to make use of the distributed power approach as shown in Figure 1.3. The AC input is rectified, filtered, and converted into an unregulated intermediate voltage which is distributed throughout the system. Each subsystem uses localized voltage regulators (usually switching-types for high efficiency) for generating required voltages. This simplifies the power distribution problem and also allows individual voltages to be shutdown if they are not in use.

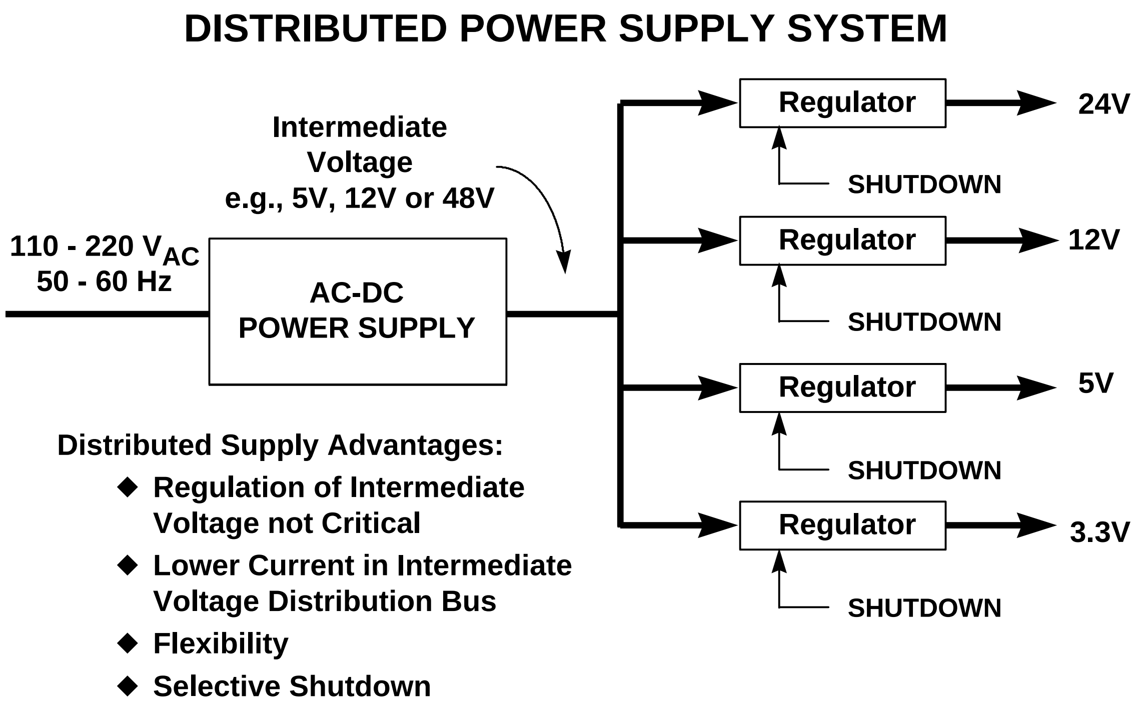


Figure 1.3

To see how this concept is extended to the PC board level design, Figure 1.4 shows a simplified block diagram of a data acquisition board. The unregulated intermediate voltage enters the board and drives the switching regulators. In the example shown, one switching regulator is dedicated to the processor, and the other drives a low dropout linear regulator. The critical analog circuits on the board, including the signal conditioning and A/D converter, are supplied from the output of the linear regulator. This ensures that the analog circuits operate with a well-regulated and low noise supply voltage. A separate low noise voltage reference is used in conjunction with the 16 bit A/D converter for even lower noise and higher accuracy.

The hardware monitoring circuits monitor the processor power supply voltages to ensure the processor functions properly. Airflow and heat sinking is often required with modern high-speed DSPs or microprocessors because of their high power dissipation. Therefore a temperature sensor monitors the processor temperature and works in conjunction with the temperature monitoring and control circuit to regulate the airflow.

Figure 1.5 summarizes some of the trends in digital and analog signal processing.

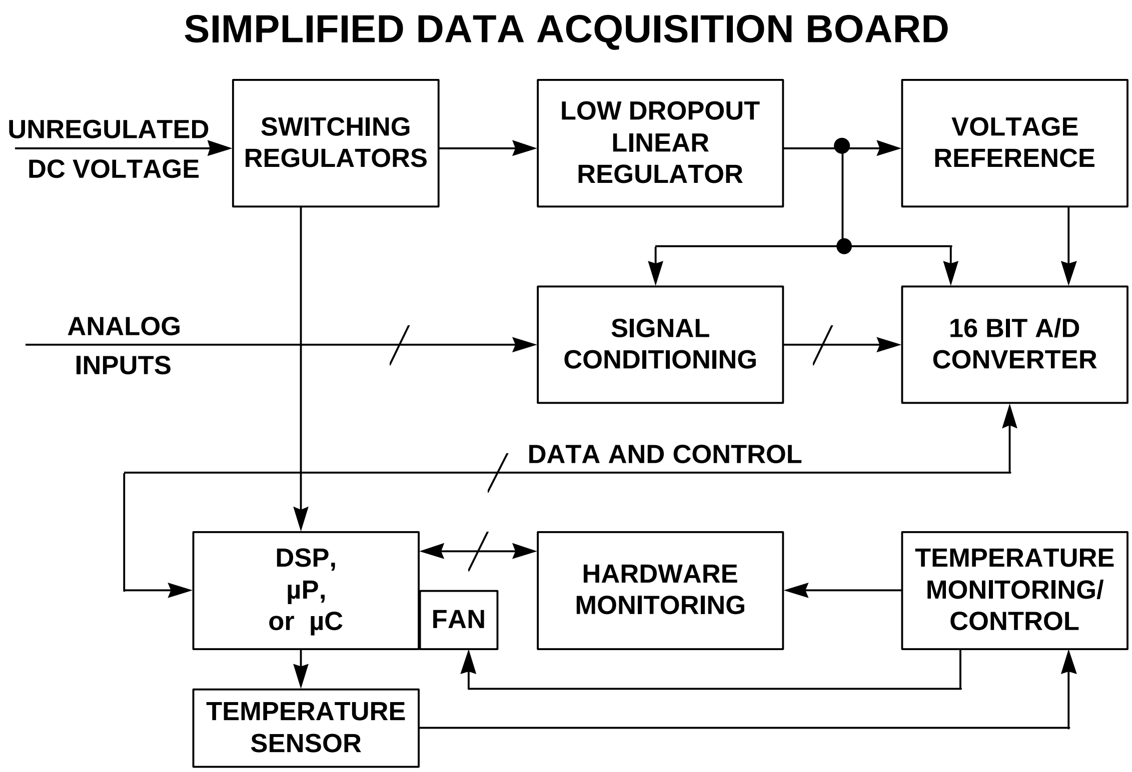


Figure 1.4

TRENDS IN DIGITAL AND ANALOG SIGNAL PROCESSING

- **Faster Digital and Analog Signal Processing**
- **Higher Power - Requires Thermal Management**
- **Distributed Power Systems vs. Single Power Supply- Implies On-Board Regulation**
- **Energy Efficient - Requires Switching Regulators and Low Dropout Linear Regulators**
- **16+ Bit ADCs Require Precision Voltage References**

Figure 1.5

Portable electronic equipment such as laptop computers and cell phones require other types of hardware monitoring as well as power and thermal management circuits. Today's laptop computers are replacing the traditional desktop systems in many companies (see Figure 1.6). Laptops, however, present a large number of design challenges because of the emphasis on performance, light weight, low power, and long battery life. Battery charging circuits are quite complex, and battery voltage and temperature must be monitored and controlled during the charging cycle. Redundancy must be built into these circuits in order to prevent damage to the battery or dangerous outgassing.

Thermal and power management is therefore critical to laptop computers, not only relating to the high-power microprocessor, but also with respect to the battery charging function (see Figure 1.7). Most laptops have internal fans to cool the microprocessor when the internal temperature exceeds safe levels, but the fan should only operate when necessary to conserve battery life.

LAPTOPS ARE GREAT, BUT PRESENT SIGNIFICANT DESIGN CHALLENGES!

- **High Levels of Functionality and Performance**
- **Light Weight**
- **Longer Battery Life**
- **Fast Battery Charging**
- **Li-ion Batteries Emerging as the Battery of Choice**
- **Lower Cost**

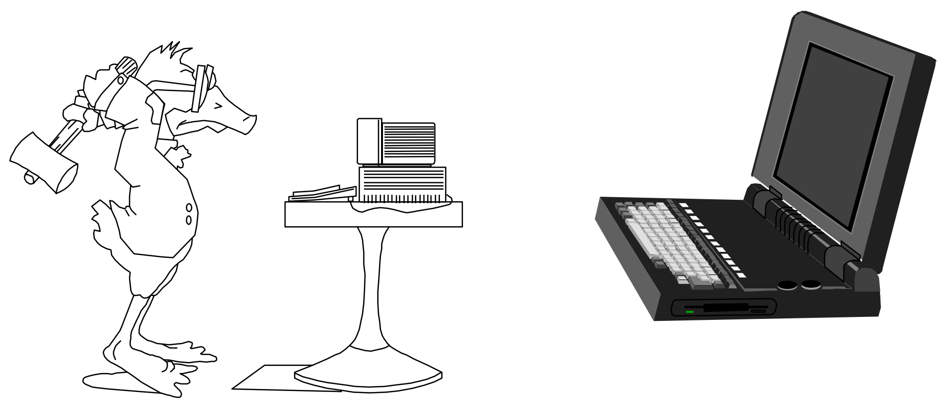


Figure 1.6

Cell phones and other types of hand-held electronic equipment make wide use of power management techniques (see Figure 1.8). Certain critical parts of a cell phone such as the oscillator and frequency synthesis circuits are generally powered by low dropout linear regulators for low noise and accuracy, while high efficiency switching regulators are most often used in the high-power transmitter circuits. Shutdown features are also vital to preserve battery life while the phone is idle.

LAPTOP COMPUTERS REQUIRE

- Battery Charger Circuits
- Switching Regulators
- Low Dropout Linear Regulators
- Temperature Sensors and Control
- µP Supervisory Circuits
- Airflow (Fan) Control

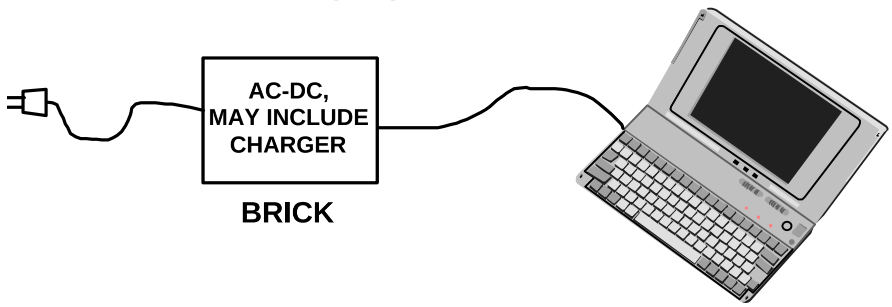
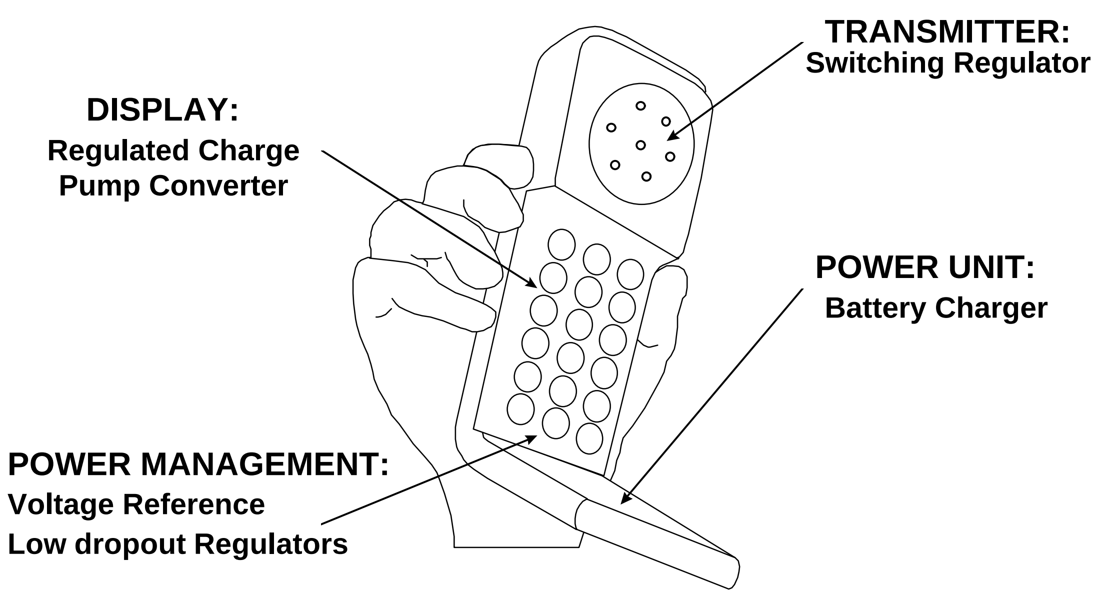


Figure 1.7

CELL PHONES



- High Performance and Functionality
- Small Size, Light Weight
- Long Battery Life, Fast Charging
- Low Cost

Figure 1.8

Temperature sensors and temperature control circuits are widespread in industrial applications such as process control. In many cases, the output signal levels are low level ones (as in a thermocouple), and low noise high gain conditioning is required before further processing. Semiconductor temperature sensors are useful in many applications and offer high-level output signals which reduces the burden on the signal conditioning circuitry (see Figure 1.9). In addition, semiconductor sensors are ideally suited to applications such as PCs, because their operating temperature range, power supply requirements, and packaging closely match the other types of ICs in the system.

APPLICATIONS OF THERMAL MANAGEMENT

- **Instrumentation**
- **Process Control**
- **IC Temperature Monitoring**
- **Airflow Control**
- **Battery Charging**
- **Heat Sink Design**

Figure 1.9

Finally, proper hardware design techniques are critical to all modern systems. Layout, grounding, and decoupling are extremely critical to successful system design as well as controlling EMI and RFI. Also an understanding of thermal techniques for maintaining safe junction temperatures is critical due to the high power dissipated in many digital ICs. Discussions regarding these practical issues conclude the book (see Figure 1.10).

HARDWARE DESIGN TECHNIQUES

- Verifying the Design
  - Simulation
  - Prototyping
- Minimizing Noise
  - Layout
  - Grounding
  - Decoupling and Filtering
  - Shielding
- Thermal Management
  - Temperature Sensing
  - Airflow Control
  - Heat Sinks
- EMI / RFI Qualification

Figure 1.10