Micrel's Guide to

Designing PCMCIA Power Control

Second Edition, February 1996

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Micrel, The High Performance Analog Power IC Company

Micrel Semiconductor designs, develops, manufactures, and markets high performance analog power integrated circuits on a worldwide basis. These circuits are used in a wide variety of electronic products, including those in cellular communications, portable and desktop computers, and in industrial electronics.

Micrel History

Since its founding in 1978 as an independent test facility of integrated circuits, Micrel has maintained a reputation for excellence, quality and customer responsiveness that is second to none.

In 1981 Micrel acquired its first independent semiconductor processing facility. Initially focusing on custom and specialty fabrication for other IC manufacturers, Micrel eventually expanded to develop its own line of semicustom and standard product Intelligent Power integrated circuits. In 1993, with the continued success of these ventures, Micrel acquired a new 57,000 sq. ft. facility and in 1995 expanded the campus into a 120,000 sq. ft. facility. The new Class 10 facility has allowed Micrel to extend its process and foundry capabilities with a full complement of CMOS/DMOS/Bipolar/NMOS/PMOS processes. Incorporating metal gate, silicon gate, dual metal, dual poly and feature sizes down to 1.5 micron, Micrel is able to offer its customers unique design and fabrication tools.

Micrel Today and Beyond

Building on its strength as an innovator in process and test technology, Micrel has expanded and diversified its business by becoming a recognized leader in the high performance analog power control and management IC markets.

The company's initial public offering in December of 1994 and recent ISO9001 compliance are just two more steps in Micrel's long range strategy to become the preeminent supplier of high performance analog power management and control ICs. By staying close to the customer and the markets they serve, Micrel will continue to remain focused on cost effective standard product solutions for an ever changing world.

The niche Micrel has carved for itself involves:

- **High Performance**.....precision voltages, high technology (Super ßeta PNP™ process, patented circuit techniques, etc.) combined with the new safety features of overcurrent, overvoltage, and overtemperature protection
- **Analog**.....we control continuously varying outputs of voltage or current as opposed to digital ones and zeros (although we often throw in "mixed signal" i.e. analog with digital controls to bring out the best of both worlds)
- **Power ICs**.....our products involve high voltage, high current, or both

We use this expertise to address the following growing market segments:

1. Power supplies
2. Battery powered computer, cellular phone, and handheld instruments
3. Industrial & display systems
4. Desktop computers
5. Aftermarket automotive
6. Avionics
7. Plus many others

Some products in this book are protected by one or more of the following patents: 4,914,546; 4,951,101; 4,979,001; 5,034,346; 5,045,966; 5,047,820; 5,254,486; and 5,355,008. Additional patents are pending.

Designing PCMCIA Power Control

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Introduction: Micrel and the PCMCIA

The PCMCIA (Personal Computer Memory Card International Association) was founded in June 1989 for the purpose of promoting interchangeability of PC Card-based products. PCMCIA defined both data storage ("memory") and peripheral expansion ("I/O") card types using a common 68-pin slot and three standard card sizes.

The PCMCIA serves both as a technical standards-setting body and a trade association, and has active marketing as well as technical committees. The Technical Committee is concerned with the standard itself, and the Marketing Committee is primarily concerned with market development and promotional activities. Membership is open to individuals and organizations in three classes: Executive, Associate, and Affiliate.

PCMCIA Release 1.0, introduced in November 1990, defined issues relating to functionality and handling memory cards used as data storage devices in various environments.

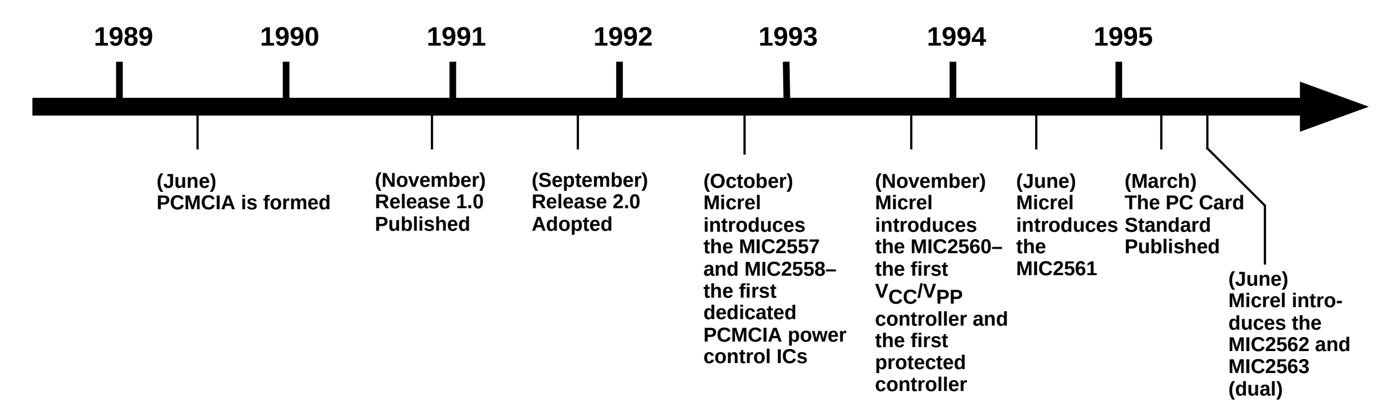
Release 2.0, issued in September, 1991, added I/O functionality as well as a host of new features and requirements. Release 2.01, issued shortly thereafter, incorporated numerous typographical error corrections. With the addition of I/O functionality, the allure of PC Cards leaped forward. Previously simply an expensive novelty, appealing only to tiny palmtop systems or under powered notebooks, Release 2 PCMCIA slots had substantial market appeal. At this point, real PCMCIA market growth began.

As system manufacturers examined the specifications, they realized slot implementation was a daunting task. A whole new layer of software and hardware was necessary for the most rudimentary application. Worse, the power control requirements were vague and confusing.

Micrel Semiconductor began working with computer manufacturers in early 1992. Micrel devised a number of solutions, using off-the-shelf components, that provided the necessary functionality for the V_{PP} (programming and peripheral voltage) pins. These solutions, although rather large in PC board space and expensive, were far better than the discrete transistor alternatives. Micrel immediately began designing a monolithic power control IC for V_{PP} control. Introduced in October 1992, the MIC2557 (single) and MIC2558 (dual) V_{PP} Switching Matrices were the first dedicated PCMCIA power control devices. When dual-voltage V_{CC} slots became a reality, Micrel introduced another first, the fully protected MIC2560, which controlled 3.3V and 5V V_{CC} lines in addition to full V_{PP} control. Later, the low-cost MIC2561 was designed for extremely cost sensitive applications.

March 1995 saw the introduction of "The PC Card Specification", the follow-on to Release 2.1. This document formalized dual-V_{CC} specifications as well as adding the CardBus option. Micrel's MIC2560, already in production for months, was fully compliant to the new spec.

In June 1995, Micrel introduced two new V_{CC}/V_{PP} power controllers, the MIC2562 (single slot) and the MIC2563 (dual slot). These designs include additional features and give Micrel the broadest line of PCMCIA-compatible power control ICs in the industry. Micrel is committed to the PC Card market and will continue designing new and improved power control circuits.



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It is a simple fact: PCMCIA card slots are a requirement for market acceptance of portable computers today. Many systems sporting PCMCIA sockets (or "PC Card slots", as they are now called) are not compatible with the multitude of present and expected PC Cards. This incompatibility is not related to complex software issues, but is due to improper power supply design. Many card slots built today simply do not provide the proper voltages within the required accuracy at the necessary current. Full compatibility is easy to achieve using new, high performance power switching devices and a little extra care in PC board layout and power supply design. By intelligently balancing power supply tolerances and switch ON-resistance, the total power supply system cost is minimized. Additionally, although not a compatibility issue, system longevity is increased by adding power output fault protection.

The purpose of this design manual is to implement full PCMCIA power compatibility economically. The manual discusses system power supply specifications, switch and PC board trace resistances, controlled rise and fall times, and protection features.

Choosing a PCMCIA Power Controller

You should consider the following list of features when choosing a card slot power controller:

1. Functionality: 3.3V/5V V_{CC} selection, 12V/5V/3.3V/0V V_{PP} selection
2. Current handling capability
3. Acceptably low R_{ON}
4. Protection: linear current limiting and overtemperature shutdown
5. Controller interface without external components
6. Error indicator feedback to logic controller
7. Controlled rise times to insure no cross conduction, current surges, or ringing

Functionality is a basic decision. Two types of systems exist today: those that have a single V_{CC} (generally 5V), and those with dual V_{CC} (3.3V and 5V). If your intended system will only use cards with a single V_{CC}, then you need not worry about 3.3V/5V selection—however, you then need to consider the compatibility issues that will arise because your system will lack a "standard" feature. The same compatibility argument applies to the various V_{PP} voltages as well.

Current requirements are not clearly defined in the PCMCIA specifications. The CardBus option requires 1 ampere of V_{CC}; this is the default requirement for all PC Card slots.

Acceptable R_{ON} is a more difficult consideration that requires interpreting the PCMCIA specification. This parameter has direct effect on power supply accuracy requirements (and therefore on system cost) and will be discussed in detail later.

Protection features are important for a long service life and a good warranty record. Fumbling fingers, probing pencils, and shorted cards can destroy an unprotected slot.

A “glueless” interface with the logic controller minimizes board space, complexity, and cost. An error flag feeds back slot fault status information which enables protective action by the logic controller.

Controlled rise times prevent damaging current surges and voltage overshoot that could destroy sensitive card electronics and also prevents power wasting “shoot through”.

The following discussion is valid for any system, from a handheld data acquisition system to a high performance workstation. We will start by examining the PCMCIA specification.

The PC Card Standard: V_{CC} Considerations

V_{CC} is the main power for the card. Previously 5V only, the new low voltage option mandates a “cold socket” with V_{CC} disabled until the card has been inserted.

The proper initial operating voltage is determined by a combination of mechanical keys on the card and socket to differentiate standard (5V) and low voltage cards, and by voltage select pins. The keys prevent low voltage cards from fitting into 5V sockets. The voltage select pins signal which initial voltage the card accepts.

The V_{CC} supply requirement is up to 1A of current, with the V_{CC} = 5V tolerance of ± 5% and the V_{CC} = 3.3V supply between 3.00V and 3.60V. The specification allows systems with small batteries incapable of supporting large loads to simply reject high current cards.

V_{CC} Timing & Changing V_{CC}

The PC Card Standard limits rise and fall times as well as transition timing. These limits are pictured in Figure 1 (A and B). Rise time, t_1, must range between 100µs and 100ms. Fall time, t_2, must be from

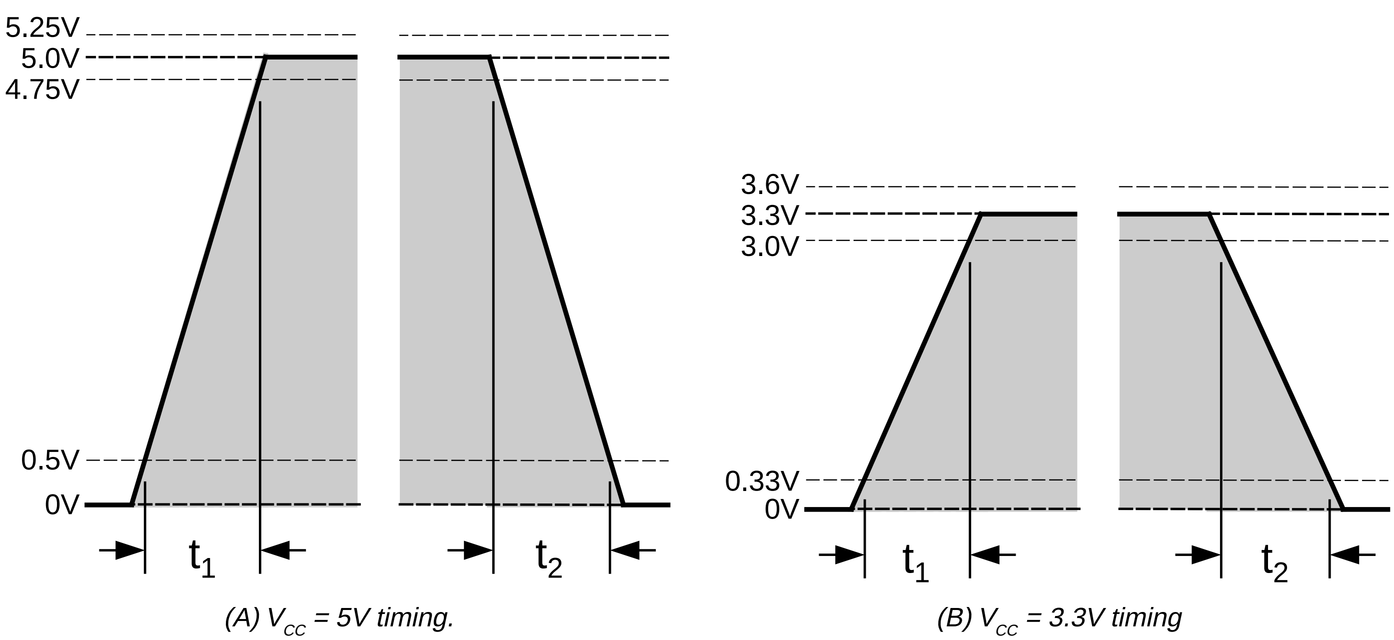
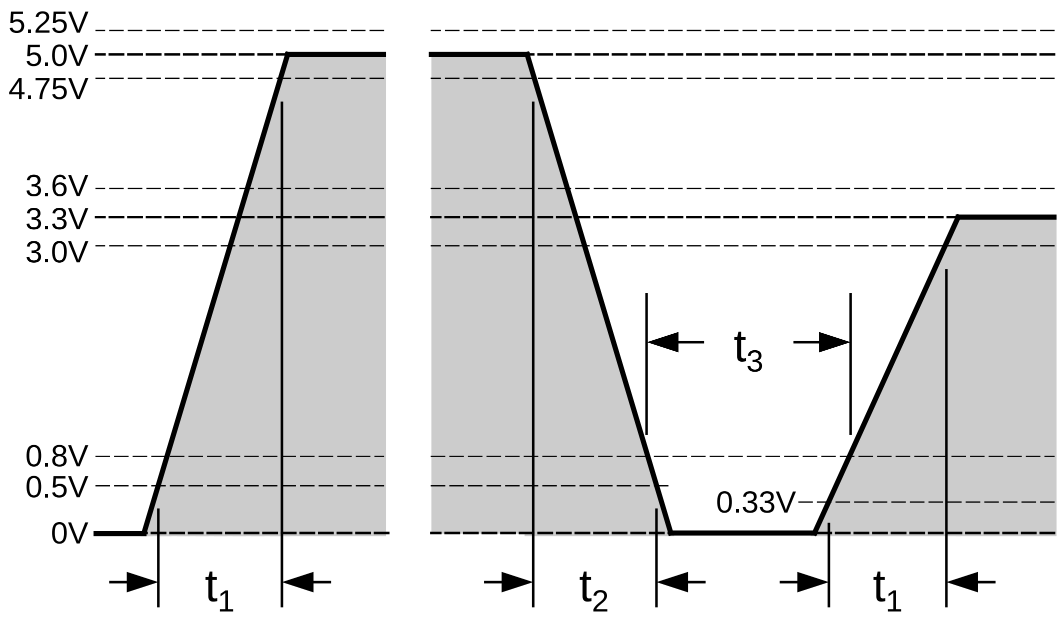


Figure 1. Rise time, t_1, must be between 100µs and 100ms. Fall time, t_2, must be from 3ms to 300ms. Rise and fall times are measured between the 10% and 90% points. Note the rise and fall times are from 10% to 90% of the nominal V_{CC} value: 0.5V to 4.5V for V_{CC} = 5V, and 0.33V to 2.97V for V_{CC} = 3.3V.



t_1: 100µs to 100ms **t_2: 3ms to 300ms** **t_3: ≥ 100ms**

Figure 2. Timing requirements for changing V_{CC} from 5V to 3.3V. Note when a change is commanded, V_{CC} must be pulled below 0.8V for at least 100ms.

3ms to 300ms. Rise and fall times are measured between the 10% and 90% points.

A new problem is caused by the dual V_{CC} voltage capability: the necessity to change from one V_{CC} level to another. This sequence is depicted in the timing diagram (Figure 2). When commanded to change V_{CC}, the power control circuit must turn OFF the present V_{CC} and let it drop below 0.8V. After at least 100ms, the new supply voltage is enabled, following the same rise time specification: 100µs to 100ms from the 10% to 90% points.

V_{PP} Requirements

The newest PC Card Standard maintains the sparsely defined specification for the “Program and Peripheral” power supply, V_{PP}, intended for FLASH memory write operations. The V_{PP} voltage is generally either V_{CC} or 12V.

Two independent V_{PP} pins, V_{PP1} and V_{PP2}, are defined. Many system manufacturers combine these pins and drive them together. No known PC card has a problem with this shortcut, but it technically violates the specification.

V_{PP} Current

While we could justify the same amount of current for V_{PP} as for V_{CC}, twelve volts at one ampere represents a power dissipation of 12W and would seriously cut battery life. A more realistic estimation is to evaluate the predominant V_{PP} client’s requirement: the FLASH memory card. Standard FLASH cards require 12V at between 30mA and 120mA for erasing and programming, and demand ±5% accuracy for this delicate operation.

V_{PP} Switching Times

V_{PP} switching times are not specified. For FLASH cards, writing may not occur until the V_{PP} supply is stable: supply stabilization effectively determines the write “access time” of a FLASH “disk”. But excessively fast rise times lead to ringing that can destroy sensitive FLASH memories. So you should strive for maximum rise time without overshoot. Practical circuits perform this task in about 10µs to 100µs.

(A)	V_{CC} = 5V Supply Accuracy	±1%	±2%	±3%	±4%	±5%
	Maximum Switch Resistance	155mΩ	105mΩ	55mΩ	5mΩ	—
(B)	V_{CC} = 3.3V Supply Accuracy	±1%	±2%	±3%	±4%	±5%
	Maximum Switch Resistance	222mΩ	189mΩ	156mΩ	123mΩ	90mΩ

Table I. V_{CC} pin power supply requirements, with composite pin resistance of 45mΩ. (A) V_{CC} = 5V (V_{MIN} = 4.75V). (B) V_{CC} = 3.3V (V_{MIN} = 3.00V). This table shows the highest switch resistance that allows pin voltage to meet the required V_{MIN} at a given input supply accuracy.

PC Card Slot Implementation

V_{CC} Switch Specification (ON Resistance)

A critical requirement for compatibility, performance, and reliability in the field is a low voltage drop at the maximum expected output current. The V_{CC} supply, with its 1A output current specification, requires an extremely low ON resistance, as shown in Table I. This table shows the highest switch resistance that allows pin voltage to meet the required V_{MIN} at a given input supply accuracy. A maximum combined pin resistance of 45mΩ is assumed (see Appendix for details).

The key point to remember is that slot voltage is a combination of several factors: input supply tolerance, card power draw, pin resistance, and switch resistance. Reasonable values of V_{CC} = 5V switch resistance and power supply tolerance indicate that a good match is found with a ±2% V_{CC} supply and a 100mΩ switch. The reduced accuracy requirements of the 3.3V supply allow a lower cost ±5% supply with a moderate performance 90mΩ switch, or a 190mΩ switch with a ±2% supply.

Small systems that will not support hard disk drives or other high current cards may increase the switch resistance, trading lower power system cost for reduced compatibility.

V_{PP} ON Resistance

V_{PP} ON resistances are shown in Table II. For V_{PP} = 12V, acceptable switch resistance is just over 1Ω if the system can guarantee ±4% accuracy. Finite pin and PC board trace resistances preclude using a ±5% supply since the pin voltage limit is also ±5%.

When $V_{PP} = V_{CC}$, the current demand changes. A few five volt programmable FLASH cards need up to 60mA at 5V (±5%). Using the same ±2% to ±3% supply required to meet the 5V V_{CC} specification, the 5V V_{PP} ON-resistance should range from 1Ω to 2.4Ω.

No presently available card requires any appreciable current when V_{PP} = 3.3V, so ON-resistance for this switch is not critical. Systems with 5Ω of V_{PP} = 3.3V ON-resistance are common with no user complaints of incompatibility.

(A)	V_{PP} = 12V Supply Accuracy	±1%	±2%	±3%	±4%
	Max. Switch Resistance (at 120mA)	4.7Ω	3.5Ω	2.3Ω	1.1Ω
(B)	V_{PP} = 5V Supply Accuracy	±1%	±2%	±3%	±4%
	Max. Switch Resistance (at 60mA)	3.3Ω	2.4Ω	1.6Ω	0.79Ω

Table II. V_{PP} pin power supply/switch requirements, with composite pin resistance of 45mΩ. (A) V_{PP} = 12V (V_{MIN} = 11.40V at 120mA). (B) V_{PP} = 5V (V_{MIN} = 4.75V at 60mA). This table shows the highest switch resistance that allows pin voltage to meet the required V_{MIN} at a given input supply accuracy.

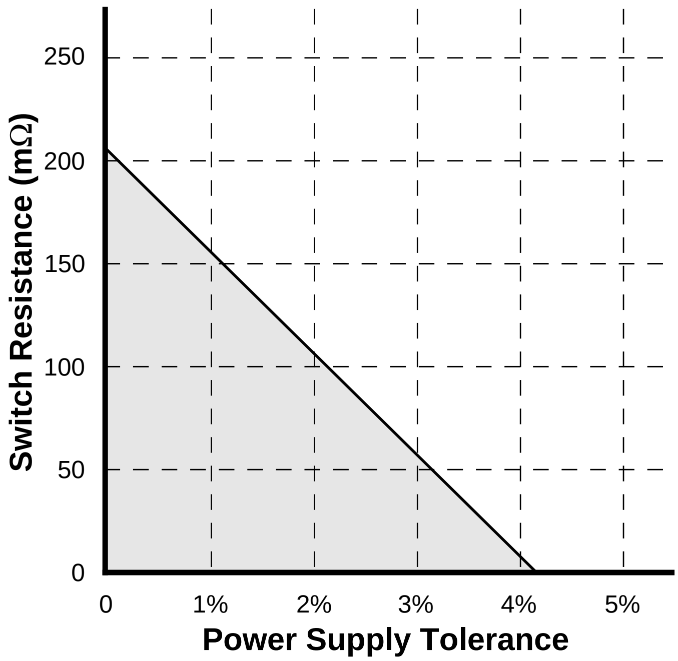


Figure 3. V_{CC} = 5V power supply tolerance versus switch resistance to meet the PC Card power specifications at 1 ampere. A composite pin resistance of 45mΩ has already been subtracted.

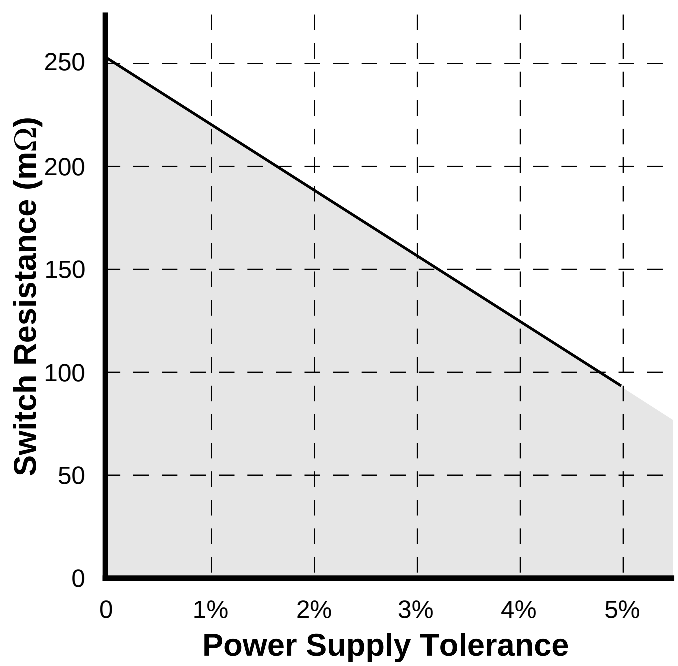


Figure 4. V_{CC} = 3.3V power supply tolerance versus switch resistance to meet the PC Card power specifications at 1 ampere. A composite pin resistance of 45mΩ has already been subtracted.

The R_{ON} vs. Power Supply Tolerance Trade-off

The PC Card Specification provides the required pin voltage tolerance, pin and socket resistance, and indicates the maximum allowable current. With these numbers, we may determine the maximum allowable power supply tolerance, power switch ON resistance, and PC board trace resistance. Note that except for the 3.3V supply, a standard ±5% power supply is inadequate to meet the specifications. A more expensive, tighter tolerance supply is necessary, and the tolerance requirement is more stringent when switches with higher ON resistance are used. Generally, the much higher cost of a high-precision power supply can be mitigated by using a slightly more expensive, lower ON-resistance switch. In general, a power supply with a ±2% rating has about a $2 per output more expensive component cost than a ±5% supply. This cost increases rapidly when even tighter tolerances are required.

The optimum budget for error terms in 5V V_{CC} systems is generally:

Power Supply	2%
Power Controller	2%
Pin Resistance	0.9%
PC Board Trace Resistance	+ 0.1%
Total	**5%**

Table I is plotted in Figures 3 and 4, graphically showing the in-specification operating area of switch ON resistance and V_{CC} supply tolerance. It shows that with a 5V ± 4% supply, a nearly perfect (≤ 5mΩ) switch is necessary, and with a 200mΩ switch, a nearly perfect (± 0%) power supply is needed. Between these endpoints, a reasonable design is possible. Prudent designs will consider performance at the maximum expected operating temperature and include the effects of any connectors or PC board trace resistance between the power supply and the switch.

The various loss resistance terms are depicted in Figure 5.

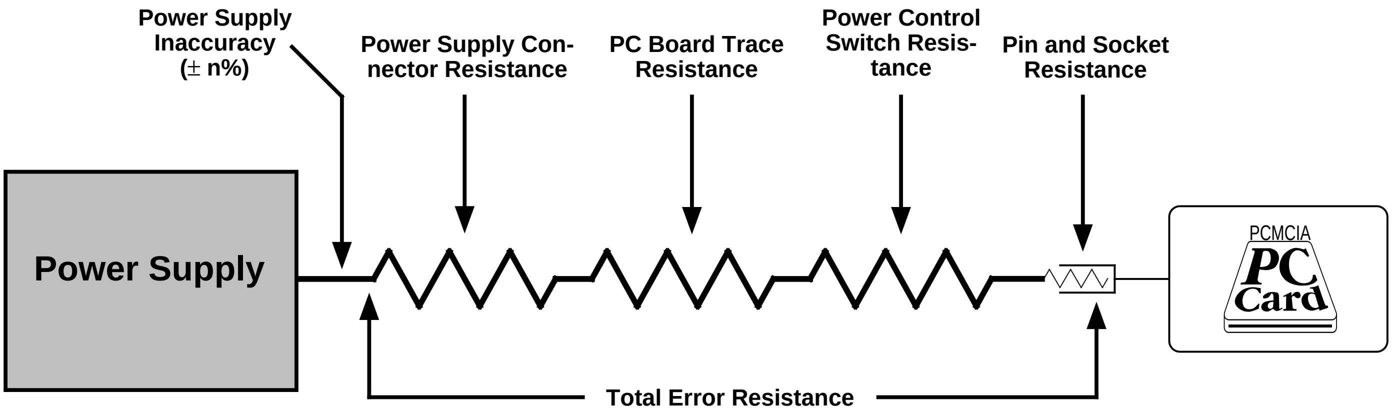


Figure 5. The error terms working against accurate voltage at the PC Card socket.

ESD Considerations

Electrostatic discharge (ESD) induced damage is a real possibility because of the nature of the PC Card socket. However, the slot power controller has good ESD immunity due to its large geometries; the physically large transistors that connect to the slot power pins are inherently less sensitive to ESD damage than the logic devices connecting to the other 60 (signal) pins. Placing small (0.1µF or so) capacitors on the V_{CC} and V_{PP} pins will further reduce ESD susceptibility and will, for practical purposes, eliminate all damage concerns.

Power Switch Thermal Design Considerations

During normal operation, the power dissipated in the control switches is low. Thermal design is not a major factor in PCMCIA power control implementations. During fault conditions, however, such as when a shorted card is powered, heat sinking of the power switch actually is counterproductive—it is better to let the switch overheat and automatically shut down rather than continually pump current into the damaged card. Effective heat sinking will prolong the overcurrent fault, wasting battery life and causing additional stress to the system power supply.

Power Dissipation and Temperature Rise Examples

A few examples will clarify the limited magnitude of temperature rise in PC Card power control switches. We will use worst case specifications—actual results will be significantly better.

Case I: CardBus Card requiring 1A.

Using the MIC2560 with its guaranteed worst case V_{CC} = 3.3V R_{ON} of 66mΩ, power dissipation is:

$$P_D = I^2 \times R$$

$$= 1A^2 \times 0.066\Omega = 66mW$$

The published thermal resistance (θ_{JA}) of the MIC2560 is 65°C/W when mounted on a minimum-geometry PC board layout. This means the junction temperature rise (ΔT_J) is

$$\Delta T_J = P_D \times \theta_{JA}$$

$$= 66mW \times 65°C/W = 4.3°$$

Which is negligible. With an ambient temperature (the temperature inside the system enclosure) of 50°C, the junction temperature is only

$$T_J = T_A + \Delta T_J = 54.3°C$$

Case II: 5V Hard Disk Drive requiring 1A

The 5V condition is slightly worse, but still inconsequential. The worst case R_{ON} for V_{CC} = 5V using the MIC2560 is 100mΩ.

$$\Delta T = I^2 \times R \times \theta_{JA}$$

$$= 1A^2 \times 0.1\Omega \times 65°C/W = 6.5°$$

Case III: Dual Slot Control with an RF Modem and CardBus Card

Using the MIC2563A dual slot power controller, the nearly "worst imaginable" thermal situation would occur when a CardBus card is driven on one slot and an RF modem resides on the other. We assume the CardBus card requires 1A at 3.3V and the RF modem takes 1A at 5V and 100mA at 12V.

P_D = P (3.3V of Socket A) + P (5V on Socket B) + P (12V on Socket B)

$= (1A^2 \times 0.15\Omega) + (1A^2 \times 0.1\Omega) + (0.1A^2 \times 1\Omega)$
$= 260mW$

Using a conservative 70°C/W thermal resistance figure, the die temperature rise is only 18°C. This heavily contrived example demonstrates that thermal parameters are of limited concern in PCMCIA slot power implementations.

PC Board Trace Width Design

Up to this point, we have discussed several terms that lead to voltage errors at the PC Card socket. Another factor that must be considered is the resistance of the copper PC board traces between the power supply and the power controller, and from the power controller and the socket. Two important PC board trace parameters affecting the available PC Card voltage are trace resistance and trace current handling capability. Trace resistance directly adds to the switch/socket contact resistance, and should be minimized. Current handling ability of the trace is proportional to its cross-sectional area. An insufficiently large trace may act as a fuse with high sustained current flow, so trace cross-sectional area should be maximized. Fortunately, both minimum resistance and maximum current handling capability are achieved with large, heavy traces.

The following three design equations provide a method of calculating the resistance and current density of a PC board trace as a function of heat dissipation. They assume a surface layer (outside) trace.

(1) $$\rho_S(T) = \frac{\rho\left[1 + \alpha\left(T_A + T_{RISE} - 20\right)\right]}{h}$$

where:

$\rho_S(T)$ = sheet resistance at elevated temp. (Ω/□)
ρ = 0.0172 = copper resistivity at 20°C (Ω • µm)
α = 0.00393 = temperature coefficient of ρ (per °C)
T_A = ambient temperature (°C)
T_{RISE} = allowed temperature rise (°C)
h = copper trace height (µm, see Appendix C).

(2) $$w = \frac{1000\, I_{MAX}}{\sqrt{\frac{T_{RISE} \div \theta_{SA}}{\rho_S(T)}}}$$

where:

w = minimum copper trace width (mils)
I_{MAX} = maximum current for allowed T_{RISE} (A)
T_{RISE} = allowed temperature rise (°C)
θ_{SA} = trace thermal resistance (°C • in^2/W)
$\rho_S(T)$ = sheet resistance at elevated temp. (Ω/□).
Note: $\theta_{SA} \approx 55$°C • in^2/W.

(3) $$l = \frac{w\,R}{\rho_S(T)}$$

where:

l = maximum trace length (mils)
w = trace width (mils)
R = maximum allowable resistance (Ω)
$\rho_S(T)$ = sheet resistance at elevated temp. (Ω/□).

Trace Width Design Example

A PC board trace is designed as follows: (1) based on copper height (from board weight and the table of Appendix C) and an allowed temperature rise for the trace, calculate the sheet resistance (Equation 1); (2) based on the maximum current the trace will sustain (1A per card slot), calculate its minimum trace width (Equation 2); and (3) based on the maximum allowable resistance, calculate the maximum trace length (Equation 3).

Step 1: Calculate Sheet Resistance

This design uses 1 oz/ft^2 weight PCB material, which has a copper thickness (trace height) of 35.6µm. (See Appendix C). It was decided to allow the trace to produce a 10°C temperature rise, which would place it at 50°C (worst case) when operating in a 40°C ambient environment. Then:

$$\rho_S(T) = \frac{0.0172\left[1 + 0.00393\,(40 + 10 - 20)\right]}{35.6}$$

$$\rho_S(T) = 540 \times 10^{-6}\ \Omega/\square = 0.540\ m\Omega/\square.$$

Step 2: Calculate Minimum Trace Width

This design example provides for an output current of 4A, comfortably above the 2A maximum current that two PCMCIA sockets could draw. The current limit circuitry inside PCMCIA power controllers is designed for protection, not accuracy; to guarantee 1A available output current across the full operating temperature range and input voltage range, the devices are designed with a higher current limit point. For safety, design your traces for as much as 4A of current during sustained current limiting. Then:

$$w = \frac{1000 \times 4}{\sqrt{\dfrac{10 \div 55}{540 \times 10^{-6}}}}$$

w = 218 mils.

Step 3: Calculate Maximum Trace Length

If we may tolerate as much as 4mΩ of trace resistance, we should determine the maximum length of a 218 mil wide trace. The maximum length of a 218 mil trace, where its resistance equals 4mΩ, is determined via Equation 3:

$$l = \frac{218 \times 0.004}{540 \times 10^{-6}}$$

l = 1615 mils.

Calculating Trace Width for a Required Length

For a given trace length and maximum trace resistance, trace width may be determined. Figure 6 shows trace width for 1 oz/ft^2 copper thickness and Figure 7 shows width for 2 oz/ft^2 copper. Both graphs assume a temperature rise of 10°C from a 40°C ambient (50°C final operating temperature). Note that there is a minimum trace width shown—this is the width required to pass 4A with suitable current density.

PC Board Temperature Considerations

The above equations and graphs produce the minimum trace width and the maximum trace length at *elevated temperature*. It is important to consider resistance at temperature because copper has a high temperature coefficient (+0.39%/°C).

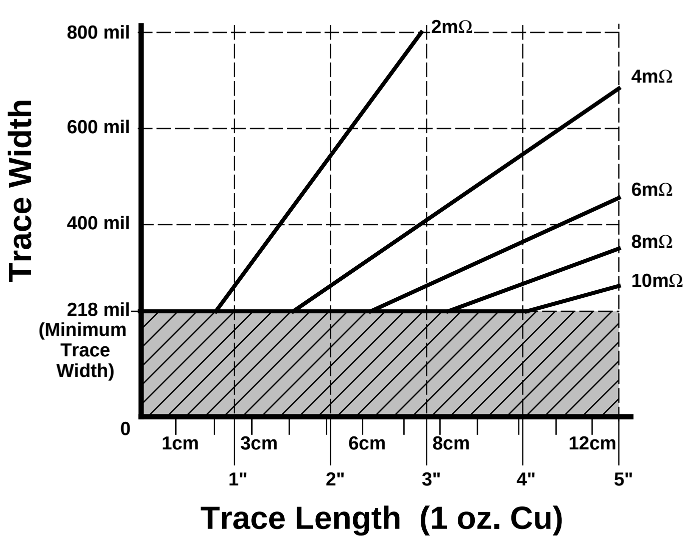


Figure 6. PC Board Trace Width for a given length and resistance using 1 oz/ft^2 copper. The minimum trace width shown is adequate to carry 4A. This graph assumes a 50°C operating temperature.

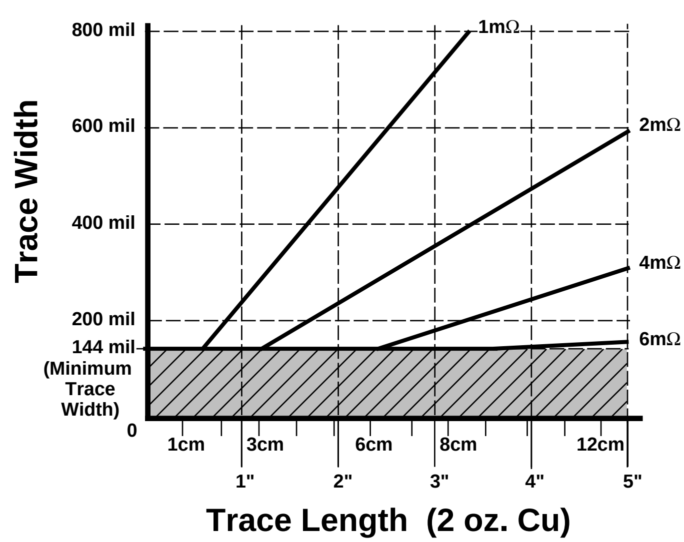


Figure 7. PC Board Trace Width for a given length and resistance using 2 oz/ft^2 copper. The minimum trace width shown is adequate to carry 4A. This graph assumes a 50°C operating temperature.

Design Examples

Let us consider three specific system applications with differing power requirements. Proper electronic design requires considering the expected worst case conditions, so we will assume a high die temperature of the switch of 70°C. ***Do not use room temperature specifications for portable systems!***

Case 1: Subnotebook Computer

A subnotebook computer with a 486 or better processor is perceived by the end user as a full featured machine. Expectations are that the machine will support “any” PC Card, including modems and hard disk drives, so it must provide the full 1A V_{CC} output capability. We choose the Micrel Semiconductor MIC2560 V_{CC} & V_{PP} Power Controller for switching. What power supply specifications are required?

V_{CC} = 5V, I_{OUT} = 1A

MIC2560 ON Resistance	100mΩ
Socket Pin Resistance	+ 45mΩ
Total Resistance	145mΩ

The minimum V_{CC} input for 4.75V at the card = 4.75 + (1A × 145mΩ) = 4.895V

The system power supply must provide 4.895V to 5.25V. This may be stated as 5V +5%, –2.1%, or 5.073V ± 3.5%. Note that this 5.073V nominal supply is well within the acceptable tolerance of a standard 5V ±5% supply, so it may be used by all 5V components in the system.

V_{CC} = 3.3V, I_{OUT} = 1A

MIC2560 ON Resistance	66mΩ
Socket Pin Resistance	+ 45mΩ
Total Resistance	111mΩ

The minimum V_{CC} input for 3.0V at the card is 3.0V + (1A × 111mΩ) = 3.111V. The required power supply voltage range is from 3.111V to 3.6V; a 3.3V +9%, –5.7% or 3.356V ± 7.3% supply is suitable.

The MIC2560 offers the lowest V_{CC} ON resistances of any PC Card power switch. It is adequate for any expected PC Card load.

Case 2: Hand Held Computer

A palmtop computer requires communications capability provided by a PC Card modem. It generally does not support a hard drive because of battery capacity constraints. Assuming a modem draws 300mA from either a 5V or 3.3V supply, we select the MIC2561 V_{CC} & V_{PP} Power Controller. The palmtop supply requirements are:

V_{CC} = 5V, I_{OUT} = 300mA

MIC2561 ON Resistance	300mΩ
Socket Pin Resistance	+ 45mΩ
Total Resistance	345mΩ

The minimum V_{CC} input for 4.75V at the card is 4.75 + (300mA × 345mΩ) = 4.835V

The system power supply must provide 4.835V to 5.25V. This may be stated as 5V +5%, –3.4%, or 5.043V ± 4.0%.

V_{CC} = 3.3V, I_{OUT} = 300mA

MIC2561 ON Resistance	185mΩ
Socket Pin Resistance	+ 45mΩ
Total Resistance	230mΩ

The minimum V_{CC} input is 3.111V, which denotes a 3.3V +9%, –5.7% or 3.356V ± 7.3% supply.

For V_{CC}, we note the ON resistances of the MIC2561 are suitable for the intended PC Card load, given 5V ± 3.4% and 3.3V ± 5.7% supplies. On the other hand, the MIC2560 would do the same job with a 5V ± 4.1% and 3.3V ± 8% supplies. You must decide if the additional cost of the MIC2560 saves the (much larger) cost of a more accurate power supply.

Case 3: Hand-Held Logging or Inventory Device

Equipment used for data taking, including storage DVMs and inventory checkers, do not require extensive compatibility with various types of PC Cards. They generally use either SRAM or FLASH memory cards and operate at a single V_{CC}. If this V_{CC} is 5V, the Specification allows hard-wiring the supply to the pin. Otherwise, a simple single pole MOSFET switch can enable V_{CC} to the card. V_{PP} control is achieved by using the Micrel MIC2557 for systems tying V_{PP1} and V_{PP2} together, or the MIC2558 to support separate V_{PP} pins. Some 5V-only FLASH cards draw as much as 60mA from V_{PP}. They may be accommodated by paralleling the two halves of the MIC2558 and using a 5V +5%, –3.4% (or a 5.04V ± 4.1%) supply. The MIC2559 has improved $V_{PP} = V_{CC}$ ON resistance and allows a 5V +5%, –4% (or 5.025V ± 4.4%) supply.

Conclusion

A power controller for PCMCIA slots must switch all required supply voltages for both V_{CC} and V_{PP} with acceptable ON resistance across the anticipated operating temperature range and without cross conduction or ringing. It should also protect the rest of the system from any fault condition and signal the logic controller when such a fault exists.

The switches used for V_{CC} selection must provide a few features not mentioned by the PC Card Specification for satisfactory operation: they must be configured to properly sequence the 3.3V and 5V supplies so no “shoot-through” paths exist, and the switch must be designed to prevent damaging voltage ringing. Protection features, such as current limiting and overtemperature shutdown, enhance system longevity.

A price/performance trade-off exists between switch ON resistance and required V_{CC} supply accuracy. For any given output current, the lower ON resistance switch allows a lower cost, lower accuracy power supply. In many cases, your lowest *system* cost is achieved with the best available (lowest R_{ON}) PC Card power switch.

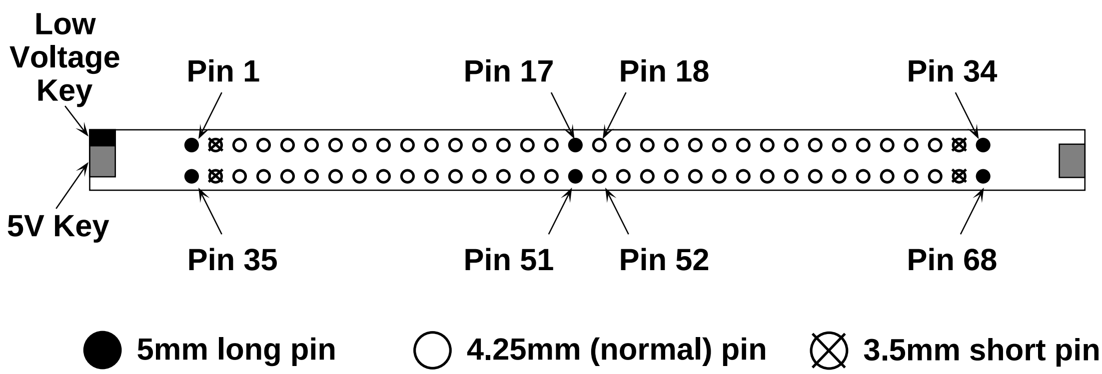
Appendices

Appendix A. Composite V_{CC} Pin Resistance Calculation

From the PC Card Specification, §7.2.1, we find a maximum initial pin resistance specification of 40mΩ that may change no more than ± 20mΩ after testing. This gives us a per-pin worst case resistance of 60mΩ. There are two V_{CC} pins and four ground pins. The total composite V_{CC} pin resistance is the series-parallel combination of these resistances:

$$\frac{60m\Omega}{2\ V_{CC}\ \text{pins}} + \frac{60m\Omega}{4\ \text{Ground pins}} = 45m\Omega$$

Appendix B. PC Card Power and Ground Pins



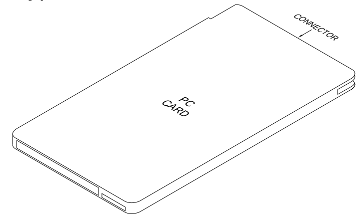
Function	Pin #	Pin Length
V_{CC}	17, 51	5mm
V_{PP1}	18	4.25mm
V_{PP2}	52	4.25mm
Ground	1, 34, 35, 68	5mm

Appendix C. Copper Trace Heights Table

PCB Weight (oz/in^2)	Copper Trace Height (mils)	(µm)
1/2	0.7	17.8
1	1.4	35.6
2	2.8	71.1
3	4.2	106.

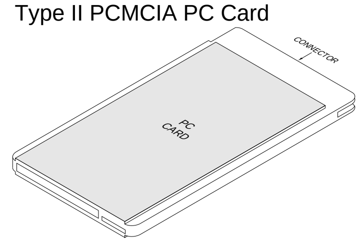
Appendix D. PC Card Sizes

Type I PCMCIA PC Card

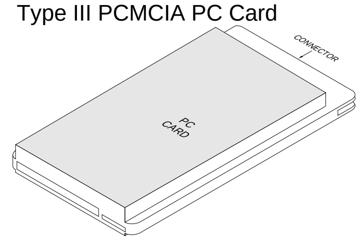


There are three approved sizes of PCMCIA cards. The Type I card is the thinnest, at 3.3mm. Type II cards are slightly thicker, 5mm, with a "bump" along the top and bottom faces of the card. Type III are the largest, at 10.5mm. Type III cards are mostly used for hard disk drives. All three types use identical socket dimensions for their 68-pin connectors.

Type II PCMCIA PC Card

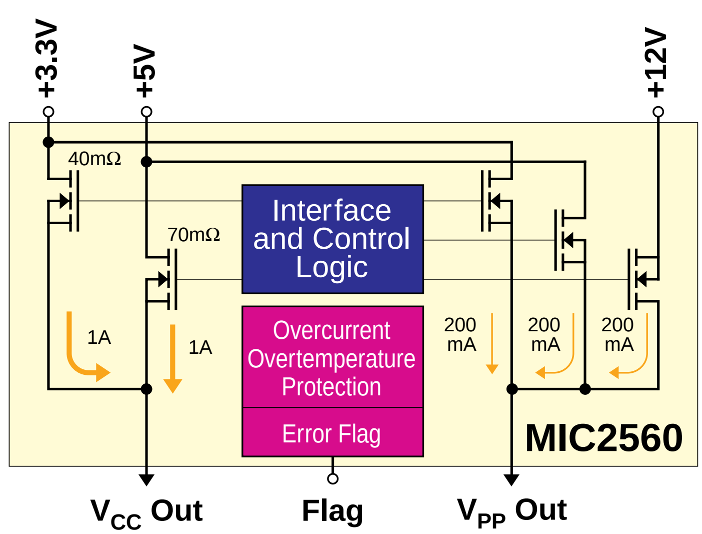


Type III PCMCIA PC Card



Appendix E. PCMCIA Slot Power Controller Block Diagram

Just what does a PCMCIA slot power controller do? A typical power controller, sometimes called a switching matrix, is shown in the figure below. The device takes 3.3V, 5V, and 12V from the system power supply and directs it to the proper output. The MIC2560 design allows connecting either 3.3V or 5V to V_{CC} and/or the V_{PP} output and automatically restricts 12V to V_{PP} only. Large N-channel MOSFETs are used for the 3.3 and 5V switches. A P-channel MOSFET controls the 12V supply. Internal logic handles interfacing with the PCMCIA logic controller, which tells the MIC2560 which voltage to apply. The logic also handles internal housekeeping, preventing internal cross-coupling (shoot through) by insuring that only one switch is active at any time. Current flow through the active FET switch is continually monitored, and the FET automatically clamps current at a predetermined level if a fault occurs. Current surges are prevented by controlling switching times and by the current limiting mechanism previously described.



PCMCIA Power Control Glossary

CIS	Card Information Structure. The data structure which contains information about the capabilities of the card as well as the formatting and organization of data on the card.
Logic Controller	The interface between a computer system bus (ISA, PCI, etc.) and the the PCMCIA slot. The logic controller instructs the power controller which voltage to apply to the slot.
PC Card	The “official” name for a PCMCIA card.
The PC Card Specification	The latest revision of PCMCIA’s specification, presently dated March, 1995. It replaces Release 2.01 of the PCMCIA specification.
Power Controller	Micrel Semiconductor’s term for the power interface that drives the V_{CC} and V_{PP} pins of the PCMCIA slot. The power controller receives instructions from the slot logic controller as to the proper voltage for each supply. It feeds back slot power status information to the logic controller.
Slot	The hardware in the host which is responsible for accepting a PC Card into the host and mapping the host’s internal bus signals to the PCMCIA interface signals.
Socket	*See Slot.*
Switch Matrix	A older term describing a slot power controller.

References

Application Hint 17: "Calculating P.C. Board Heat Sink Area For Surface Mount Packages," *Micrel 1995 Databook.*

Application Hint 21: "Sense Resistors for the Super LDO™ Regulator," *Micrel 1995 Databook.*

Application Hint 25: "Minimum Size Copper Sense Resistors," Jerry Kmetz, Micrel Incorporated.

MIL-STD-275E: *Printed Wiring for Electronic Equipment.*

Mori, Michael T. *The PCMCIA Developer's Guide*. Sunnyvale, CA: Sycard Technology, 1995

Personal Computer Memory Card International Association. *The PC Card Specification.* Sunnyvale, CA: March, 1995.

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