Application Hint 30

MIC2527 Voltage Drop, Packaging and PCB Layout

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The MIC2527 was designed to provide cost-effective individual port protection and switching for USB self-powered hub designs. Analysis of voltage drops under several design scenarios shows that the most economical approach to meeting USB voltage requirements is to use a 300 mΩ switch and a 3% power supply "biased up" to 5.1V. Most USB controllers can also operate with this supply since they are expected to operate from 4.0V to 5.25V.

Nominal Voltage	Supply Tolerance	Minimum Voltage	Maximum Voltage	Maximum R_{ON}
4.85V	1%	4.8V	4.9V	40mΩ
	2%	4.75V	4.95V	0mΩ
	3%	4.7V	5V	—
	4%	4.66V	5.04V	—
	5%	4.61V	5.09V	—
4.90V	1%	4.85V	4.95V	140mΩ
	2%	4.8V	5V	40mΩ
	3%	4.75V	5.05V	0mΩ
	4%	4.7V	5.1V	—
	5%	4.66V	5.15V	—
4.95V	1%	4.9V	5V	240mΩ
	2%	4.85V	5.05V	140mΩ
	3%	4.8V	5.1V	40mΩ
	4%	4.75V	5.15V	0mΩ
	5%	4.7V	5.2V	—
5.00V	1%	4.95V	5.05V	340mΩ
	2%	4.9V	5.1V	240mΩ
	3%	4.85V	5.15V	140mΩ
	4%	4.8V	5.2V	40mΩ
	5%	4.75V	5.25V	0mΩ
5.05V	1%	5V	5.1V	440mΩ
	2%	4.95V	5.15V	340mΩ
	3%	4.9V	5.2V	240mΩ
	4%	4.85V	5.25V	140mΩ
	5%	4.8V	5.3V	—
5.10V	1%	5.05V	5.15V	540mΩ
	2%	5V	5.2V	440mΩ
	3%	**4.95V**	**5.25V**	340mΩ
	4%	4.9V	5.3V	—
	5%	4.85V	5.36V	—
5.15V	1%	5.1V	5.2V	640mΩ
	2%	5.05V	5.25V	540mΩ
	3%	5V	5.3V	—
	4%	4.94V	5.36V	—
	5%	4.89V	5.41V	—

Table 1. Maximum Allowed On-Resistance with 30mV PCB Voltage Drop

Shading represents USB-compliant conditions.

Self-Powered Hub Design

The output voltage requirement for USB self-powered hubs is 4.75V minimum to 5.25V maximum under no-load and maximum-load (500mA) conditions. The output voltage is a function of power supply voltage and tolerance, PCB connector and trace resistances, and switch resistance:

$$4.75\text{V (min)} = V_{MIN}\ \text{(Power Supply)} - V_{DROP}\ \text{(PCB)} - V_{DROP}\ \text{(Switch)}$$

To determine the set of power supply voltages and tolerances which fall within the USB requirement, minimum and maximum output voltages were calculated for nominal supplies in the range of 4.85V to 5.15V and with 1% to 5% tolerances. See Table 1. Power supplies which have V_{MIN} < 4.75V or V_{MAX} > 5.25V cannot be used for USB applications. Note that, even for a supply centered at 5V, the supply tolerance must be better than 5% to allow for any losses due to PCB connector and trace resistance.

30mV is generally sufficient to account for voltage drops due to PCB connector and trace resistance. For recommendations to minimize PCB connector and trace losses through proper board layout and design, please refer to Application Note 17 "Universal Serial Bus Power Management."

Using minimum power supply output voltages and a 30mV drop for the PCB, we can calculate the maximum on-resistance required for the switch as follows:

$$R_{ON}\ \text{switch (max)} = \frac{V_{MIN} - 4.75\text{V} - 0.03\text{V}}{0.5\text{A}}\ \Omega$$

Calculated values for maximum switch resistance are shown in Table 1 for all usable power supply ranges. Power supply ranges requiring R_{ON} to be 0Ω are also not usable for USB since some voltage drop must be reserved for the switch. These calculations show that as the nominal power supply is increased, higher values of switch resistance, and therefore lower cost switches, can be used.

A 3% power supply tolerance generally provides a good compromise between accuracy and cost. For the usable power supply ranges in Table 1, the most economical switch (340mΩ maximum) can be used with a 5.1V, ±3% supply. The MIC2527, with 300mΩ maximum on-resistance, was designed to meet this requirement.

The 5.1V 3% supply can be generated using a Micrel MIC29311-5.1BT voltage regulator. If a 5V, ±3% supply must be used, the MIC2524 with 140mΩ on-resistance is ideally suited.

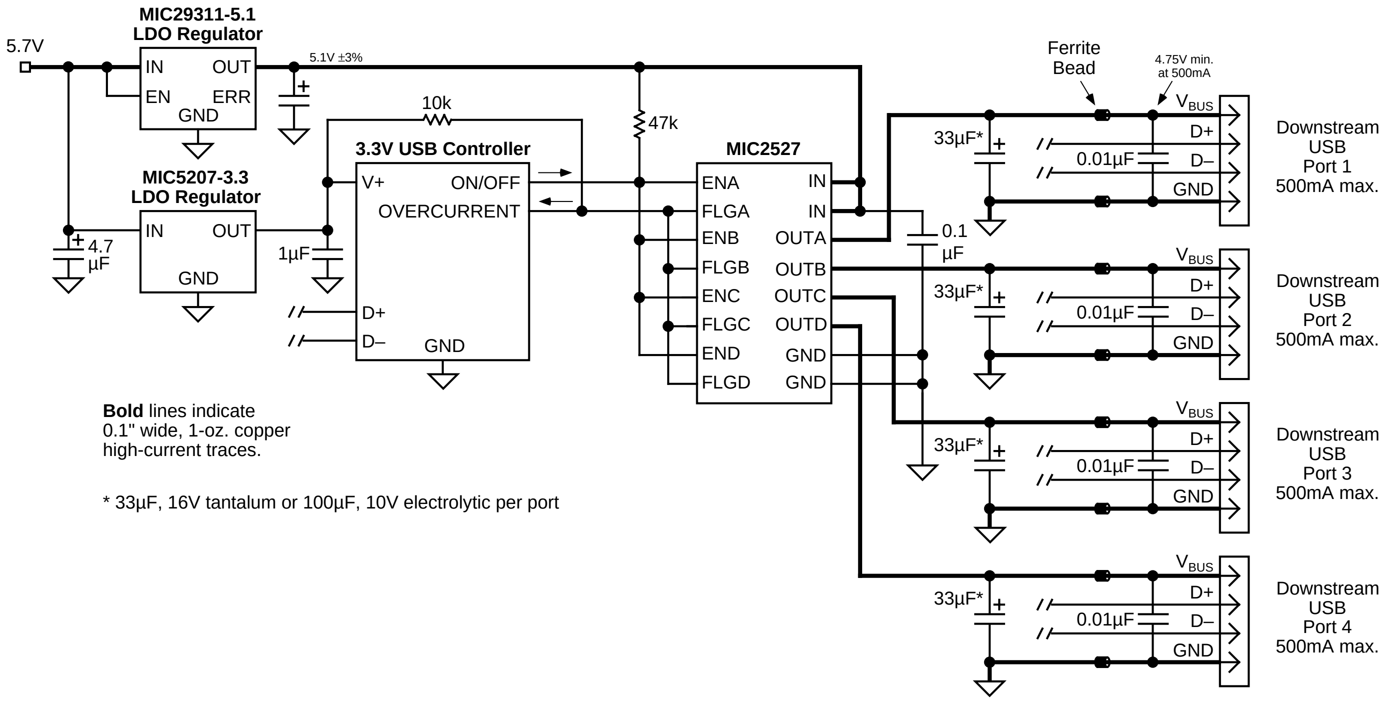

Figure 1. MIC2527 Application

Heat Sink Requirements

To determine regulator heat sink requirements, calculate the regulator power dissipation at the applicable input voltage:

$$P_D = I_{OUT}\ (1.02 \times V_{IN} - V_{OUT})$$

where:

$$V_{IN} < 7.0V$$

At $V_{IN} = 7V$:

$$P_{D(max)} = 2.1A\ (1.02 \times 7V - 5.1V)$$

$$P_{D(max)} = 4.3W$$

Using the same formula for $V_{IN} = 5.4V$, the minimum input voltage, $P_{D(max)}$ is 0.86W. For further information, see the MIC29311 data sheet.

If the average V_{IN} is greater than 7V, a 3A stepdown switching regulator, such as the MIC4576, may replace the linear regulator, with reduced heat sink requirements.

Packaging and Board Layout

The MIC2527 is offered in the 16-pin plastic DIP package for through-hole mounting and in the 16-pin 0.300-inch wide SOIC package for surface mounting. Micrel plans to add a third package option with the 16-pin 0.150-inch narrow SOIC package.

For customers who would like to migrate from the 0.300-inch to the 0.150-inch SOIC package, it is possible to layout the PCB to take either package by using longer traces to the package leads.

Figure 2 shows the nominal trace dimensions needed for a dual 0.150-inch/0.300-inch SOIC layout.

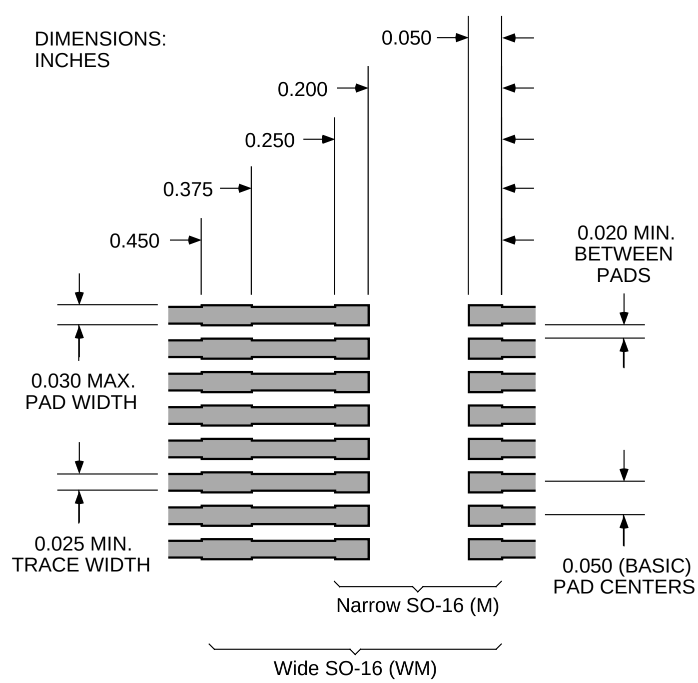

Figure 2. Dual-Package PCB Layout