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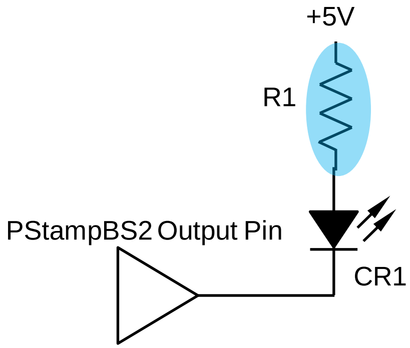
29 JAN 2012

Calculating the Current Limiting Resistor for a LED



High = +5V
Low = 0V

Voltage (V) : Pressure
Current (I) : Flow
Resistance (R) : Restriction
Power (P) : Energy (Heat)
Light Emitting Diode (LED)

R1 = Resistor 1
CR1 = Crystal Rectifier (Diode) 1

From the Data Sheet for your LED:
Let's say that this LED (CR1) has a Forward Voltage Drop (V_{fwd}) of 2.1 V and its Maximum Forward Current (I_{fwdmax}) is 20 mA (Max Brightness)

Because the LED is a non-linear device, it will always drop about 2.1V across it at various current levels passing through it (not like a resistor for example which is linear – voltage is proportional to current).

Since we have a 5 V supply (+5V) here, and the LED will drop 2.1 V, the resistor will have to drop the remainder which is 2.9V. Since the PStamp output pins can not provide (source – put out or sink – draw in) much current (only about 10 mA on average), we can not drive (turn on) the LED at its maximum brightness (20 mA), so we will drive it with 10 mA (it will be on, but roughly half the brightness).

Now we have all the terms needed to calculate the resistance of the resistor (R1) and its wattage (how hot it can get or simply its physical size)

From Ohms Law:

$$R = \frac{E}{I}$$

Watts Law:

$$P = E \cdot I$$

Where:
R = Resistance in Ohms (Ω)
E = Electro Motive Force in Volts (V)
I = Intensity or Current in Amperes (A) - sometimes called Amps for short
P = Power in Watts (W)

$$R_1 = \frac{E_1}{I_1}$$

$$R_1 = \frac{2.9}{0.01}$$

$$R_1 = 290\ \Omega$$

$$P_1 = E_1 \cdot I_1$$

$$P_1 = 2.9 \cdot 0.01$$

$$P_1 = 0.029\ W$$

$$= 29\ mW$$

A 290 Ohm ¼ Watt Resistor will be able to handle 10 mA through this LED with a 5V supply.

290 Ohm resistors are not very common, use the closest value you can find. Remember, if the resistance is lower then more current will flow through it.

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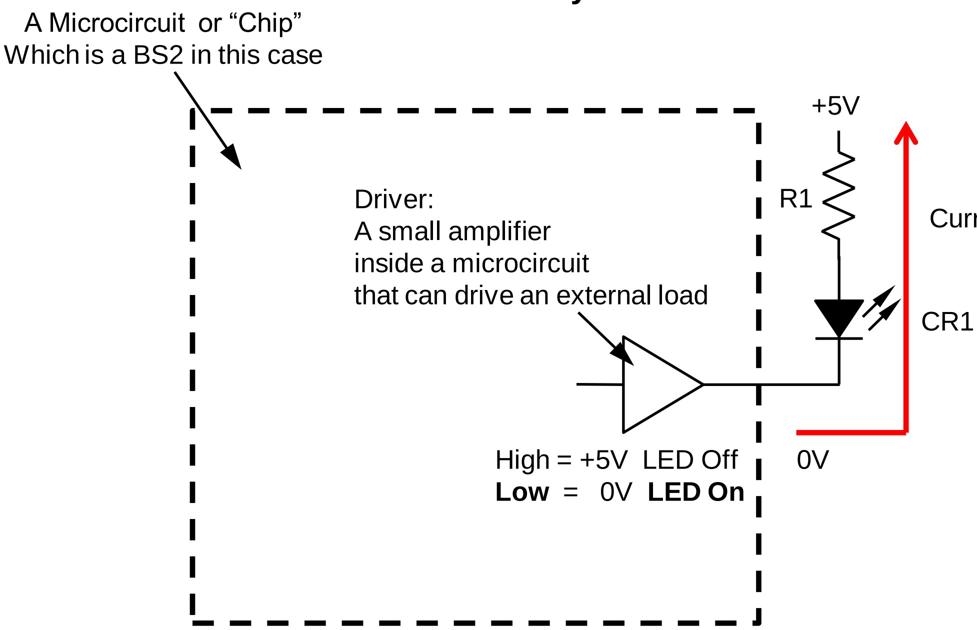
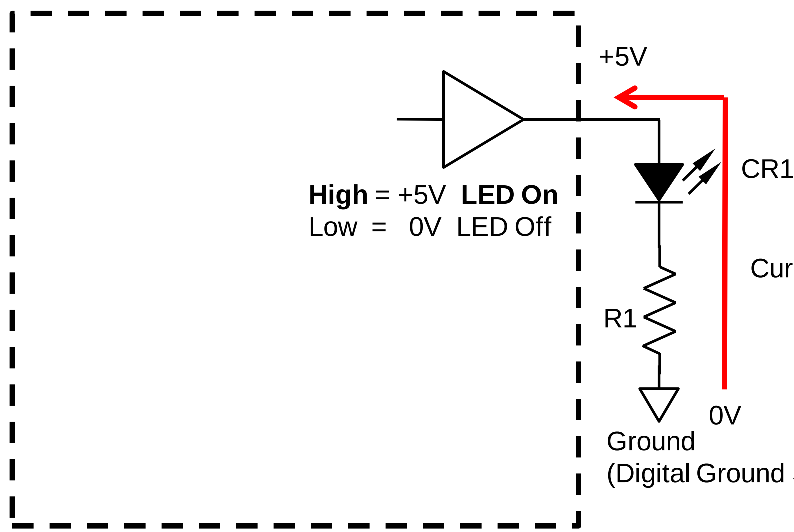
Why LEDs are Often Driven Low to Turn On



Microcircuits often can source slightly more current than they can sink. Also because the internal resistance of a driver is generally lower when it driving 0V, less heat is produced inside the microcircuit and thus it consumes less power (runs cooler).

Note: In either circuit, the resistor may be connected to the driver (the pin on the microcircuit) and the diode may be connected next (provided that the polarity of the diode remains as shown). However, traditionally the diode is connected to the driver (pin) as shown for convention only.



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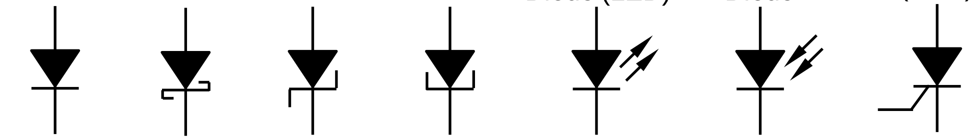
Why Current Flows Against the Arrow in a Diode

All diodes work basically the same way: Current flows easily on one direction (Forward Biased) and does not flow well in the other direction (Reversed Bias).

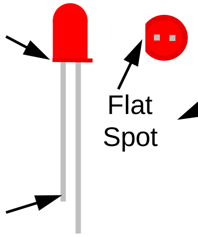
Examples of the most common types of Diodes used in electronics

Signal Diode | Sckottky Diode | Zener Diode | Tunnel Diode | Light Emitting Diode (LED) | Photo Diode | Silicon Controlled Rectifier (SCR)



Typical LED

Side View | Bottom View



Flat Spot

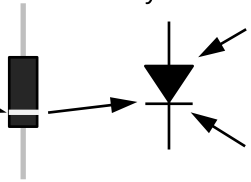
Flat Spot

Short “Clipped” Lead

The **Cathode** is almost always identified “marked” on the part. The mark looks somewhat like a **Negative** symbol (**-**)

Typical Signal Diode

Part | Symbol



Anode (+)

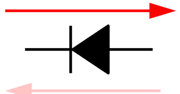
Cathode (-)

Memory Trick

Kathy is a very **Negative** girl

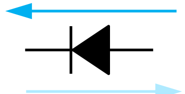
Two ways to look at current flow (Electrons or Holes)

Electrons (-) flow **against** the arrow



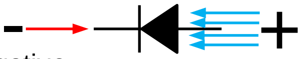
Very few Electrons (-) flow with the arrow

Holes (+) “the absence of Electrons” flow **with** the arrow



Very few Holes (+) flow against the arrow

Memory Trick



Negative Fits in the other side

Positive Fits in the Funnel

Because of the way semiconductors (like Diodes) work at the atomic level, and since most engineers like to follow Hole flow by convention, the symbol was created to favor Hole flow. There are also many other historic reasons why this was done, but this should suffice for this discussion

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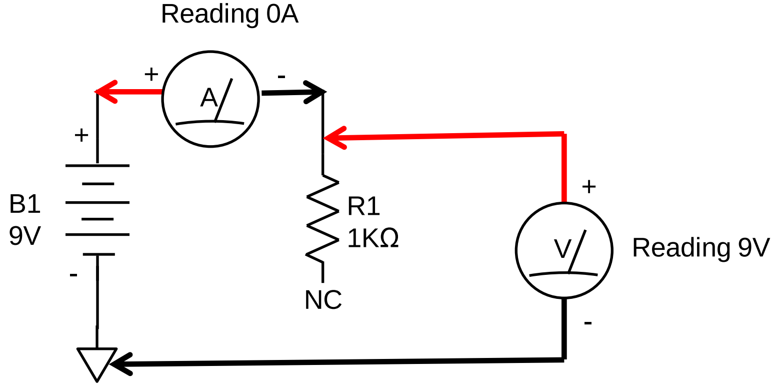
What is Zero and Infinite Ohms

Remember, your meters (instruments) are part of the circuit.

What you think your circuit is:

A **Perfect Ammeter**
Has **0 Ohms** inside,
(it looks like a wire is there
to the circuit)

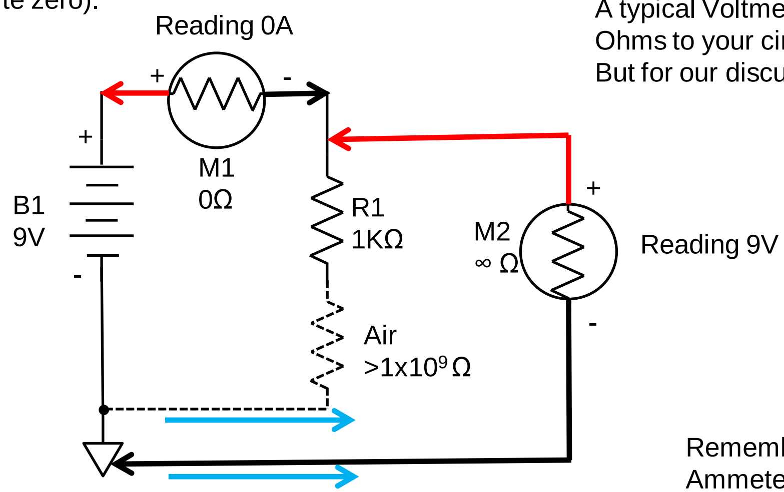


A **Perfect Voltmeter**
Has **Infinite (∞) Ohms** inside,
(it looks like nothing is there
to the circuit)

Now, **Meters are nowhere near perfect**.
A typical Ammeter will look like about 0.01
Ohms to your circuit (very, very, low but not quite zero).
But for our discussion we can call it 0 Ohms.

Is actually more like:

Again, Meters are nowhere near perfect.
A typical Voltmeter will look like about 10 M (10 million)
Ohms to your circuit (very, very, high but not quite infinite).
But for our discussion we can call it infinite Ohms.



Remember:
Ammeters look like a Short and
Voltmeters look like an Open

Notes:
NC is Not Connected

Air and M2 have too much resistance, so
virtually 0 Amps flows in the circuit.

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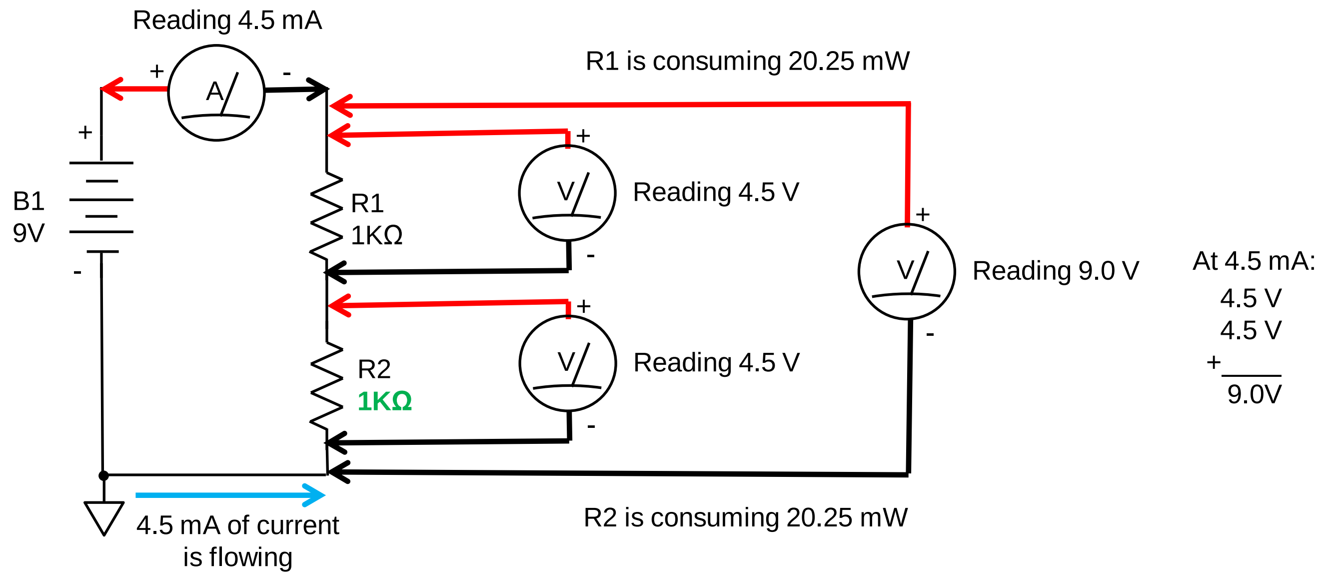
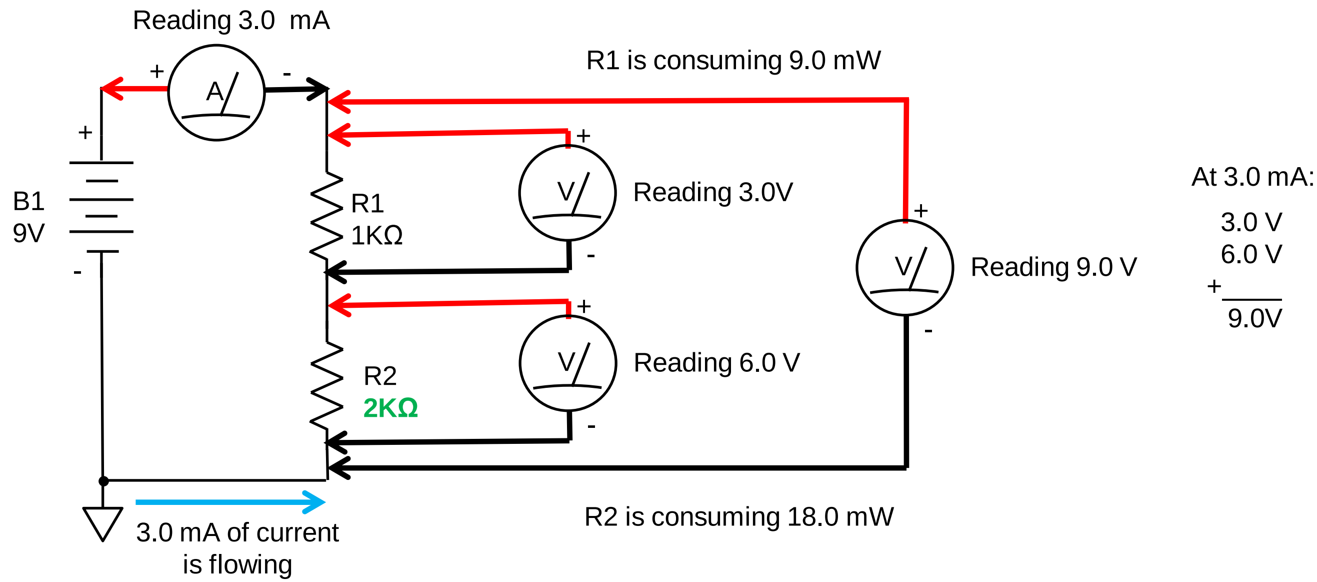
A Simple Series Circuit





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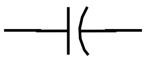
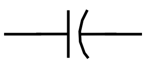
Resistors, Capacitors, and Inductors

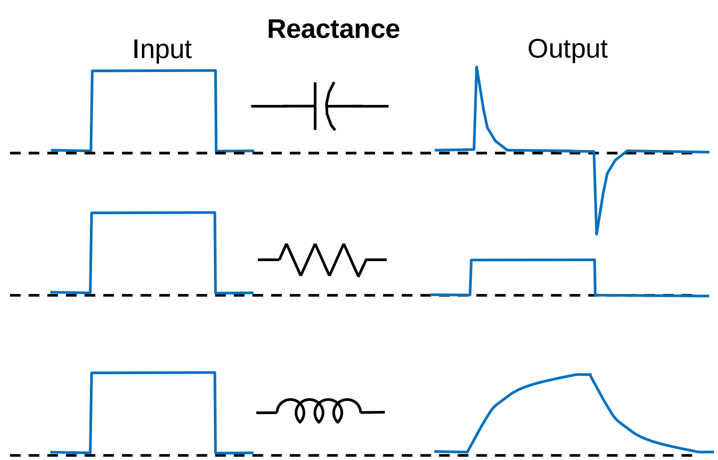
A very basic conceptual introduction

Everything in electronics (and Nature for that matter) is effected by varying degrees of Resistance, Capacitance, and Inductance

Energy in this case is primarily Electrons

Fundamental "Elements" of Electronics	Basic Schematic Symbol	Measurement Unit	Measurement Symbol	Reference Designator	Basic Function	Basic Structure
Capacitor		Farad	F	C	Holds Energy in an Electric (Electro-Static) Field	Two Conductive Plates Separated by an Insulator
Resistor		Ohm	Ω	R	Radiates (Consumes) Energy	Any Material that Impedes the Flow of Electrons
Inductor		Henri	H	L	Holds Energy in a Magnetic (Magneto-Static) Field	A Coil made of an Insulated Coated Conductor

		Basic Function	Effect
Capacitor		Blocks DC, Passes AC	Differentiator
Resistor		Partially Blocks DC and AC	Attenuator
Inductor		Blocks AC, Passes DC	Integrator



Think of Capacitors and Inductors as "Opposites" of each other and Resistors as "Neutral"

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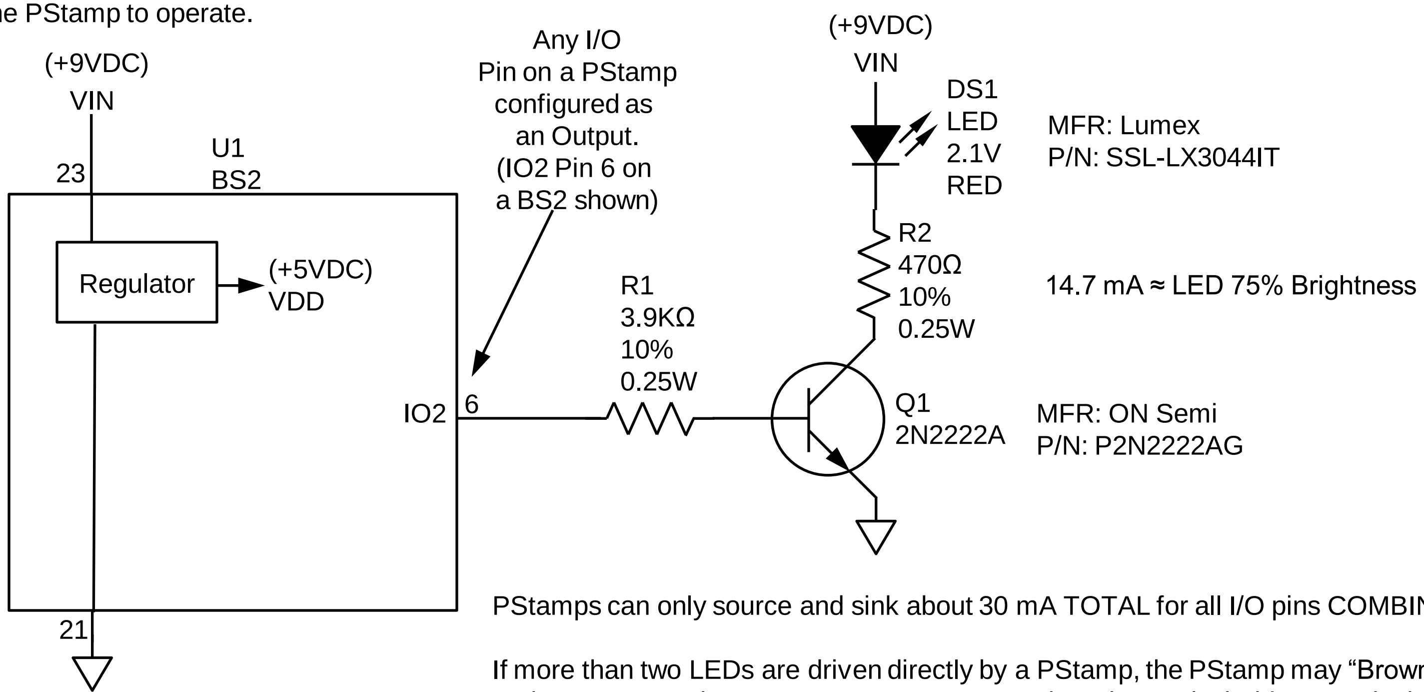
How to Drive Multiple LEDs from a PStamp

VIN = Unregulated 9V on the Parallax Board of Education (BOE).

WARNING

NEVER connect VIN (or any voltage more than 5V) to any IO pins on any PStamp device - doing so will damage the PStamp device instantly.

A PStamp can convert VIN (that can range from 5.5V to 12V) to VDD (5V) which is required by the parts on the PStamp to operate.



PStamps can only source and sink about 30 mA TOTAL for all I/O pins COMBINED.

If more than two LEDs are driven directly by a PStamp, the PStamp may “Brownout” and Reset every time two or more LEDs go on (causing undesirable operation).

By using a “LED Driver” circuit (shown above) for each LED (for each respective I/O pin), the PStamp can drive up to 16 individual LEDs and not Reset due to a Brownout (voltage sag on the PStamp due to over current from all the LEDs).

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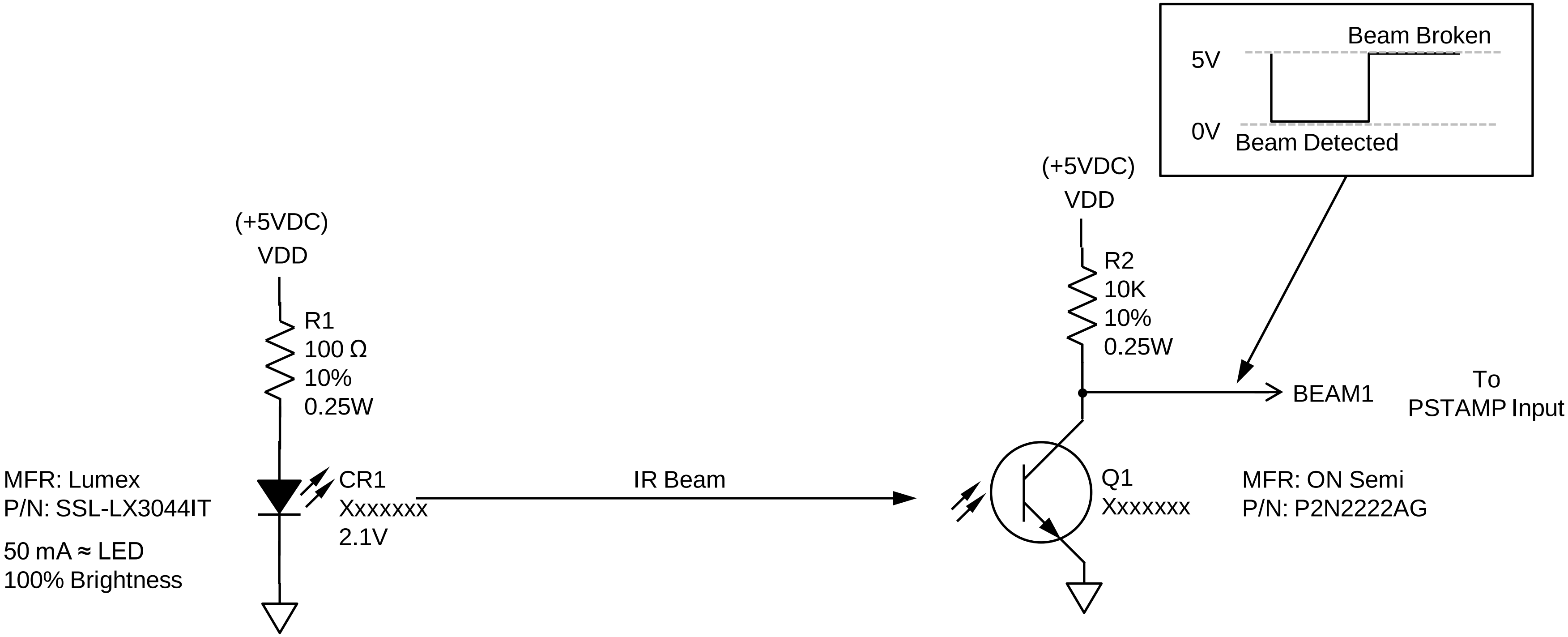
Typical IR LED Emitter/Detector Beam



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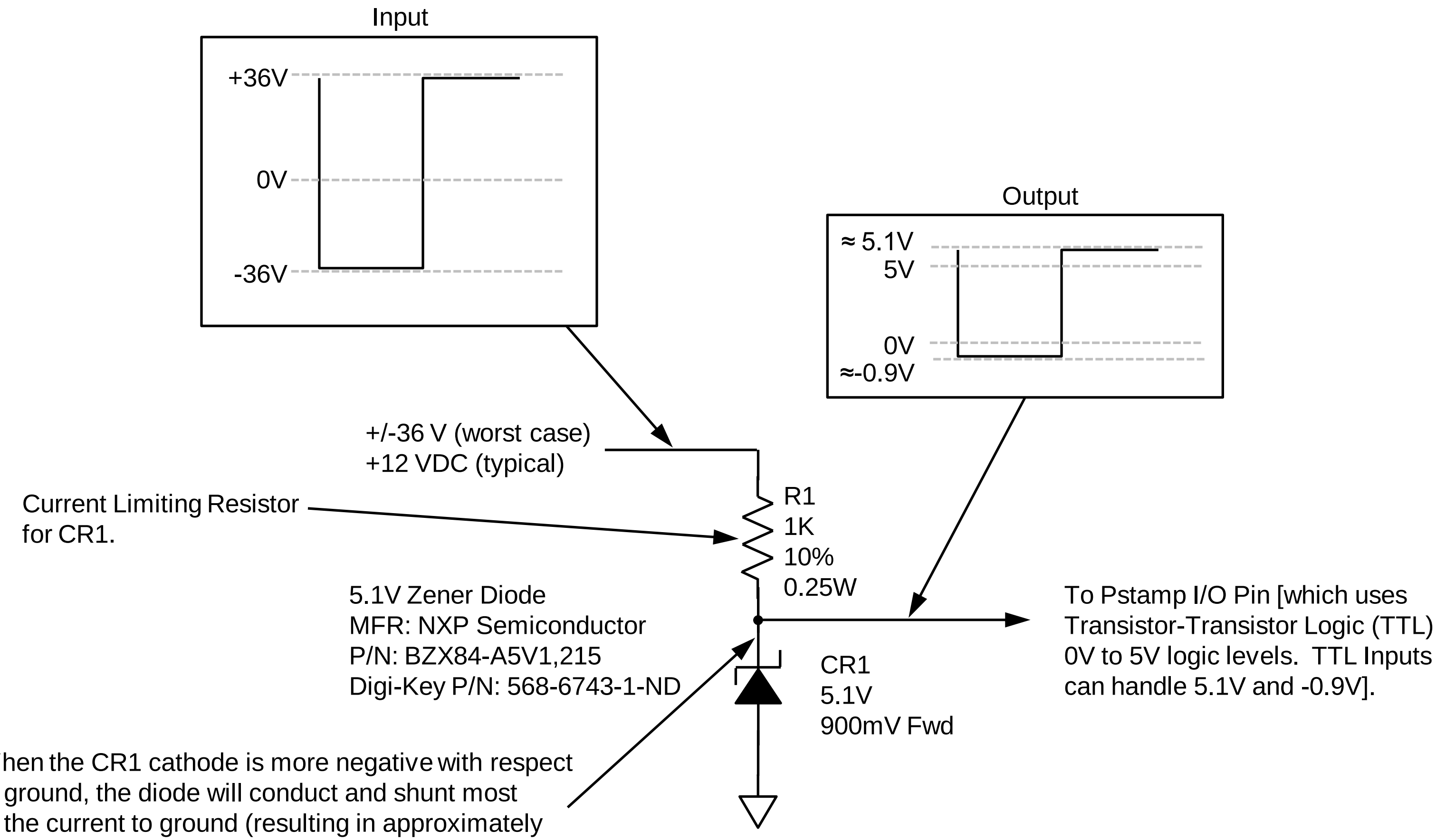
Voltage Limiting for TTL Inputs



When the CR1 cathode is more negative with respect to ground, the diode will conduct and shunt most of the current to ground (resulting in approximately -0.9V worst case to the PStamp I/O pin). When the CR1 cathode is more positive with respect to ground but less than +5.1V, then voltage to the PStamp pin will follow the input signal (resulting in levels between 0V to 5.1V). When the CR1 cathode is greater than 5.1V with respect to ground, then the diode will start to conduct (reversed bias) and shunt current that is proportional to keep no more than 5.1V at the cathode – this is the “Zener” effect and thus acts as a simple voltage regulator (or limiter in this case).