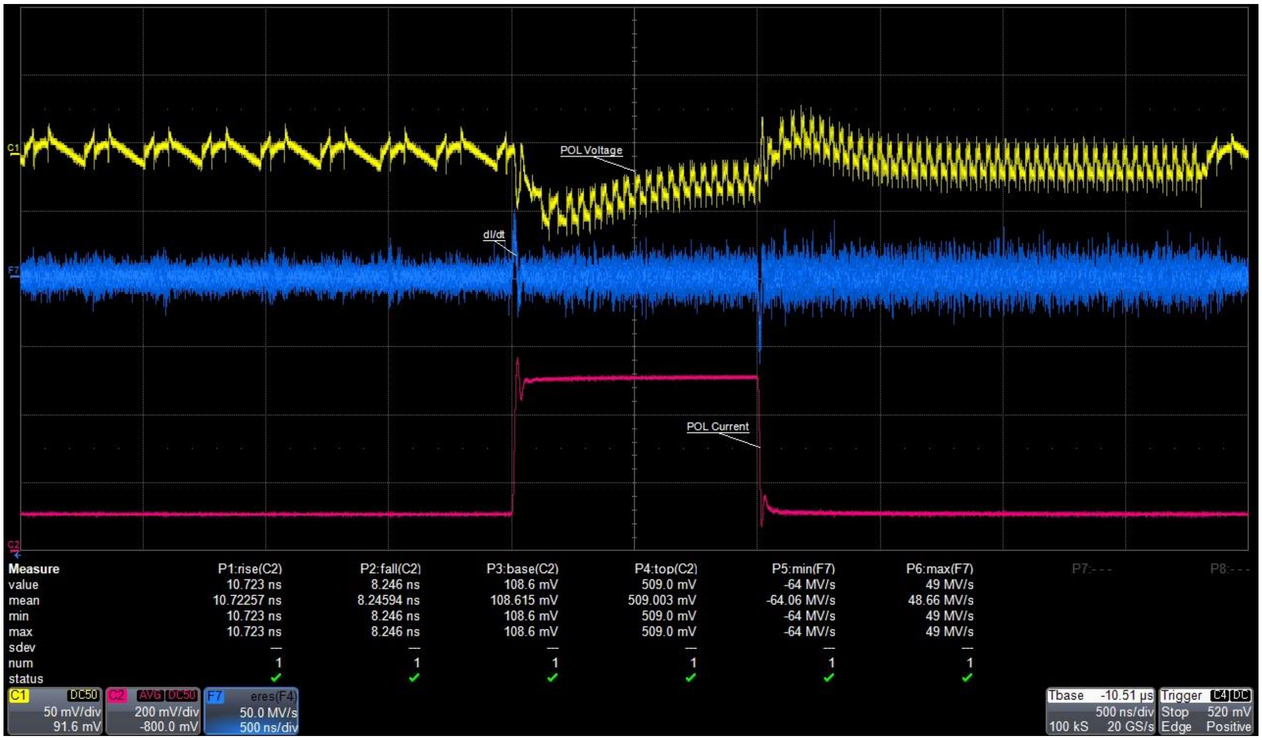
New Injector Supports Testing of POLs

--TheJ2112A - Faster, Non-invasive, and High Fidelity POL Step Load Testing



Summary

Testing the step load performance of Point of Load (POL) regulators and Low Dropout linear regulators (LDOs) requires an electronic load that is non-invasive, easily controlled, has fast edge speeds and is capable of providing large current steps. The new J2112A has these features and supports regulator testing, as well as PDN measurements.

Keywords

Step load, transient load step, high speed, POL, PDN, EVM, electronic load, output impedance, input impedance, transient response, interconnects

Introduction

Testing the step load performance of Point of Load (POL) regulators and Low Dropout linear regulators (LDOs) requires an electronic load that is non-invasive, easily controlled, has fast edge speeds and is capable of providing large current steps.

The J2112A is just such an electronic load. The J2112A is also known as a Current Injector for its ability to sink current. It can provide load steps up to 1Amp, in place of or in parallel with, your existing load circuitry. Depending on the interconnect impedances, the J2112A outperforms most electronic loads with 10nS rise and fall times with a 40MHz repetition rate. This makes it the perfect piece of test equipment for high speed applications, such as POL, FPGA and CPU based power supplies.

Many engineers are already familiar with popular the J2111A Current Injector, which has a step load capability of approximately 100mA and rise and fall times on the order of 25nS. Its wide bandwidth current injection supports output impedance, non-invasive stability and small signal transient load step testing, primarily for switchers, linear regulators, voltage references and opamps.

Like the J2111A, the J2112A is non-invasive, meaning it does not in any way "load" or impact the circuit it is connected to; an essential feature required for ensuring measurement integrity.

The testing of high demand voltage regulators requires higher current capability and higher speed. This is a challenge not only at the semiconductor level, but also at the board level.

In order to obtain a particular rise time, a primary limitation is the test equipment's internal control loop bandwidth. The required control loop bandwidth can be estimated from the desired rise time.

$$\text{Bandwidth}=\frac{1}{\text{Trise}}$$

The control loop bandwidth required to achieve a 10nS rise and fall time is approximately 100MHz. The bandwidth of the J2112A exceeds this.

Another more practical limitation comes from the inductance of the interconnection between the current injector and the regulator being tested. A significant voltage is dropped across the interconnecting inductance, limiting the speed of the load step.

This is a critically important aspect of any test interface, especially one requiring fast large signal step loads.

If we assume the current injector is an ideal switch (i.e. no voltage drop due to saturation voltage or on state resistance and infinite slew rate and we want to test a 1V POL with a rise time of 10nS, we can define the maximum allowable interconnecting inductance, assuming no other contributions or limitations to the rise time:

$$\text{Lmax} = \frac{\text{Vout} * \text{Trise}}{\Delta \text{I}}$$

Achieving a 1Amp pulse in 10nS requires an interconnecting inductance that is a maximum of 10nH. In reality there are other contributions, such as saturation voltage and saturation resistance as discussed below, in addition to the interconnecting inductance, which will generally be greater than 10nH.

Interconnects

The J2112A output connector is a typical BNC and measurements indicate that the inductance is approximately 17nH. Assuming a 6" Tempflex low inductance coaxial cable with a BNC connector on one end to connect to the injector and soldered directly to the POL or LDO on the other end, a typical inductance connection is 36nH. A similar interconnecting inductance is achieved if the POL has a BNC or SMA connector, as well and a short barrel connector is used to connect the J2112A to the POL or LDO.

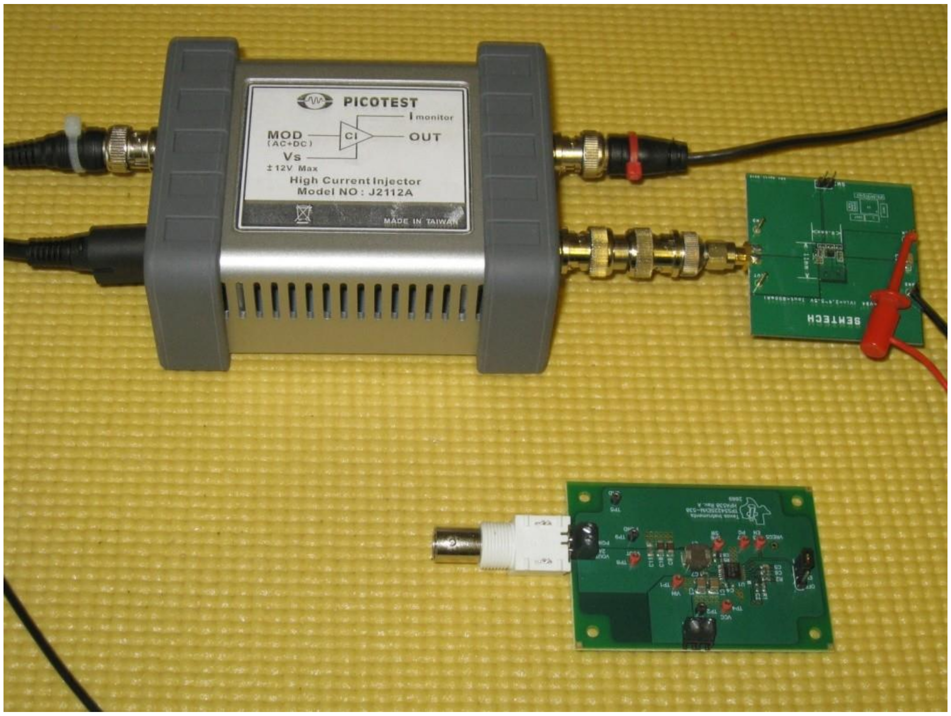


Figure 1, The J2112A Current Injector can be connected to POLs or LDOs using short connections such as BNC or BNC/SMA adapters, as well as with a short BNC Tempflex cable.

Saturation Resistance

The saturation resistance of the J2112A is approximately 675 milliOhms and the saturation voltage can be calculated, based on the operating current, I, as:

$$\mathrm{Vsat} = 0.675 * \mathrm{I}$$

The rise time can more accurately be computed, based on the POL or LDO voltage as:

$$\mathrm{Trise} = \frac{\mathrm{Linterconnect} * \mathrm{I}}{\mathrm{Vout} - 0.675 * \mathrm{I}}$$

Using our very short connections, as shown in Figure 1, we can estimate the interconnect limit on the rise time as a function of the regulator voltage and interconnecting inductance. The rise time will also be limited by the rise time of the external signal generator and the rise time of the J2112A. A typical AWG, such as the Picotest G5100A can produce edge speeds as low as 5nS.

Fastest Rise Time for 32nH Interconnect (nSec)					
I_amps	1V	1P5V	1P8V	2P5V	3P3V
0.035	1.22	0.81	0.67	0.48	0.36
0.1	3.66	2.38	1.97	1.40	1.05
0.25	10.14	6.35	5.19	3.64	2.71
0.5	24.53	14.25	11.39	7.75	5.68
0.7	42.50	22.45	17.50	11.55	8.32
1	104.62	41.21	30.22	18.63	12.95

As an example, a Texas Instruments TPS54225 1V POL regulator was tested with a short interconnect, measured to be approximately 32nH.

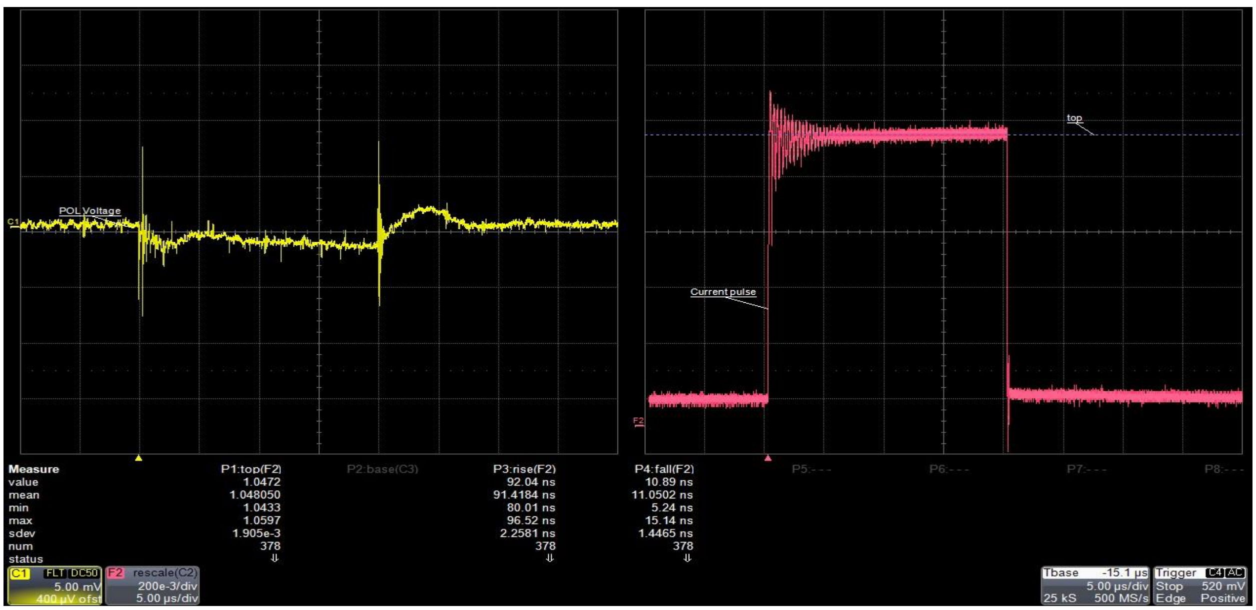


Figure 2, TPS54225 POL with a 32nH interconnect to the J2112A. A 900mA current pulse was achieved in 92nS, consistent with 90% of 104.6nS.

Note that the inductance of the interconnect limits the rising edge, but not the falling edge of the current pulse. The rise time is 92nS and the fall time is 10.9nS.

Another example using a Semtech SC221 1.8V 20MHz POL is shown in Figure 3.

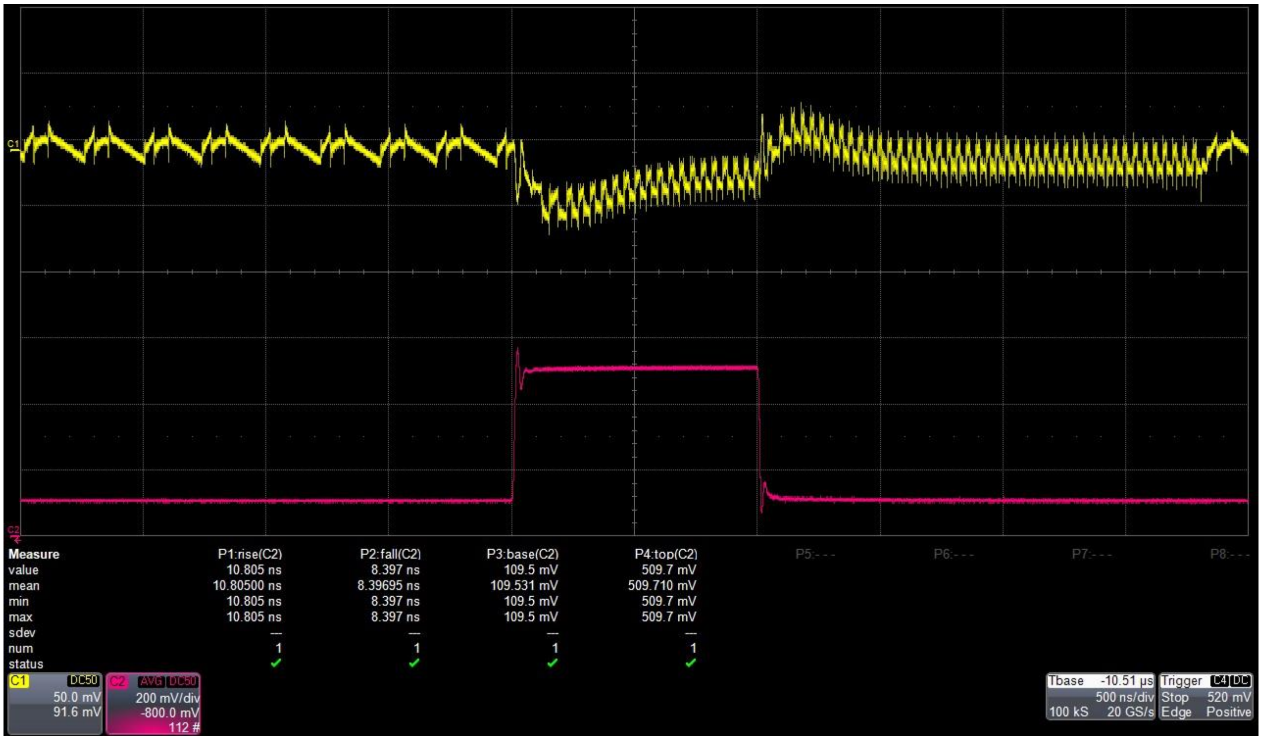


Figure 3, Semtech SC221 1.8V 20MHz POL with a 32nH interconnect to the J2112A achieves a rise time of 10.8nS for a 460mA peak pulse consistent with the 11.4nS expected for a 500mA pulse. (output voltage 200mV/div top, step load current bottom, 500ns/div)

Conclusion

The J2112A Current Injector is an essential tool for evaluating today's high speed POL and LDO regulators, especially in high demand applications. Achieving maximum speed requires careful consideration of the interconnecting inductance to the current injector. The achievable speed will be a function of the regulator voltage, as well as the interconnecting inductance and the amplitude of the current pulse.

It is not possible to use banana jacks or a 50 Ohm coaxial cable with the J2112A as doing so will interfere with the stability of the injector control loop, as well as resulting in excessively slow switching speeds. The J2112A Current Injector, like the J2111A can also be used with a vector network analyzer to measure output impedance and perform non-invasive stability measurements.