

DRAFT V02

Tentlabs Application Note AN.04 - Shunt regulators

This note describes the use of Tentlabs the shunts. It shows how:

- they work in general
- to connect them in new and existing designs

Finally an FAQ is added to help trouble shooting, and the specifications are listed for reference.

Shunts - general

Shunt regulators always consist of a current source and a shunt element. The current source supplies a constant current, and the shunting element shorts (part) of that current to ground, such that a certain output voltage is the result. The remainder part of the current is thus supplied to the circuit.

Since the current source has high output impedance and the shunting element low impedance, the noise from the power supply is highly attenuated, over a wide bandwidth.

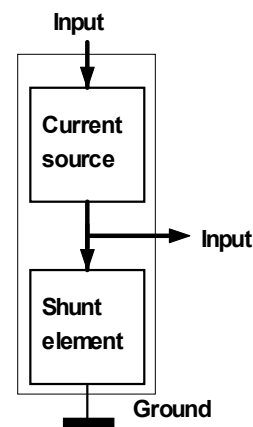
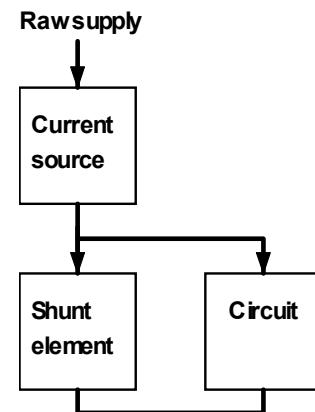
Another advantage is that the circuit currents run in a small loop containing the shunt element and the circuit itself. Assumed that the shunt is placed closed to the circuit, and wired correctly, the PCB earth plane currents are greatly reduced as well, yielding reductions in induced jitter in digital circuits, for example.

Finally, shunts are short circuit proof at their outputs.

The Tentlabs shunts have the current source and shunting element integrated on a small board. The external connections are:

- Input
- Ground
- Output

The current source is a active circuit which reveals a very high output impedance over the whole shunt bandwidth. The active shunt element provides a low (few tens of $m\Omega$) output impedance at the output.



Contrary to commonly used voltage regulators, like 7805 and LM317 types, a shunt *always* draws (a very constant) current from its' input. When no output current is drawn, all current is shunted. Now the shunt dissipates most energy. When the circuit draws all available current, only the current source dissipates energy, the shunt element does not. However, for proper operation, the shunting element should always draw some current, in order to operate and maintain specifications. Therefore the maximum output currents of the shunts are specified (see specifications).

Application

- General

The shunts are intended to supply opamps and or discrete circuits in output stages, and various digital / mixed signal chips. Another interesting application is the supply of [Tentlabs low jitter clock oscillator for CD player upgrades](#).

The shunts are *not suited* to supply power applications like output amplifiers, as the available current is not sufficient.

Shunts are available for both positive and negative supplies, and have a fixed output voltage.

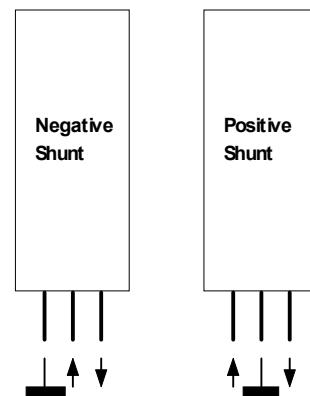
Since the output current of the shunts is limited, always check (measure or consult datasheet) the current consumption of the circuit(s) to be supplied, before installation of a shunt.

- Connections

The I/O connections for the shunts are shown right:

Please note that their connections *differ* !

Component sides shown



Input voltage requirements

The shunts are kept as small as possible, to facilitate a variety of applications. A drawback is the absence of heatsinks, hence dissipation is limited. Therefore the input voltage should be more or less optimized. The following input voltage ranges are recommended:

3.3V: 7 to 10V

5V: 8 to 12V

15V: 18 to 23V

In case the available input voltage exceeds the above specification, a resistor can be placed in series with the shunt input. The voltage drop across this resistor is constant, since the shunt draws a constant input current. A provision has been made to place this resistor at the back of the shunt, but it can also be placed elsewhere. It will not affect the performance. The calculation of the resistor is as following:

3.3V: 6.4Ω per V to be dropped

5V: 7.2Ω per V to be dropped

15V: 17.2Ω per V to be dropped

For both positive and negative version equal calculations shall be applied. Calculate the values and round down to the nearest E12 value.

Example:

A 5V regulator needs to be fed from 12V raw supply. We choose the final voltage should end up at 9V so we need to drop 3V; a resistor of $3 \times 7.2\Omega$ is needed. A 22Ω resistor will do fine. Use a 3W carbon or metal type resistor.

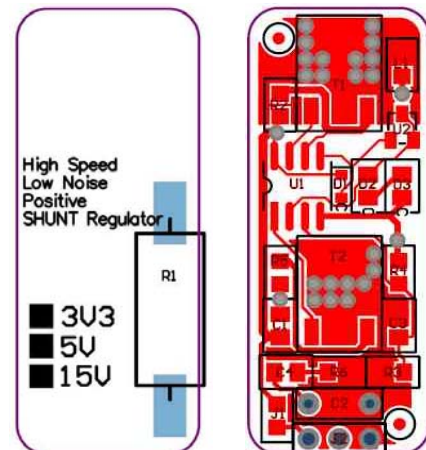
Placement of dropper on shunt PCB

The dropper is placed at position R1

Prior to placing the dropper resistor at the back of the shunt, the 0 ohm resistor at J1 should be removed. J1 is at the SMD side, in the lower left corner (right drawing).

Placement of dropper elsewhere

In case the dropper is not placed at position R1, but placed elsewhere, jumper J1 should *not* be removed.



In any case, the raw supply should never exceed 36V, regardless of any dropper resistor in front.

Lastly, always check the actual shunt input voltage to see if it matches with the range given above.

- Input voltage ripple

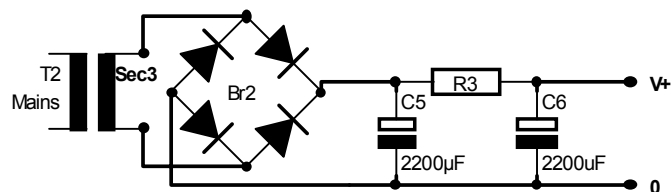
When the input voltage ripple is high, the momentary value of the input can be too low, resulting in output ripple. It is advised to supply the shunt with a voltage containing a ripple < 1V. Lower input ripple is always better. This can be obtained by:

- 1 – Feeding the shunts from a standard voltage regulator
- 2 – Feeding the shunts with a dedicated transformer / rectifier / filter

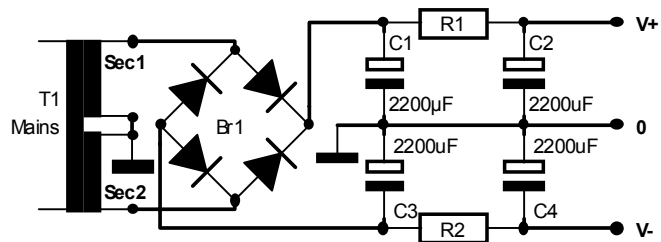
1 – The voltage regulator should supply an output voltage that matches the input requirements of the shunt. The voltage regulator can be placed anywhere, so the shunt can always be placed closest to the circuit to be supplied.

2 – A typical separate supply circuit could look like:

Single supply



Dual supply



Whereas the filtering resistors R1, R2 and R3 may serve as dropper resistors, instead of the resistors placed at the shunts themselves, and are calculated the same way. We recommend Schottky diodes for B1 and B2.

Output voltages for T1 and T2 on the shunts used, but typically are:

Shunt version	3V3dc	5Vdc	15Vdc
Secondary 1, 2, 3	6Vac	9Vac	15Vac

The transformer power depends on the number of shunts to be supplied, one should take care of the following current consumption (DC, per shunt):

Shunt version	3V3dc	5Vdc	15Vdc
Current (each shunt)	155mAdc	138mAdc	58mAdc

Capacitors C1 to C6 should be able to handle the minimum working voltage:

Secondary	6Vac	9Vac	15Vac
Capacitor voltage (min)	10Vdc	16Vdc	25Vdc

The total transformer power can be calculated by summing all consumption and taking a factor of 1.5 into account.

Example 1:

A +5V and -5V shunt are fed from 1 transformer. $2*9V*0.138*1.5 = 3.78VA$

Example 2:

A +5V and +3.3V shunt are fed from 1 transformer. $1*9V*(0.138+0.155)*1.5 = 3.95VA$

Example 3:

Two of each +15V and -15V shunt are fed from 1 transformer.
 $2*2*15V*0.08*1.5 = 5.22VA$

Always round the calculated power up to the next transformer value available

- Input capacitor

An input capacitor of 10uF/40V can be placed close to the input of the shunt. Connect it between input and ground and watch polarity.

- Output capacitor

An output capacitor is integrated on the shunt, and no additional external decoupling is required, in the case the shunt is placed close to the circuit. If that is not possible, it is advised to connect the shunt using a ferrite bead in the output, and a local decoupling close to the circuit as possible, see also:

- Decoupling notes

Advise and hints on [Supply decoupling](#)

- Location of shunts

If possible, place the shunt regulators as close as possible to the circuit or chip supply pins.

- Wiring

Wire the shunt output and ground connection directly to the supply pins of the circuit, as if the shunt were a decoupling capacitor. As such, the supply currents run exactly through these wires, and we avoid currents through the ground plane / wiring of the existing application.

- Heat and temperature

Shunts always dissipate, so they run hot. External current consumption reduces the dissipation. Anyhow, the Tentlabs shunts may run that hot, that the PCB temperature reaches 60°C. Although it may feel a bit frightening, the units are designed to withstand this temperature

FAQ

- No or too low output voltage

Q: I checked the output voltage and it is below specification

A: The input voltage is too low, or

A: The current consumption of the circuit exceeds the shunt specification

A: The shunt is not wired correctly, check pinning

- No LED burning

Q: When I switch on the application, the LED on the shunts is not visible

A: The input voltage is not present, or too low

- Ripple in shunt output voltage

Q: I checked the output using an oscilloscope, and saw a ripple

A: It is very likely that the input voltage is too low, or excessive ripple is present at the raw supply. Increase input voltage and or decoupling capacitance.

Specifications Electrical

Supply input ranges:

3.3V: 7 to 10V

5V: 8 to 12V

15V: 18 to 23V

When the input voltage exceeds above specification, a series resistor should be placed at the back of the regulator, see this application note for suitable values.

Output voltage: within +/- 5% of specification

Bandwidth: DC to 250kHz (all versions)

Typical performance parameters

	Output noise [nVSqrrtHz]	Output current max [mA]	Supply current [mA] nominal	Output impedance [mΩ]
3.3V	70	100	155	tbd
5V	50	80	138	tbd
15V	120	30	58	tbd

Notes

- The output impedance is specified over the entire bandwidth
- Output capacitor integrated (100nF Wima MKS02)
- All versions are short circuit proof at their outputs

Mechanical

Size: 15*35*8 mm³

Weight: 5 gram

Mounting: 3 pin header

Mounting pitch: 2.54 mm

All specs and parameters subject to change without prior notice.