Power supply circuit for sap flow probes (TDP system)

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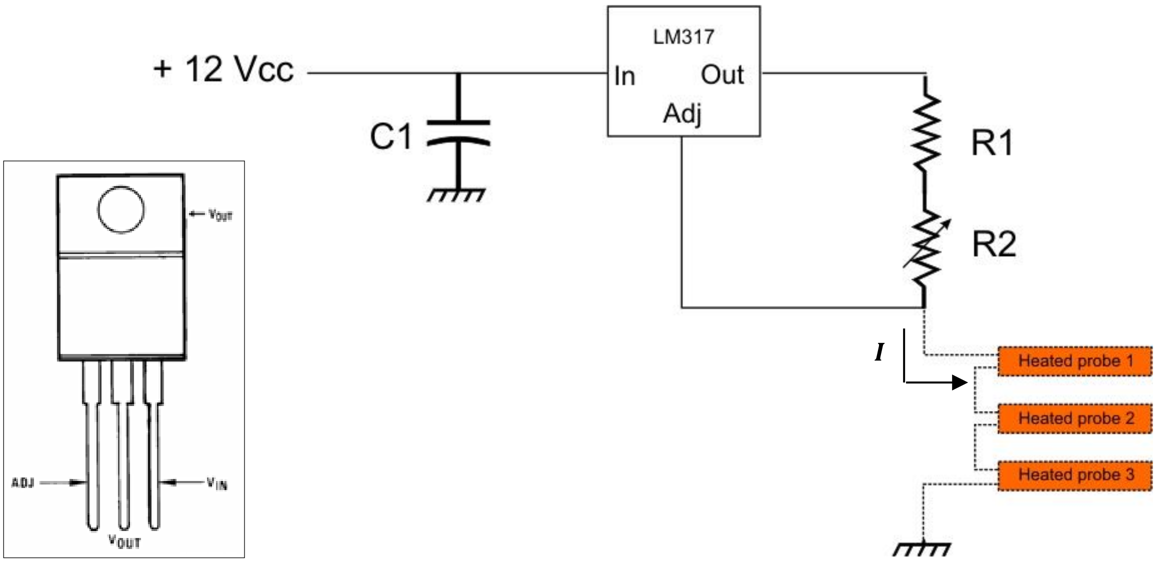
In this note a very simple circuit to powering the TDP probes is proposed.
According to IC LM317 characteristics, the output current is equal to $\frac{1.25}{R1+R2}$, therefore with the following configuration the possible output range is about 75 ÷ 180 *mA.*

The required power (P) is 0.2 *W* for 2 cm long probe and 0.1 *W* for 1 cm probe. Knowing the coils resistance (R) (the heated part of probe), $R2$ must be regulated in order to get a current equal to: $I = (\frac{P}{R})^{0.5}$.



R1 = 6.8 Ω (0.33 W), R2 = 10 Ω variable (0.33 W), C1 = 0.1 μF ceramic disk or 1 μF solid tantalum

Operation limits

LM317 has a maximum dropout voltage* of about 3 V, that means probes can supplied with a real power of:
$P = V\,I = (V_{IN} - 3)\,I$. In other words, this value must be equal to: $Rtot\,I^2$, with $Rtot$ the total load resistance (probes + cables). If less, probes wouldn't be supplied with the required power.

These considerations are important to assess the maximum length of elongation cables. Considering that minimun voltage battery of 12 V, the real IC output voltage is 12 – DropOut Voltage = 9 V. It means that the total resistance $Rtot$ (cables + probes) must be $Rtot \leq \frac{V}{I} \leq \frac{9}{I}$, con I the current used to powering the probes.
Therefore, knowing the specific resistance of elongation cables (Rsc, *Ω/m*), the IC voltage output V, the current supply and total probes resistance, the cumulated length L *(m)* of cables will be:

$$L \leq (\frac{V}{I} - R_{probes})/R_{sc}$$

Total consumed power: although some papers report that is $R_{probses}\,I^2$, the real consumption is independent from the numbers of probes and it is $V_{battery}\,I$. A part of this power is used by the probes ($R_{tot}\,I^2$) and the rest is dissipated by LM317 (heat emission).

Some considerations about the circuit

An input bypass capacitor (C1) is recommended. A 0.1 *μF* disc or 1 *μF* solid tantalum on the input is suitable input bypassing for almost all applications.
In general, the best type of capacitors to use are solid tantalum. Solid tantalum capacitors have low impedance even at high frequencies. Depending upon capacitor construction, it takes about 25 *μF* in aluminium electrolytic to equal 1 *μF* solid tantalum at high frequencies. Ceramic capacitors are also good at high frequencies; but some types have a large decrease in capacitance at frequencies around 0.5 *MHz.*
As the circuit is a current regulator and the load doesn't have a high capacitance, no output capacitors are needed.
The adjustment terminal maight be bypassed to ground on the LM117 to improve ripple rejection. This bypass capacitor prevents ripple from being amplified as the output voltage is increased. With a 10 *μF* bypass capacitor 80 *dB* ripple rejection is obtainable at any output level.
If the bypass capacitor is used, it would be better to include a protection diodes to prevent the capacitor from discharging through internal low current paths and damaging the device.
As there aren't any output capacitors and load doesn't have any capacitance, LM317 doesn't need of a diode protection.
A diode between In and Out terminals could be insert to prevent C1 spike, but it's not so important when the input voltage and C1 capacitance are respectively lower than 25V and 10 *μF*.

(*) LM1117IDT-ADJ has a maximum dropout voltage of 1.2 V, but the maximum input voltage cannot exceed 15 V.

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