

Basic Electronics for Amateur Radio

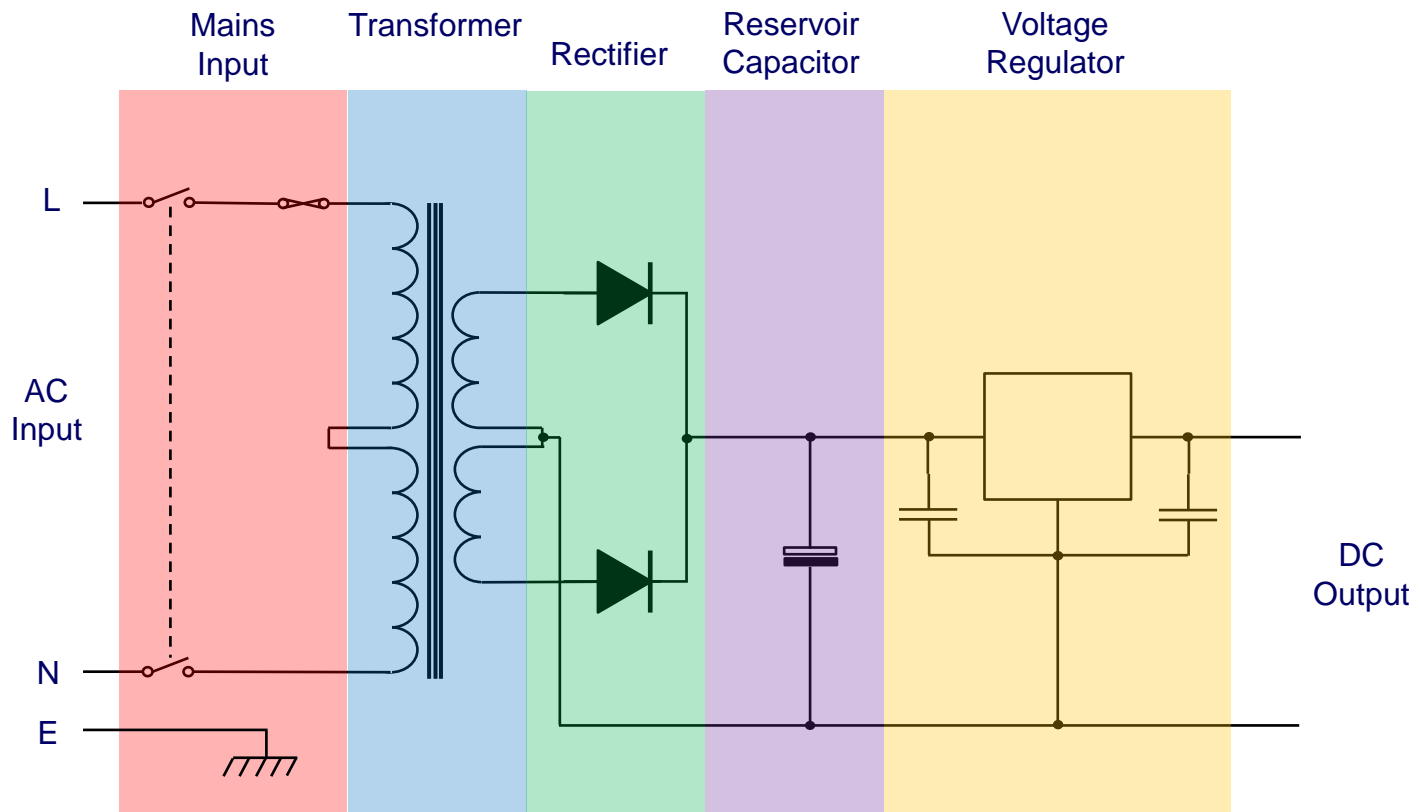
Simple Power Supplies

by

Jim Butler GM3ZMA

Introduction

We will discuss the design of a simple fixed voltage power supply as may be used to power accessories in the radio shack, or a simple circuit under test.

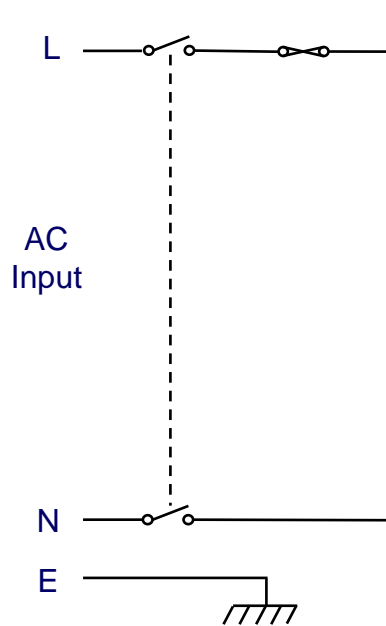


Mains Input

The incoming mains supply Line and Neutral wires connect to a suitably rated double pole switch.

Where the mains cable enters the unit it should pass through a correctly sized gromet or a cable gland.

Alternatively an IEC C14 type connector may be mounted to the chassis.



A correctly rated fuse should be installed in the Line (Live) wire.

The Neutral line should not be fused.

The earth lead should be securely attached to metal case of the unit.

IEC Mains Connectors

Basic Connector



Connector with
EMC Filter



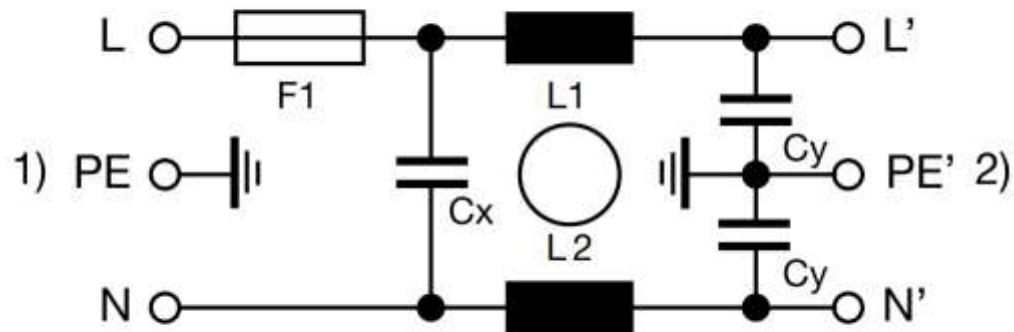
Connector with EMC Filter, switch and fuse



Mains filter – Datasheet 1

Schematic – Schurter Type 5200 datasheet, page 4

5200 Standard Version



- 1) Line
- 2) Load

Mains filter – Datasheet 2

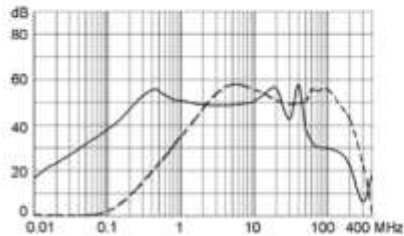
Attenuation graphs – Schurter Type 5200 datasheet, page 4

Attenuation Loss

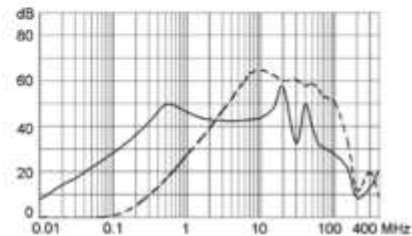
Standard version

----- 50Ω differential mode _____ 50Ω common mode

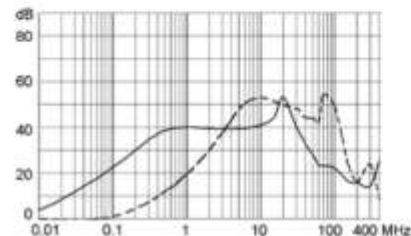
1 A



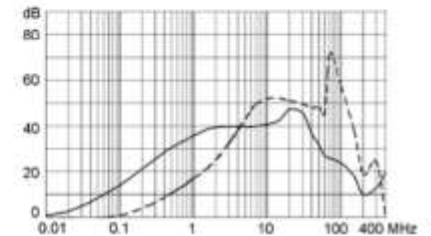
2 A



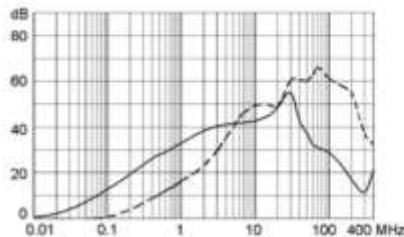
4 A



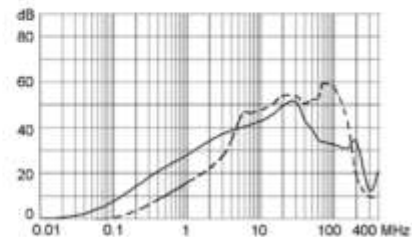
6 A



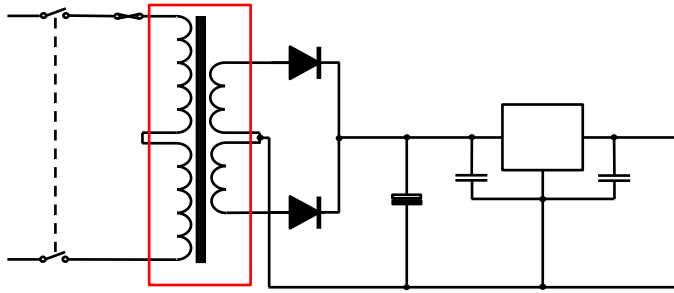
8 A



10 A



The Transformer - 1



The transformer takes the incoming mains supply and transforms it to a low voltage which is isolated from the 240v mains (ie safer).

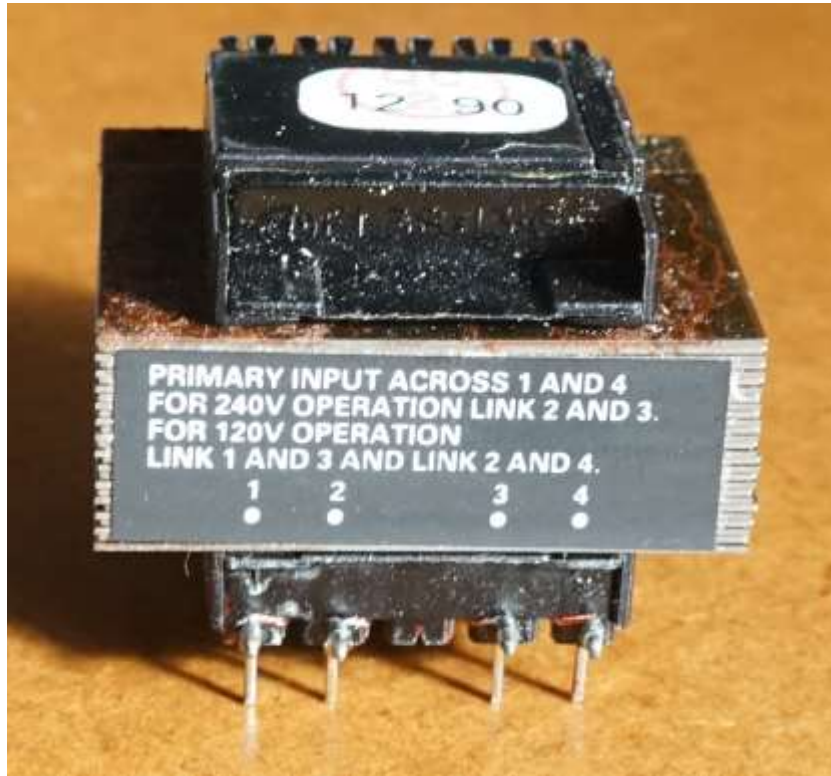
The value of the low voltage will depend on the desired output voltage from our PSU.

The physical size of the transformer will depend on its “power” rating.

Transformers are usually rated in **VA (Volt.Amperes)** ie the product of their output voltage and current, rather than **Watts**.

Transformers can have one or sometimes two **primary windings**, where the incoming mains is connected, and one or more **secondary windings** from where the output is connected to the low voltage circuits.

The Transformer - 2



This small (3VA) transformer has two 120V primary windings, which may be wired in series for 240V operation, or in parallel for 120V operation.

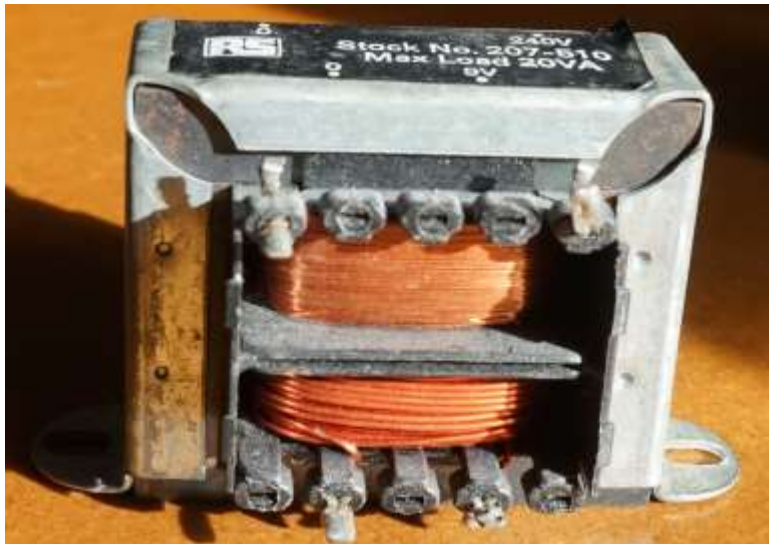
The two 6V secondary windings may be wired in parallel to supply 6V at 0.5A, or in series to supply 12V at 0.25A.

The Transformer - 3



A 12VA transformer, two 120V primary windings, wired parallel for 120V or series for 240V.

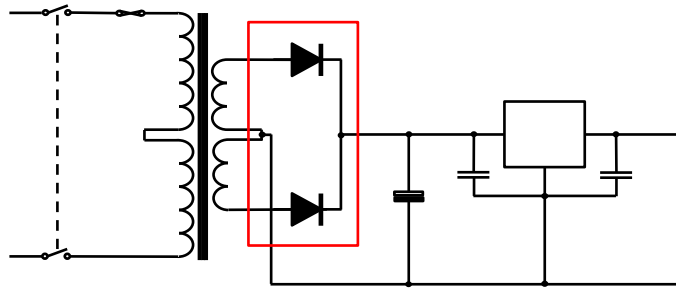
Two 9V 6VA secondaries may be wired in series for 18V at up to $(12VA)/(18V) = 0.66A$, or, wired in parallel for 9V at up to $(12VA)/(9V) = 1.3A$



This 20VA transformer has:
one 240V primary winding (thin wire)
and
one 9V secondary winding (thick wire).

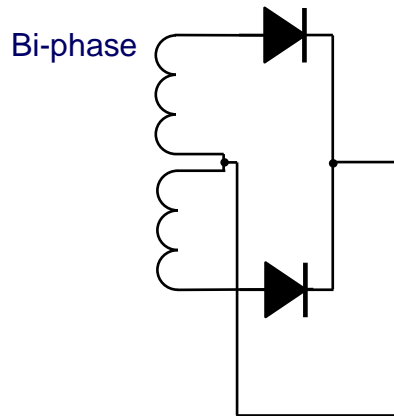
The secondary current may be up to $(20VA)/(9V) = 2.2A$

The Rectifier



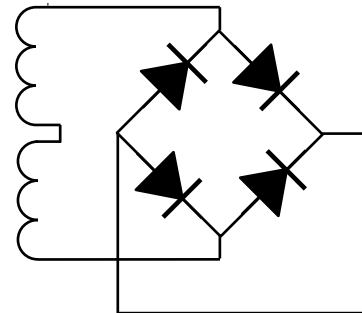
The rectifier converts the AC from the transformer to a pulsating DC waveform.
The rectifier types shown here are full-wave rectifiers, ie they use both cycles of the AC waveform.

The bi-phase rectifier uses only two diodes, but requires a transformer with a centre-tapped secondary winding, or two secondary windings connected in series.

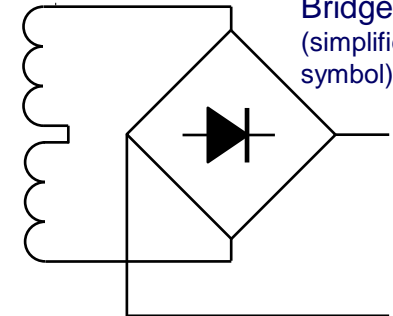


The bridge rectifier uses four diodes, but may use a transformer without a centre-tapped secondary winding.

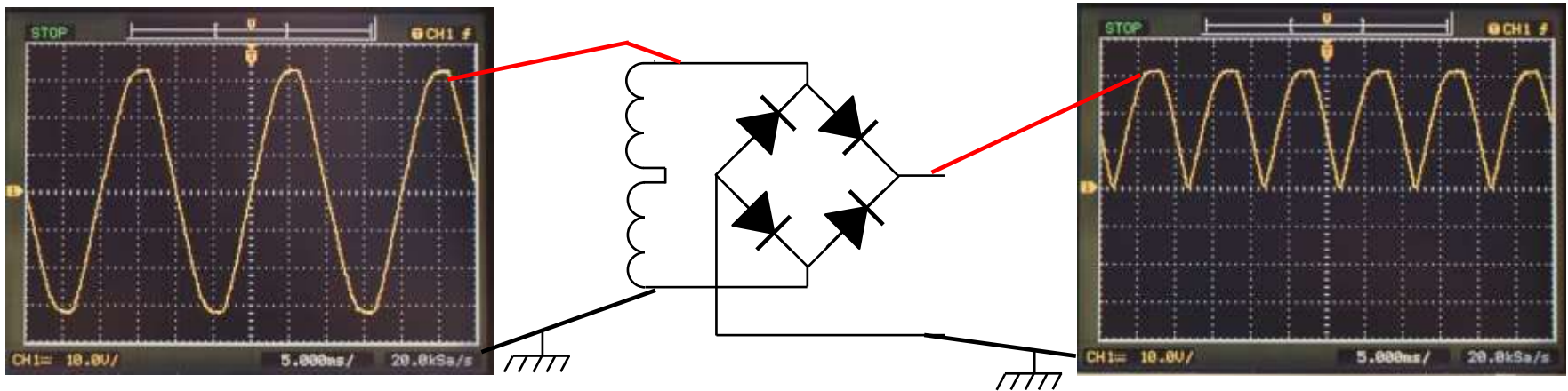
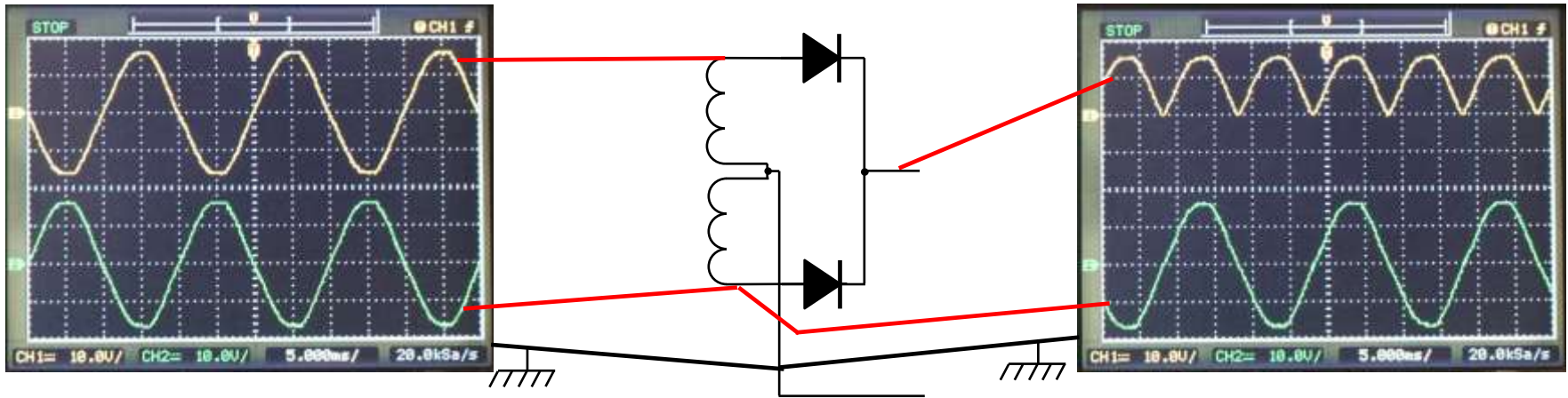
Bridge



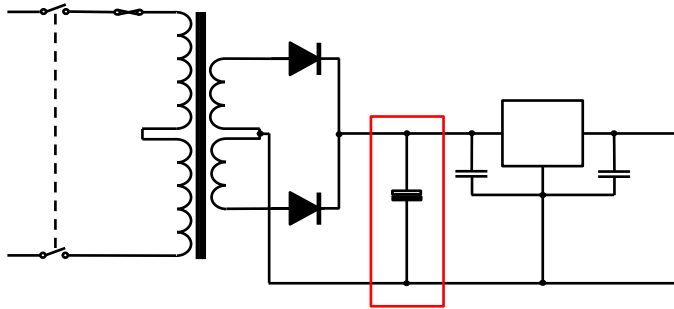
Bridge
(simplified
symbol)



The Rectifier – On the Oscilloscope



The Reservoir Capacitor - 1



The reservoir capacitor smooths the rectified AC from the rectifier.

The capacitance required depends on:
The maximum current which will be drawn from the rectifier
The ripple frequency
The maximum ripple voltage which can be tolerated.

We can calculate the required value of the reservoir capacitor using the formula:

$$C = \frac{(I_L \times t)}{V_{rip}}$$

Where

C is the capacitance in Farads

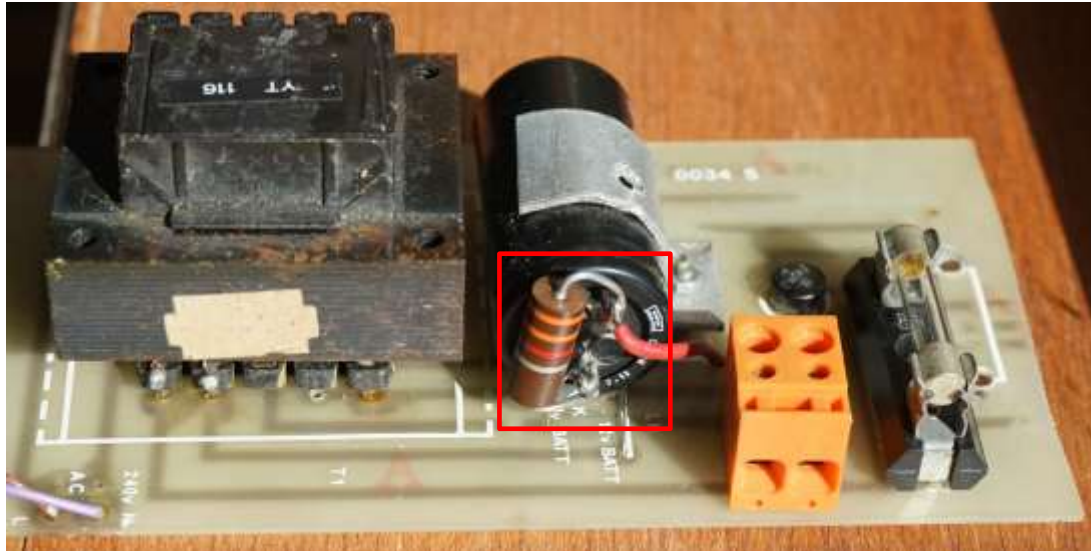
I_L is the load current in Amperes

t is the period of the ripple in seconds

V_{rip} is the peak to peak ripple in Volts

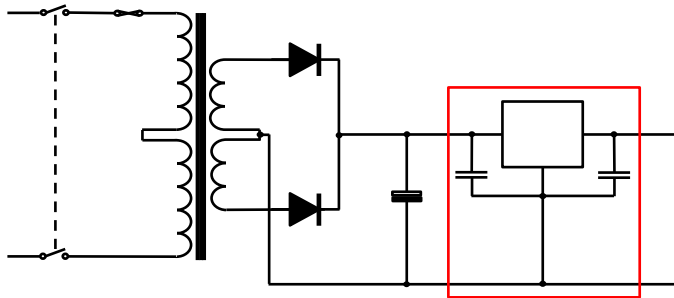
The Reservoir Capacitor - 2

Depending on the circuit, a capacitor can hold a charge for a long time, so it is desirable to install a “bleeder resistor” in parallel with the reservoir capacitor in order to discharge the capacitor when the PSU is disconnected from the mains and unused. This can prevent unpleasant surprises when working on a circuit which is assumed to be “dead”.



Bleeder resistors are essential on high voltage PSU as used with valved equipment.

The Voltage Regulator - 1



As the load current increases, the output voltage from the reservoir capacitor reduces, and the ripple voltage increases.

For some applications this may be acceptable, but where a constant voltage ripple free supply is required, a voltage regulator is used.

Some voltage regulators can be quite complicated, built using many discrete components.

However simple to use “Three Terminal Regulators” are available in a range of useful output voltages and currents.

78xx Series

Up to 1 amp output current

78Lxx Series

Up to 100 mA output current

LM350

Up to 3amp output current

Variable voltage

Expensive!



STMicroelectronics
L7805ACV, 1 Linear
Voltage, Voltage
Regulator 1A, 5 V 3-Pin,
TO-220

RS Stock No.: 298-8508
Mfr. Part No.: L7805ACV

Datasheets:



STMicroelectronics
L78L05ACZTR, 1 Linear
Voltage, Voltage
Regulator 100mA, 5 V 3-
Pin, TO-92

RS Stock No.: 714-7768
Mfr. Part No.: L78L05ACZTR

Datasheets:



Texas Instruments
LM350K STEEL/NOPB , 1
Linear Voltage, Voltage
Regulator 3A, 1.2 → 33 V
3-Pin, TO-3

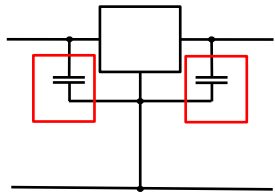
RS Stock No.: 663-3244
Mfr. Part No.: LM350K STEEL/NOPB
No.:

Datasheets:

The Voltage Regulator - 2

The part number of most three terminal regulators indicates the output voltage:

7805	78L05	5 volts
7809	78L09	9 volts
7812	78L12	12 volts
7815	78L15	15 volts
7833	78L33	3.3 volts



The small capacitors on the input and output of the regulator are important, if these are not fitted the regulator circuit can oscillate under some conditions.



A volt or so of 300kHz ripple on the output is not a good idea.



STMicroelectronics
L7805ACV, 1 Linear
Voltage, Voltage
Regulator 1A, 5 V 3-Pin,
TO-220

RS Stock No.: 298-8508

Mfr. Part No.: L7805ACV

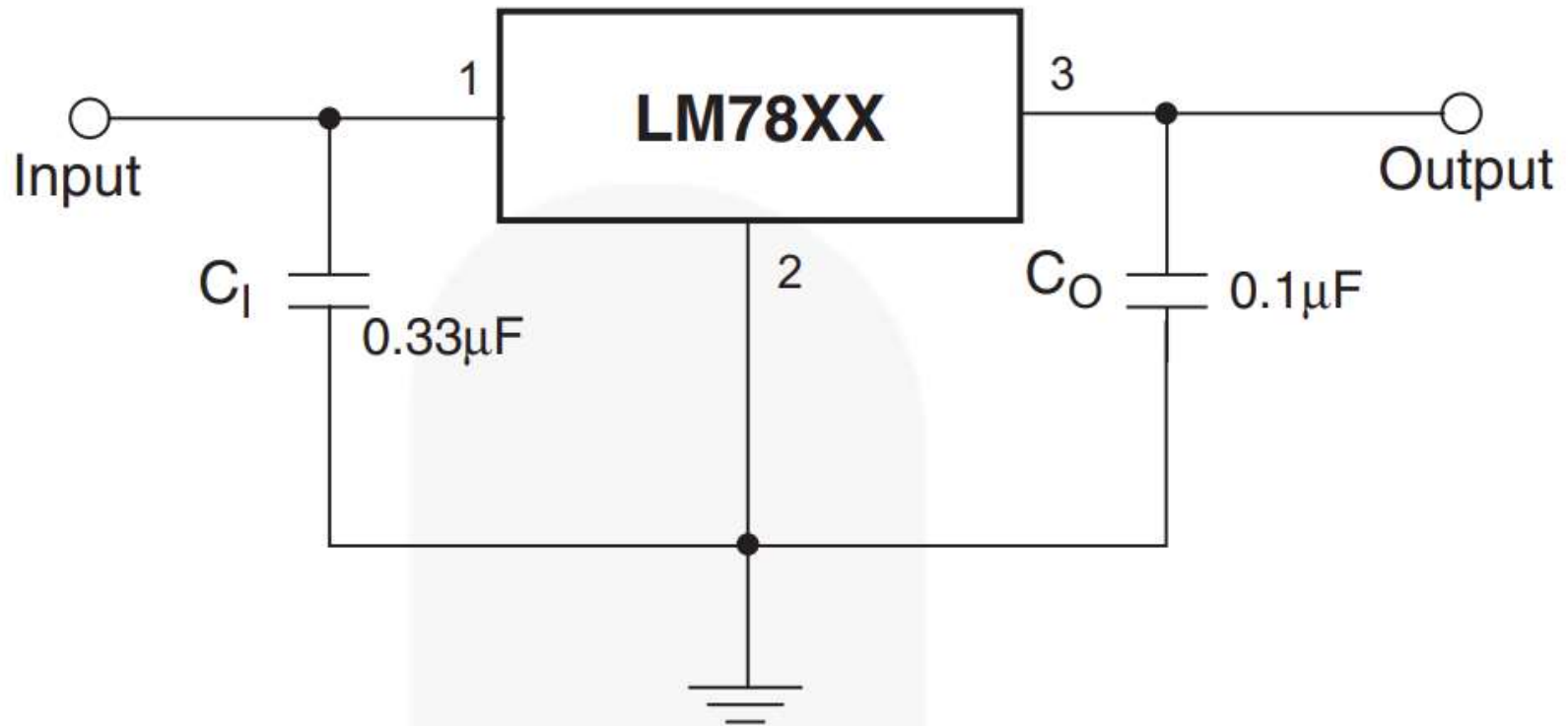
Datasheets:  

If you have any questions about a regulator (or any electronic device), read the datasheet.

Available in many places on the internet.
In this case in the RS Components website

LM7805/LM7812 Basic application circuit

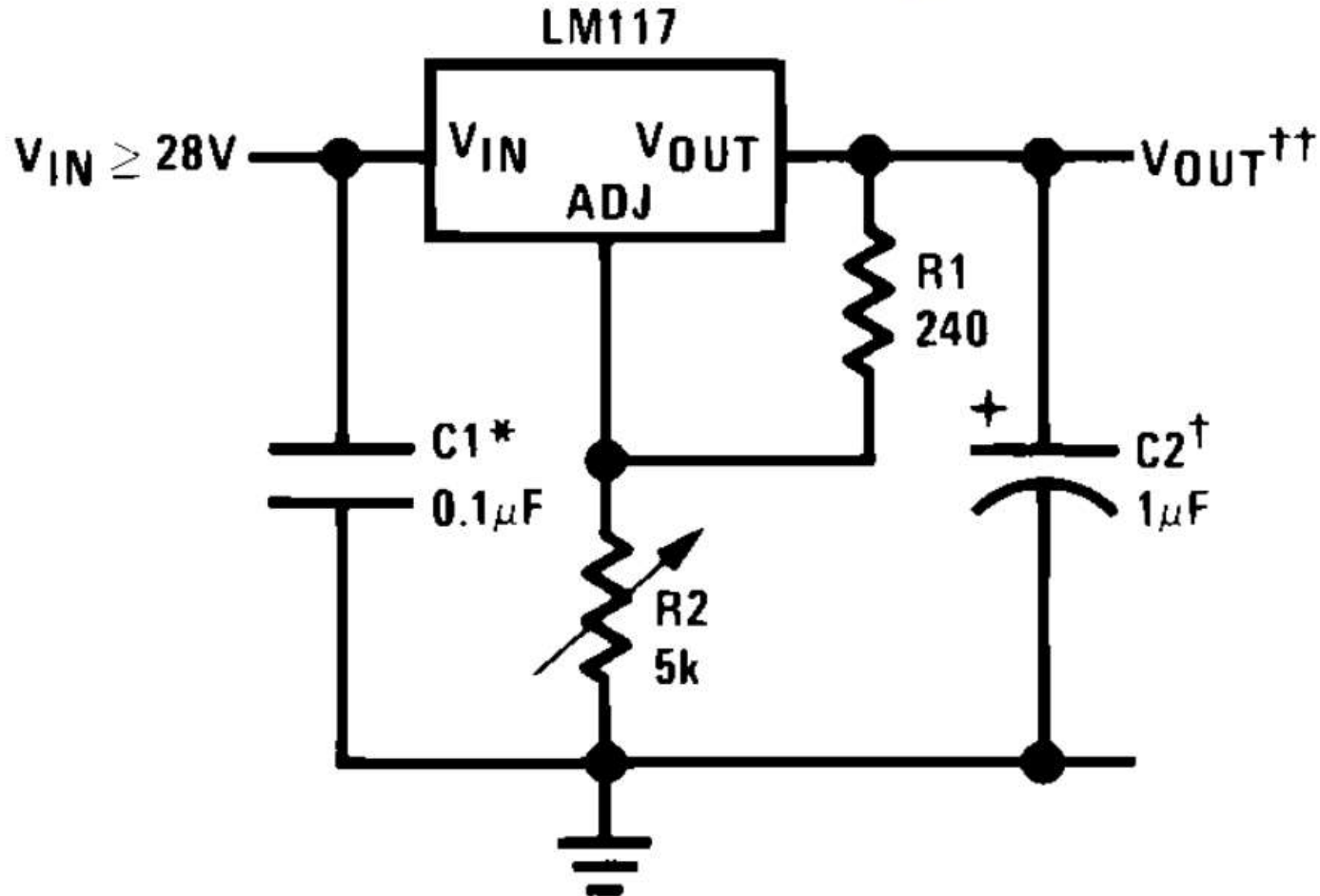
From manufacturers datasheet.



LM317 Basic application circuit

From manufacturers datasheet.

1.2V–25V Adjustable Regulator



The Heatsink - 1

Linear voltage regulators can become very hot during normal operation.

Consider a 7812 with an input of 20 volts,
delivering an output current of 500mA.

It will dissipate $(20 - 12) \times 0.5 = 4$ Watts of power.

This will make it very hot and it will be damaged quite quickly.



Attaching the regulator to a heatsink, such as those shown here will lower the temperature of the regulator to a reasonable value.

Or...

The Heatsink - 2

The regulator may be affixed to the metal chassis of the equipment, as shown in this power supply:



Note that the 7912 (second from right) is insulated from the chassis using a mica washer. The 79xx series are negative voltage regulators and the mounting tab connects to the input from the reservoir capacitor, and must be isolated from the chassis (0v).

What is missing from this PSU?
There are no capacitors adjacent to the regulator terminals.
And, yes, one of the regulators does oscillate.

The End