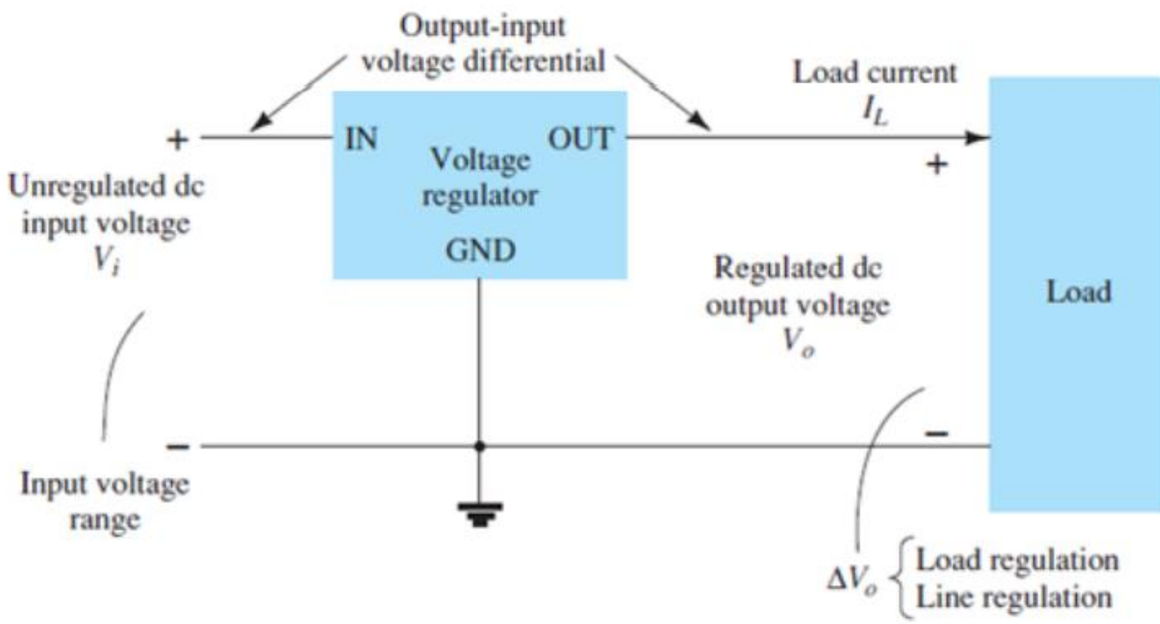
Al-Mustaqbal University College
Department of Medical Instrumentation Techniques Engineering
Class: Three
Subject: Medical electronic system
Lecturer: Dr. zahraa hashim kareem
Lecture-5: Switching regulator

Switching Regulation

A type of regulator circuit that is quite popular for its efficient transfer of power to the load is the switching regulator. Basically, a switching regulator passes voltage to the load in pulses, which are then filtered to provide a smooth dc voltage. Figure shows the basic components of such a voltage regulator. The added circuit complexity is well worth the improved operating efficiency obtained.



Block representation of three-terminal voltage regulator.

IC VOLTAGE REGULATORS :Voltage regulators comprise

a class of widely used ICs. Regulator IC units contain the circuitry for reference source, comparator amplifier, control device, and overload protection all in a single IC. Although the internal construction of the IC is somewhat different from that described for discrete voltage regulator circuits, the external operation is much the same. IC units provide regulation of either a fixed positive voltage, a fixed negative voltage, or an adjustable set voltage.

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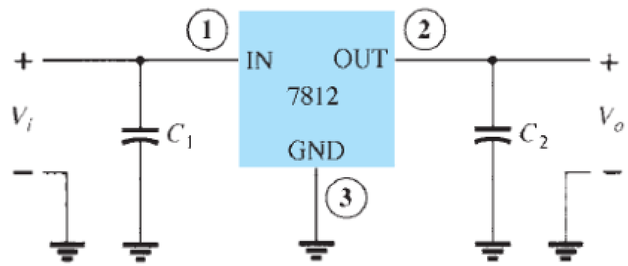
Fixed-Positive-Voltage Regulators

The series 78 regulators provide fixed regulated voltages from 5 V to 24 V. Figure shows how one such IC, a 7812, is connected to provide voltage regulation with output from this unit of +12 V dc. An unregulated input voltage V_i is filtered by capacitor C_1 and connected to the IC's IN terminal. The IC's OUT terminal provides a regulated +12 V, which is filtered by capacitor C_2 (mostly for any high-frequency noise). The third IC terminal is connected to ground (GND). Whereas the input voltage may vary over some permissible



Connection of a 7812 voltage regulator.

Positive-Voltage Regulators in the 7800 Series

IC Part	Output Voltage (V)	Minimum V_i (V)
7805	+5	7.3
7806	+6	8.3
7808	+8	10.5
7810	+10	12.5
7812	+12	14.6
7815	+15	17.7
7818	+18	21.0
7824	+24	27.1

Fixed-Negative-Voltage Regulators

The series 7900 ICs provide negative-voltage regulators, similar to those providing positive voltages. A list of negative-voltage regulator ICs is provided in Table As shown, IC regulators are available for a range of fixed negative voltages, the selected IC providing the rated output voltage as long as the input voltage is maintained greater than the minimum input value. For example, the 7912 provides an output of −12 V as long as the input to the regulator IC is more negative than −14.6 V.

Negative-Voltage Regulators in 7900 Series

IC Part	Output Voltage (V)	Minimum V_i (V)
7905	−5	−7.3
7906	−6	−8.4
7908	−8	−10.5
7909	−9	−11.5
7912	−12	−14.6
7915	−15	−17.7
7918	−18	−20.8
7924	−24	−27.1

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EXAMPLE Draw a voltage supply using a full-wave bridge rectifier, capacitor filter, and IC regulator to provide an output of +5 V.

Solution: The resulting circuit is shown in Fig.

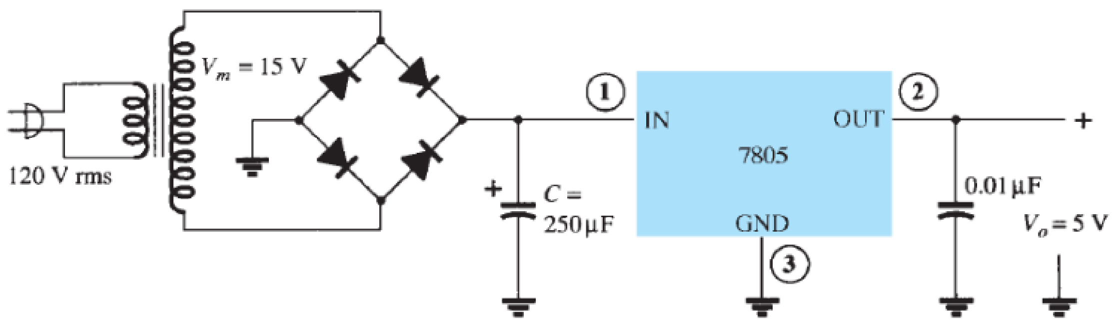

FIG.
A +5-V power supply.

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حفظ

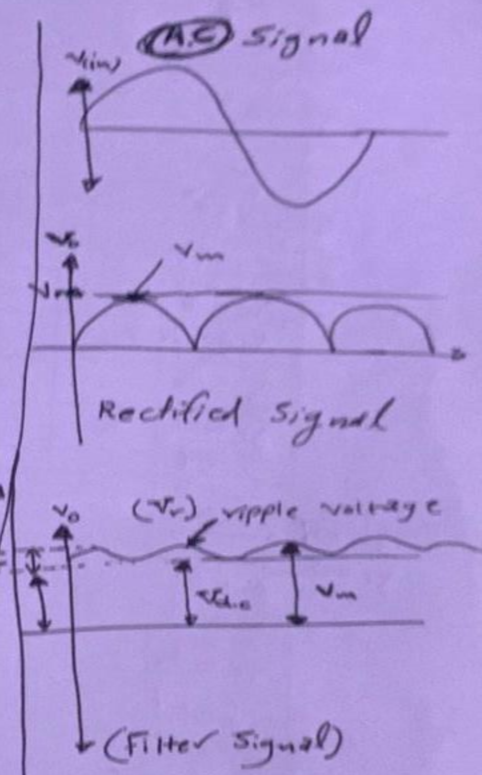
$$V_{r(rms)} = \frac{2.4\, I_{dc}}{C}$$

حفظ

$$V_r(peak) = \sqrt{3}\, V_r(rms) = \sqrt{3}\left(\frac{2.4\, I_{dc}}{C}\right)$$

$$V_{dc} = V_m - V_r(peak)$$

هذا القانون من الرسم



(Vo) الفولتية الخارجة من دائرة (
هي فولتية إدخال لدائرة
"Regulator"

$$V_{o\ filter} = V_{in\ regulator}$$

* عند إعطاء قيمة الـ (Vo) في السؤال للـ (Filter) معناها لدينا فو
الادخال لدائرة (Regulator) .. أو عند طلب فولتية الادخال ل
(Regula) نستطيع ايجادها من استخراج (Vo) لدائرة الـ(Filter)

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EXAMPLE For a transformer output of 15 V and a filter capacitor of 250 μF, calculate the minimum input voltage when connected to a load drawing 400 mA.

Solution: The voltages across the filter capacitor are

$$V_r(\text{peak}) = \sqrt{3}\,V_r(\text{rms}) = \sqrt{3}\,\frac{2.4I_{dc}}{C} = \sqrt{3}\,\frac{2.4(400)}{250} = 6.65\ \text{V}$$

$$V_{dc} = V_m - V_r(\text{peak}) = 15\ \text{V} - 6.65\ \text{V} = 8.35\ \text{V}$$

Since the input swings around this dc level, the minimum input voltage can drop to as low as

$$V_i(\text{low}) = V_{dc} - V_r(\text{peak}) = 15\ \text{V} - 6.65\ \text{V} = \mathbf{8.35\ V}$$

Since this voltage is greater than the minimum required for the IC regulator (from Table $V_i = 7.3$ V), the IC can provide a regulated voltage to the given load.

EXAMPLE Determine the maximum value of load current at which regulation is maintained for the circuit of Fig. 15.29.

Solution: To maintain $V_i(\text{min}) \geq 7.3$ V,

$$V_r(\text{peak}) \leq V_m - V_i(\text{min}) = 15\ \text{V} - 7.3\ \text{V} = 7.7\ \text{V}$$

so that

$$V_r(\text{rms}) = \frac{V_r(\text{peak})}{\sqrt{3}} = \frac{7.7\ \text{V}}{1.73} = 4.4\ \text{V}$$

The value of load current is then

$$I_{dc} = \frac{V_r(\text{rms})C}{2.4} = \frac{(4.4\ \text{V})(250)}{2.4} = \mathbf{458\ mA}$$

Any current above this value is too large for the circuit to maintain the regulator output at +5 V.

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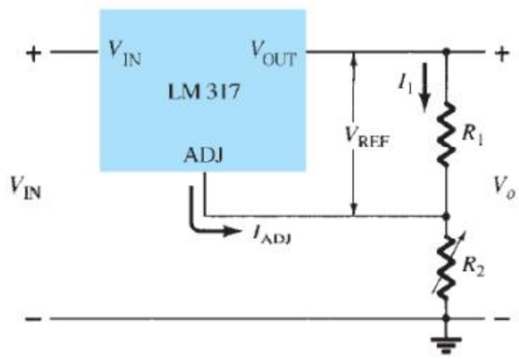
Adjustable-Voltage Regulators

Voltage regulators are also available in circuit configurations that allow the user to set the output voltage to a desired regulated value. The LM317, for example, can be operated with the output voltage regulated at any setting over the range of voltage from 1.2 V to 37 V. Figure shows how the regulated output voltage of an LM317 can be set.

$$V_{ref} = 1.25\text{ V} \quad \text{and} \quad I_{adj} = 100\ \mu\text{A}$$



Connection of LM317 adjustable-voltage regulator.

$$Vo = V_{ref}\,(1+R_1/R_2) + I_{adj}\,R_2$$

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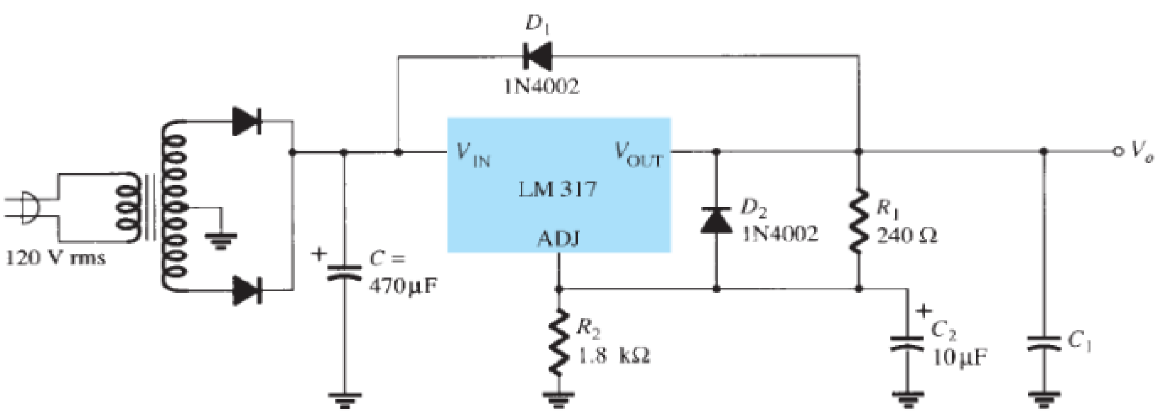
EXAMPLE Determine the regulated voltage in the circuit of Fig. with $R_1 = 240\ \Omega$ and $R_2 = 2.4\ k\Omega$.

Solution:

$$\text{Eq. (15.21):} \quad V_o = 1.25\ \text{V}\left(1 + \frac{2.4\ k\Omega}{240\ \Omega}\right) + (100\ \mu A)(2.4\ k\Omega)$$
$$= 13.75\ \text{V} + 0.24\ \text{V} = \mathbf{13.99\ V}$$

EXAMPLE Determine the regulated output voltage of the circuit in Fig.



Solution: The output voltage calculated using

$$V_o = 1.25\ \text{V}\left(1 + \frac{1.8\ k\Omega}{240\ \Omega}\right) + (100\ \mu A)(1.8\ k\Omega) \approx \mathbf{10.8\ V}$$

A check of the filter capacitor voltage shows that an input–output difference of 2 V can be maintained up to at least 200 mA load current.