ECE121: Electronics (1)

Lecture 1: Regulated Power Supply

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Spring 2017

Lecture Outline:

1. Introduction.
2. Concept of Voltage Regulation.
3. A Zener-Regulated DC Power Supply.
4. Basic Linear Voltage Regulator.
5. Integrated Circuit Voltage Regulators.

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Introduction:

DC Power supply:

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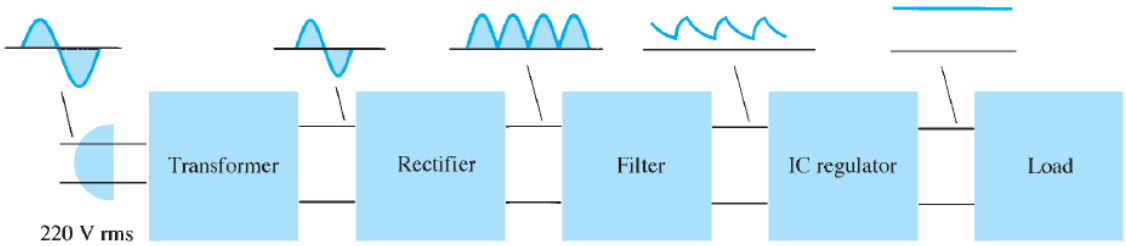
- Around 95% of the electronic equipments are powered from low voltage DC supplies.
- The source will be either a battery or a power supply converting AC mains into one or more low voltage DC supplies.
- Electronic components require a DC supply that is **well regulated**, has **low noise characteristics** and provides a **fast response to load changes**.




Introduction:

Components of DC Power Supplies:



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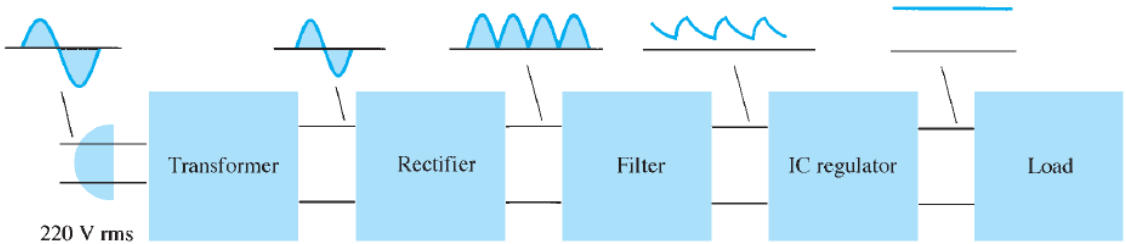

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2. A diode rectifier then provides a full-wave rectified voltage, which is initially filtered by a basic capacitor filter to produce a dc voltage.

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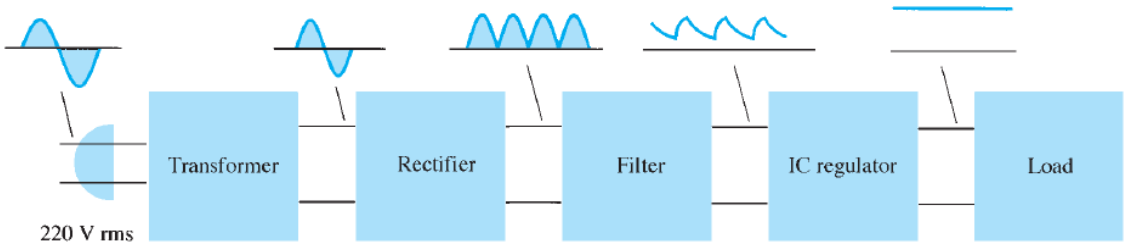


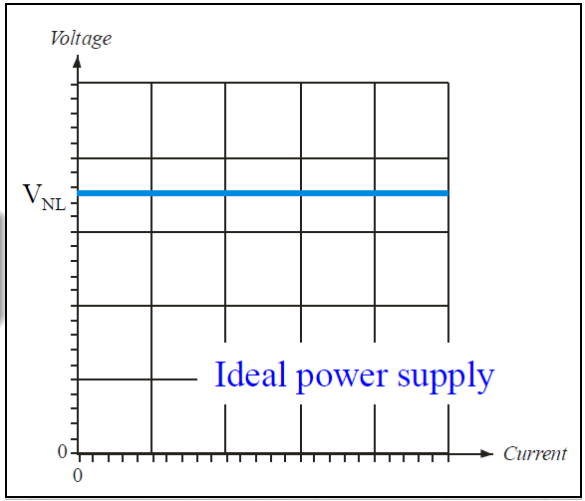
1. The AC voltage, typically 220 V RMS, is connected to a transformer, which steps that ac voltage down to the level for the desired dc output.
2. A diode rectifier then provides a full-wave rectified voltage, which is initially filtered by a basic capacitor filter to produce a dc voltage.
3. A regulator circuit can use this dc input to provide a dc voltage that **remains constant if input or load changes.**

Introduction:

Ideal Vs. Real DC Regulated Power Supply:

Ideal Power Supply:

It provides a constant dc voltage despite changes to the input voltage or load conditions.

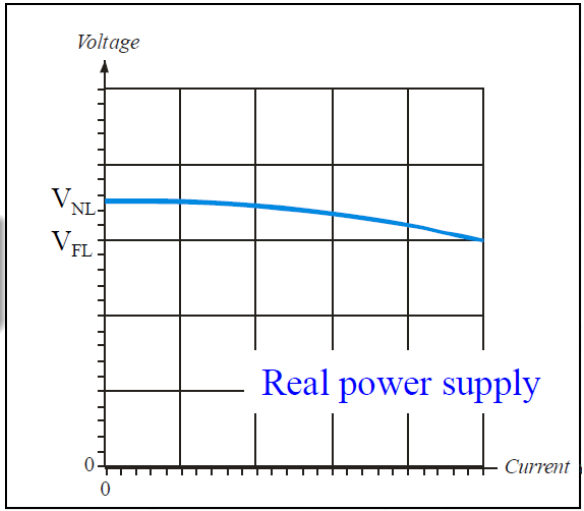


Introduction:

Ideal Vs. Real DC Regulated Power Supply:

Real Power Supply:

The output voltage of a real power supply changes under load or line (input) change.



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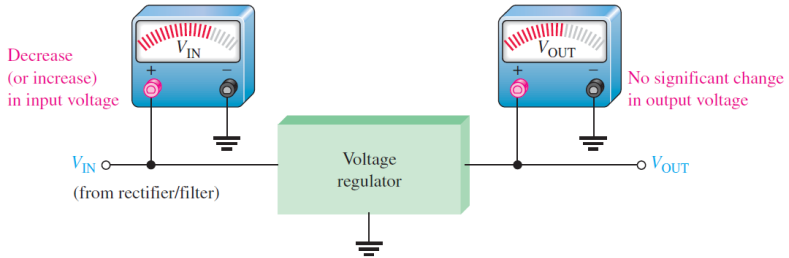
Concept of Voltage Regulation:

Line Regulation:



Line Regulation:

It is the percentage change in the output voltage for a given change in the input voltage. It can be expressed in units of $(\%/V)$.

$$\text{Line regulation} = \frac{(\Delta V_{OUT}/V_{OUT})100\%}{\Delta V_{IN}}$$

Concept of Voltage Regulation:

Line Regulation:

Line Regulation: (Example)

When the ac input voltage of a certain power supply changes, the input to the voltage regulator decreases by 5 V as a result, and the output of the regulator decreases by 0.25 V. The nominal output is 15 V. Determine the line regulation in $\%/V$.

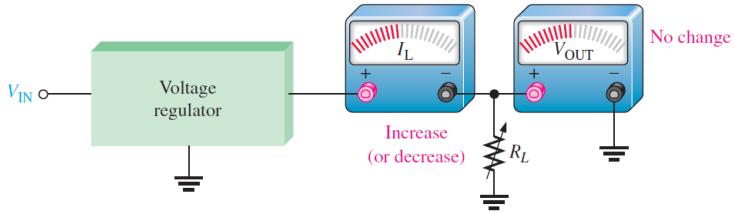
Solution:

The line regulation as a percentage change per volt is:

$$\text{Line regulation} = \frac{(\Delta\ V_{out}/V_{out})100\%}{\Delta\ V_{in}} = \frac{(0.25\ V/15\ V)100\%}{5\ V} = 0.333\%/V$$

Concept of Voltage Regulation:

Load Regulation:



Load Regulation:

It is the percentage change in output voltage for a given change in load current.

One way to express load regulation is as a percentage change in output voltage from no-load (NL) to full-load (FL).

$$\textbf{Load regulation} = \left(\frac{V_{NL} - V_{FL}}{V_{FL}}\right)100\%$$

Concept of Voltage Regulation:

Load Regulation:

Load Regulation: (Example)

A certain voltage regulator has a 12 V output when there is no load When there is a full-load output voltage is 11.9 V. Express the voltage regulation as a percentage change from no-load to full-load.

Solution:

The load regulation as a percentage change from no-load to full-load is:

$$\text{Load regulation} = \frac{(V_{NL} - V_{FL})}{V_{FL}} 100\% = \frac{(12\ V - 11.9\ V)}{11.9\ V} 100\% = 0.840\%$$

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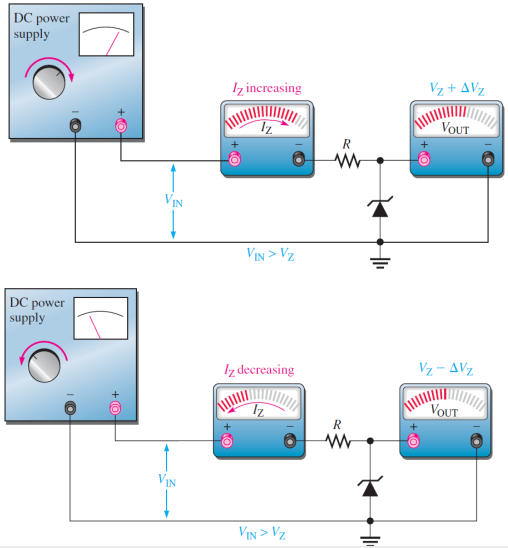
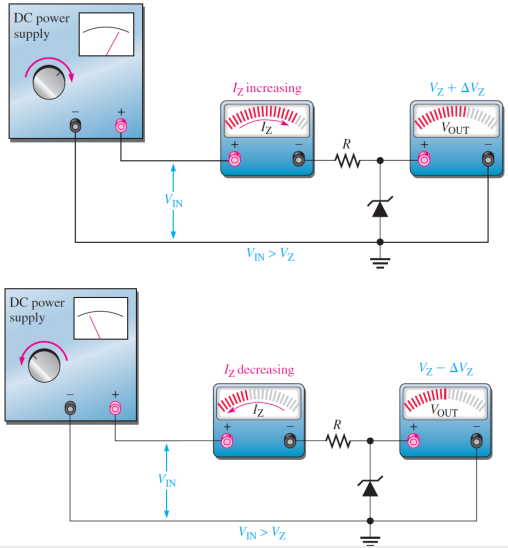
A Zener-Regulated DC Power Supply:

- The zener diode can be used as a type of voltage regulator for providing stable reference voltages.



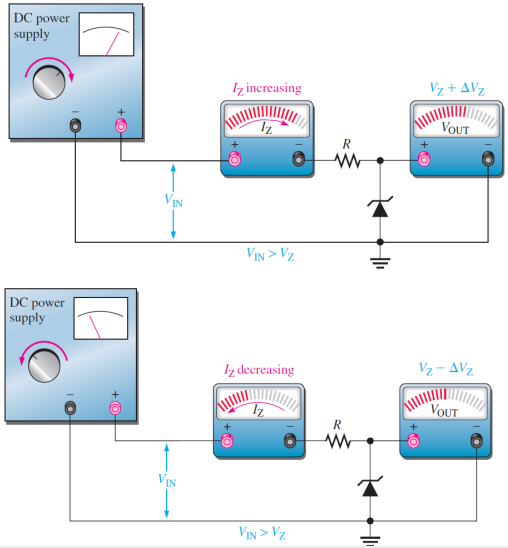
A Zener-Regulated DC Power Supply:

- The zener diode can be used as a type of voltage regulator for providing stable reference voltages.
- As the input voltage varies (within limits), the zener diode maintains a nearly constant output voltage across its terminals.



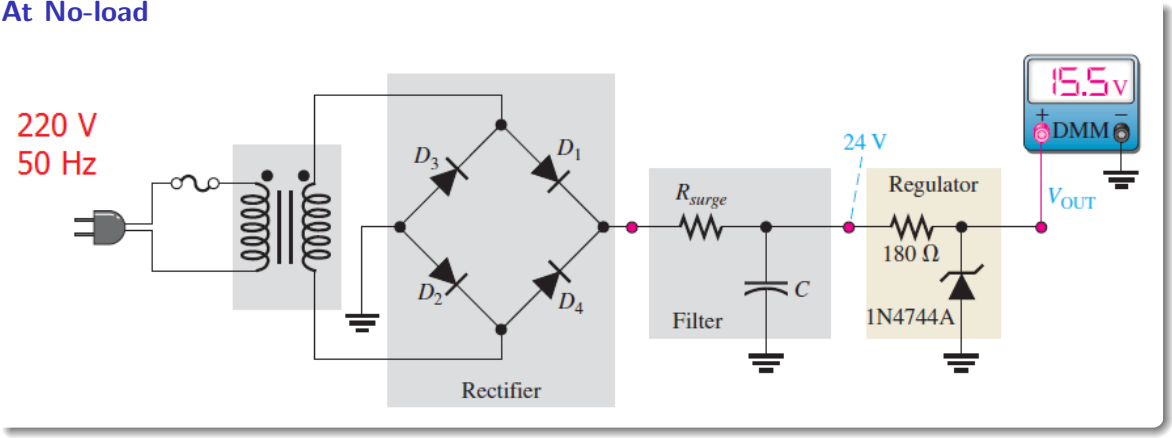
A Zener-Regulated DC Power Supply:

- The zener diode can be used as a type of voltage regulator for providing stable reference voltages.
- As the input voltage varies (within limits), the zener diode maintains a nearly constant output voltage across its terminals.
- However, as V_{IN} changes, I_Z will change proportionally so that the limitations on the input voltage variation are set by the minimum and maximum current values (I_{ZK} and I_{ZM}) with which the zener can operate.



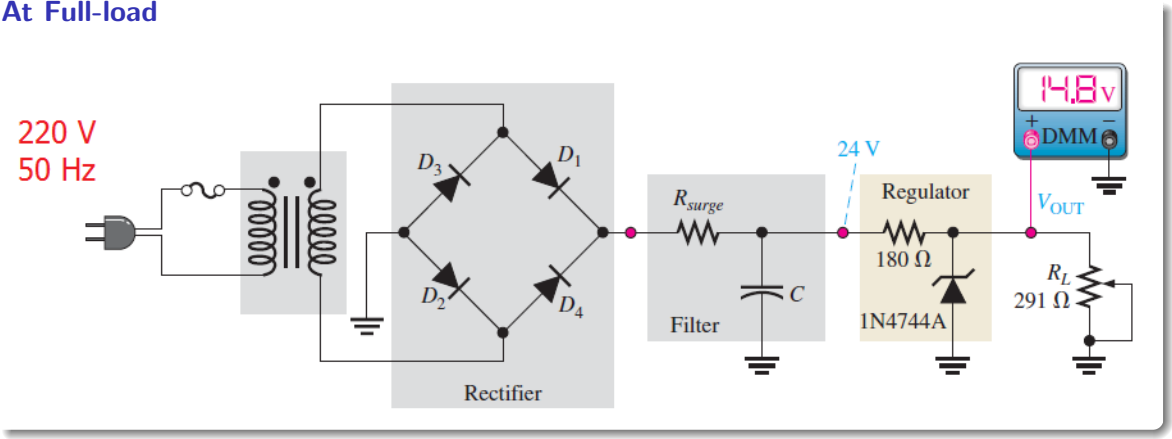
A Zener-Regulated DC Power Supply:

At No-load



A Zener-Regulated DC Power Supply:

At Full-load



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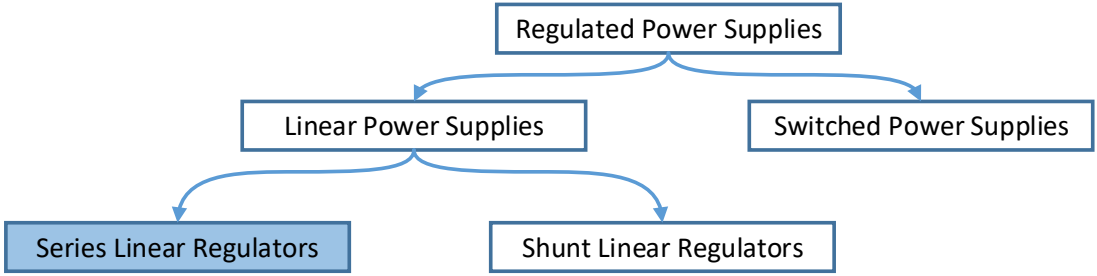
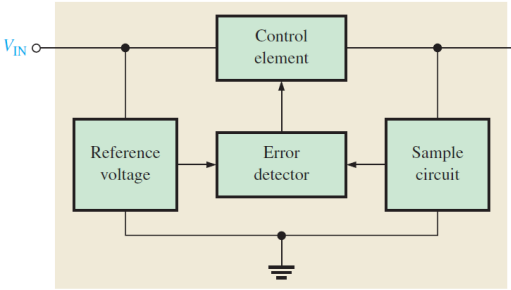
Basic Linear Voltage Regulator:



Basic Linear Voltage Regulator:

Series Linear VR:

- The control element is a pass transistor in series with the load between the input and output.



Simple series voltage regulator

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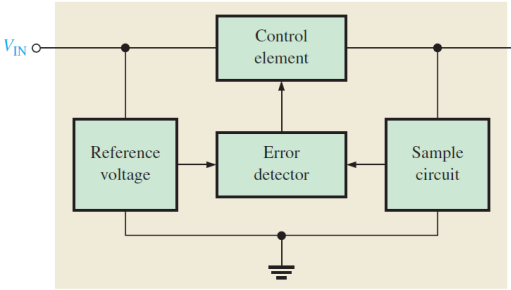
- The output sample circuit senses a change in the output voltage.



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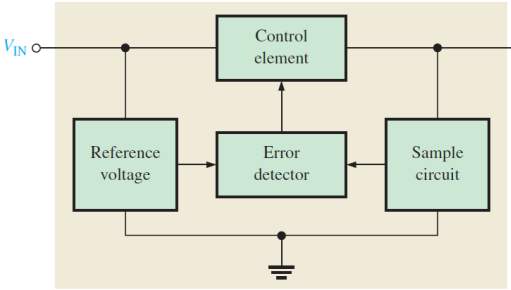
Basic Linear Voltage Regulator:

Series Linear VR:

- The control element is a pass transistor in series with the load between the input and output.
- The output sample circuit senses a change in the output voltage.
- The error detector compares the sample voltage with a reference voltage and causes the control element to compensate in order to maintain a constant output voltage.



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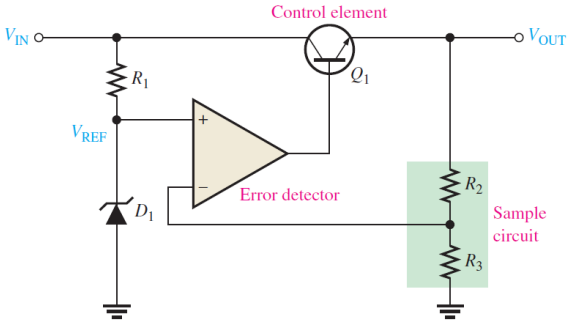

Basic op-amp series regulator

- The resistive voltage divider senses any change in the output voltage.
- The op-amp circuit amplify the difference voltage (error voltage) between the reference and the sensed values.
- This amplified difference voltage is applied to the transistor Q_1 to make the load voltage equals to the reference.

$$V_{OUT} \cong \left(1 + \frac{R_2}{R_3}\right) V_{REF}$$

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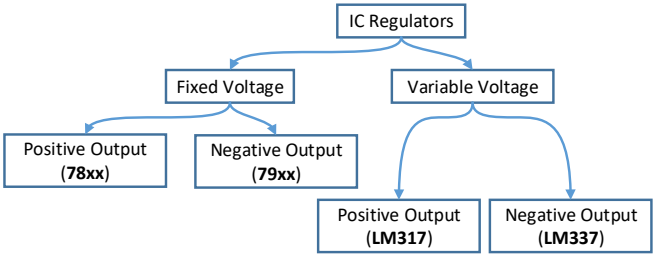
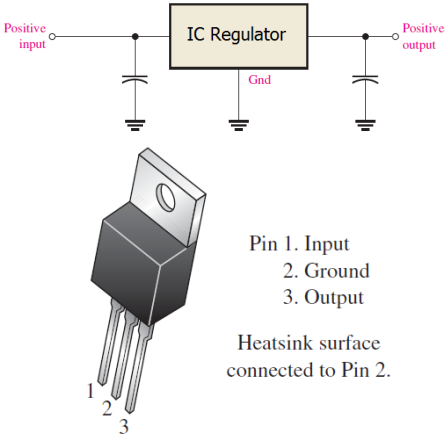
Integrated Circuit Voltage Regulators:

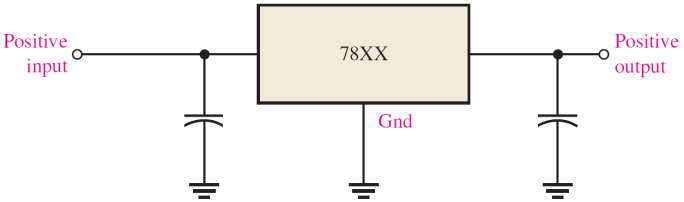
- Integrated circuit voltage regulators are available as series regulators.
- The IC regulator contains the reference voltage, the error detector and the control unit in one package.





Integrated Circuit Voltage Regulators:

Fixed Positive Linear Regulator (78xx)



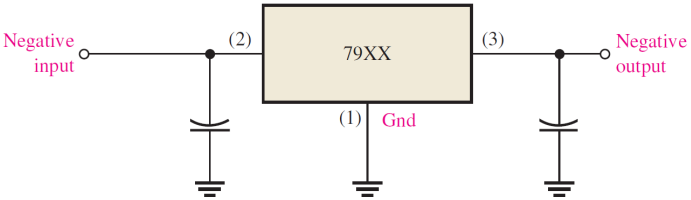
- The last two digits in the part number designate the output voltage. For example, the 7805 is a 5 V regulator.

Type number	Output voltage
7805	+5.0 V
7806	+6.0 V
7808	+8.0 V
7809	+9.0 V
7812	+12.0 V
7815	+15.0 V
7818	+18.0 V
7824	+24.0 V

The 78XX series

Integrated Circuit Voltage Regulators:

Fixed Negative Linear Regulator (79xx)



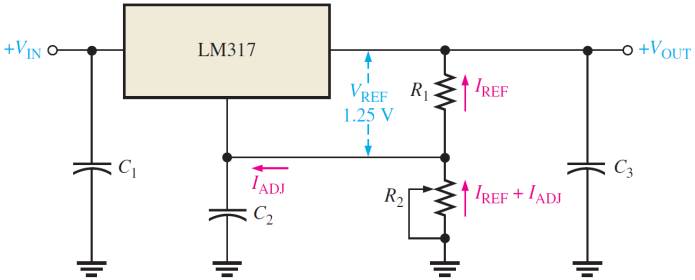
- The last two digits in the part number designate the output voltage. For example, the 7905 is a -5 V regulator.

Type number	Output voltage
7905	–5.0 V
7905.2	–5.2 V
7906	–6.0 V
7908	–8.0 V
7912	–12.0 V
7915	–15.0 V
7918	–18.0 V
7924	–24.0 V

The 79XX series

Integrated Circuit Voltage Regulators:

Variable Positive Linear Regulator (LM317)

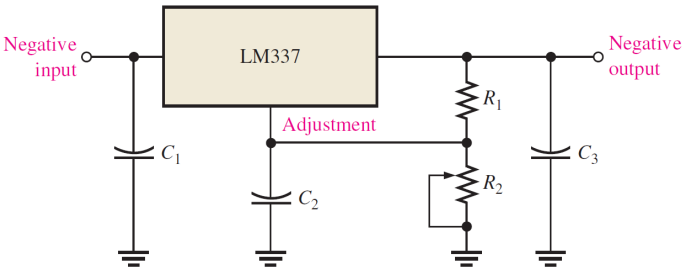


$$V_{OUT} = V_{REF}\left(1 + \frac{R_2}{R_1}\right) + I_{ADJ}R_2$$

- The external fixed resistor R_1 and the external variable resistor R_2 provide the output voltage adjustment.
- The output can be varied from 1.2 V to 37 V depending on the resistor values.
- The LM317 can provide over 1.5 A of output current to a load.
- We can neglect I_{ADG} which is small 50 μA.

Integrated Circuit Voltage Regulators:

Variable Negative Linear Regulator (LM337)

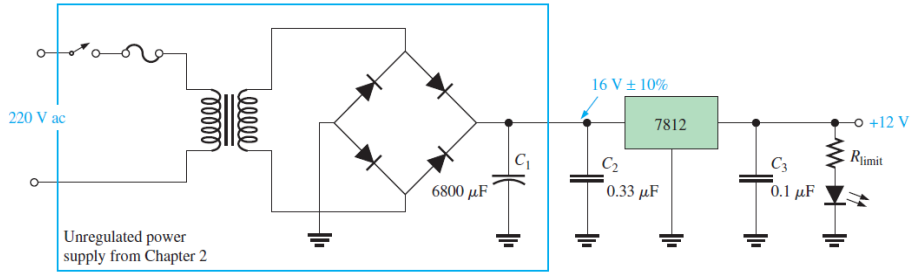


- The external fixed resistor R_1 and the external variable resistor R_2 provide the output voltage adjustment.
- The output can be varied from -1.2 V to -37 V depending on the resistor values.
- The LM337 can provide over 1.5 A of output current to a load.
- We can neglect I_{ADG} which is small 50 μA.

Integrated Circuit Voltage Regulators:

Power Supply Project:

Example of a typical 12 V power supply:



- Select one of the IC regulator and simulate it **individually** using Proteus. Send it by **Sunday 19 Feb. 2017.**
- Each team (one to four members) should deliver a variable (+ve or -ve) power supply by **Sunday 26 Feb. 2017.**

End of Lecture

Best Wishes

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