LESSON 4 -INTEGRATED CIRCUIT VOLTAGE REGULATORS

REGULATOR I.C's

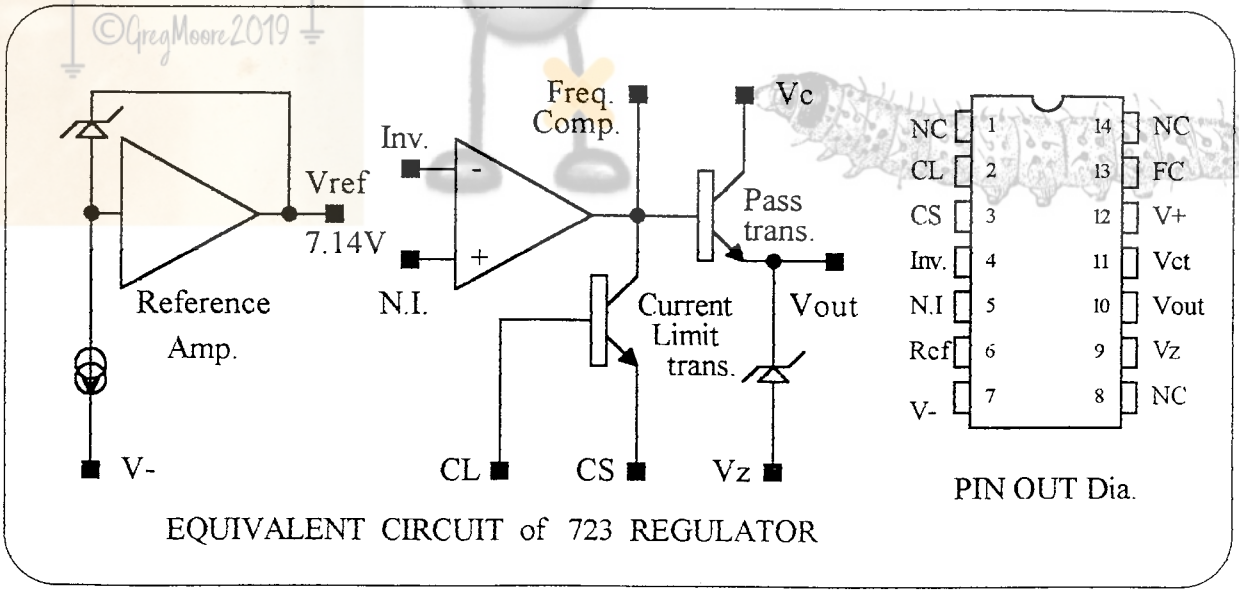
All the features of variable regulated output voltage and current overload protection can be obtained using commercially available Integrated Circuits.

e.g.	MANUFACTURER	TYPE No.
	NATIONAL SEMICONDUCTOR	LM376
	" "	LM723
	SIGNETICS CORPORATION	NE550

The I.C.'s are available in 8 pin or 14 pin D.I.L. packaging and the current capabilities range from 50mA to 150mA. This current range can be extended with "external" power transistors to around perhaps 10A.

1. 723 SERIES REGULATOR FEATURES

- As described by the manufacturer, the device contains a temperature compensated reference source, an error amplifier, a series pass transistor and a current limiting transistor.
- The device can be wired to provide a variety of positive or negative supplies with current limiting options.
- To achieve the above options a number of external components are required.
- If a fixed voltage is required, then a 3 terminal regulator is easier to use. (See NE04)
- The basic internal arrangements are shown below



EQUIVALENT CIRCUIT of 723 REGULATOR

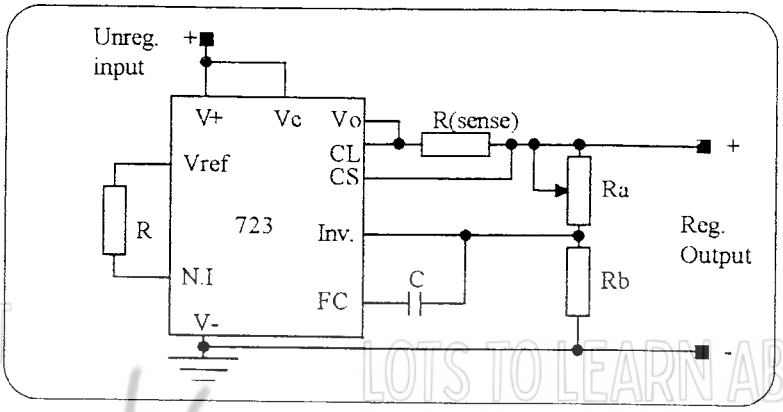
PIN OUT Dia.

The maximum input voltage is 40V and the chip can be used to regulate between 2 to 37V using selected circuits. The zener diode Vz is to allow the regulator to operate as a high voltage floating supply or to produce negative voltage using a suitable circuit.

7 - 37 VOLT REGULATOR CIRCUIT

- The regulated output can be calculated from

$$Vreg = Vref \times \frac{(Ra + Rb)}{Rb}$$

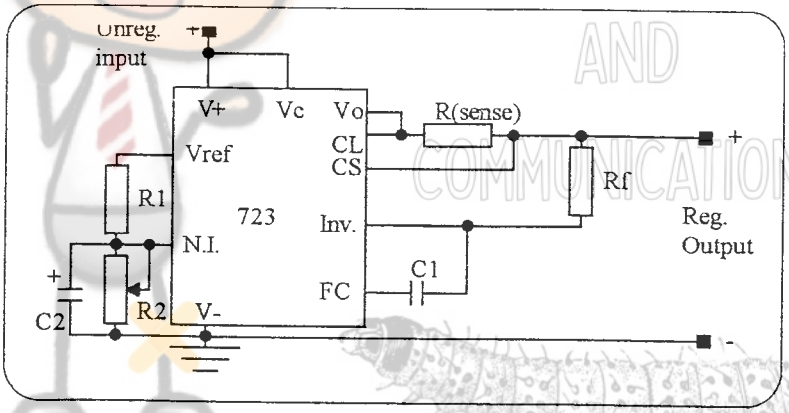


- Vref = 7.14V
- R is employed to minimise temperature drift and input current offset. R = Ra//Rb

- Constant current limiting is shown in this circuit and to ensure the maximum current of the internal series pass transistor is not exceeded (150mA) then R(sense) should never be less than 4R7
- I(limit) = 0.7V ÷ R(sense)

2 - 7 VOLT REGULATOR CIRCUIT

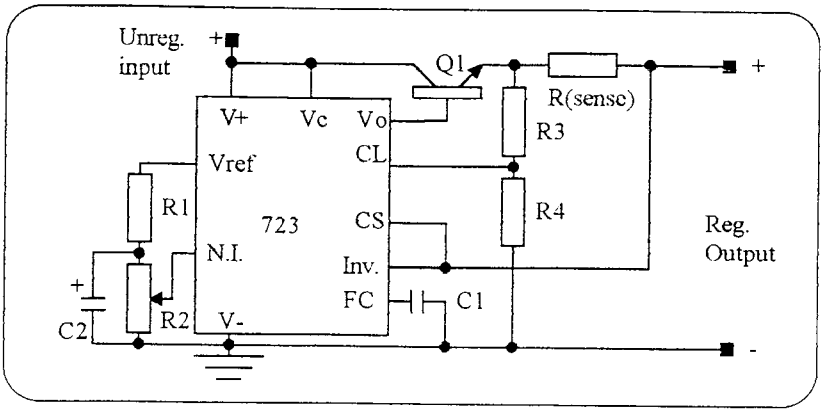
- To obtain an output voltage smaller than 7V requires that Vref. be reduced by a voltage divider circuit.
- $Vreg. = Vref. \times \frac{R2}{(R1 + R2)}$



- Rf = R1//R2
- I(limit) = 0.7V ÷ R(sense)

EXTERNAL SERIES PASS TRANSISTOR WITH FOLDBACK I LIMITING

- Foldback current limiting is achieved by adding R3 & R4.
- The series pass transistor Q1 will allow a much greater load current.
- $Vreg = Vref. \times \frac{R2}{(R1 + R2)}$



- I(limit) = (R3 × Vreg.) ÷ (Rsense × R4) + [(R3 + R4) × 0.7V] ÷ (Rsense × R4)
- I(short circuit) = [(R3 + R4) × 0.7V] ÷ (Rsense × R4)

723 REGULATOR Cont.

The example circuits are all positive voltage regulator configurations that are limited to the a maximum output voltage of 37V. It is possible to use the 723 in higher voltage configurations that allow the regulator chip to float at up to 250 volts above ground. The chip may also be used to regulate negative voltage supplies and used in a form of switching regulator configuration. The manufacturers databook can be consulted for the various possibilities and characteristics of this integrated circuit regulator chip.

THREE TERMINAL REGULATORS

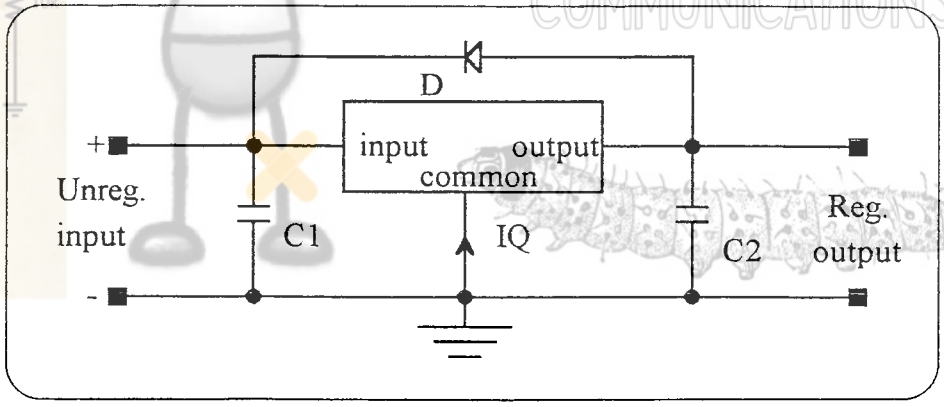
The trend in modern electronic circuits is toward 3 terminal regulator IC's for many power supply applications. The 3 terminal regulators have the following features

- Small size and low in cost.
- Regulation with current rating up to 10A
- May be obtained in fixed or variable output voltage configurations
- They are available in TO92, TO39, T0220 & TO3 packages.
- Automatic overload and thermal shutdown protection.

POSITIVE VOLTAGE 3 TERMINAL REGULATORS

The 78XX series and the 340-XX series are typical positive voltage regulators with a current rating of around 1A for the TO220 package.

TYPICAL BLOCK CIRCUIT



- C1 = 0.1µF to 0.47µF. Required for stable operation if the regulator is sited some distance from the rectifier. (say 50mm or more)
- C2 = 0.01µF ceramic or 1µF tantalum. Required for an improvement in transient response at the output.

PRECAUTIONS IN USE

- The input voltage of the power supply must be at least 2.5V above the regulated output.
- The ripple voltage of the input power supply must not dip below the above differential.
- If the input voltage is too large, voltage breakdown can occur.
- The greater the voltage between Vin and Vout, the more power dissipated by the regulator and hence a heatsink is required to stop thermal shutdown.
- A diode (D) is often placed across the regulator. If a short circuit occurs at the input filter capacitor, then the probable destructive current from C2 is bypassed around the regulator.
- IQ is typically 5mA for fixed regulator operation.

NEGATIVE 3 TERMINAL REGULATORS

The 79XX and the 320-XX series are typical examples of negative three terminal regulators with a current rating of around 1.5A for the TO220 package..

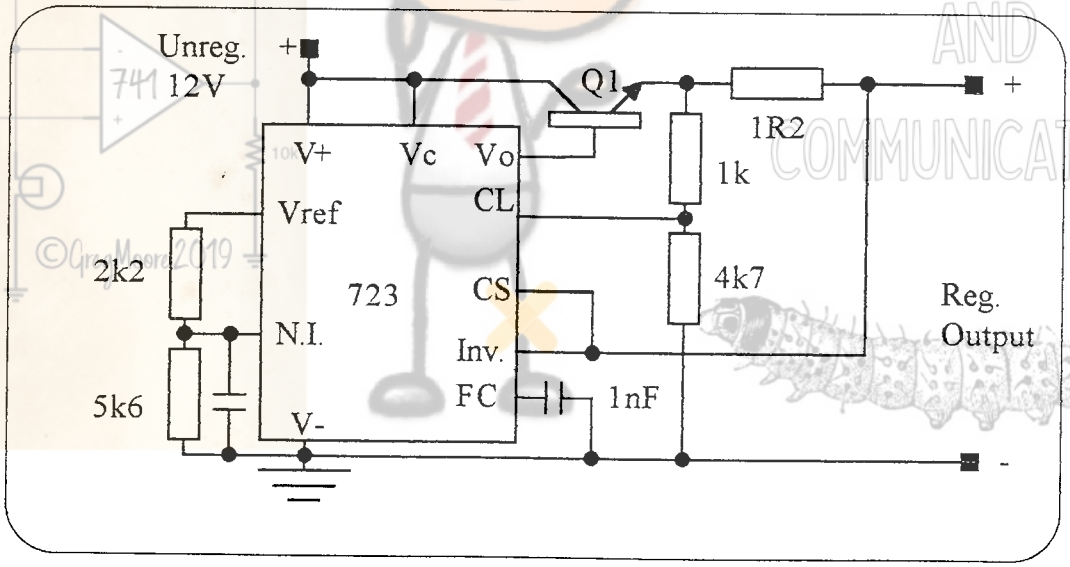
- All the points listed for positive regulators are applicable to negative regulators.
- TO220 packages do not have the same pin out connections for negative regulators compared to positive regulators.

GENERAL INFORMATION

The maximum input voltage depends on the type number in many cases but for the types listed it is about 35V. Although the regulators have thermal shut down circuitry, it is still possible to develop an internal short circuit and hence a faulty regulator is still listed as a possible fault in 3 terminal type power supplies. Ripple reduction is around 70 times and it becomes difficult to measure accurately with a CRO. The line regulation is about 1% and the load regulation is about the same at the maximum current rating.

PRACTICE PROBLEMS

Q.1 For the following circuit, determine



i) The regulated output voltage.

ii) The approximate current limit point.

iii) The short circuit current.

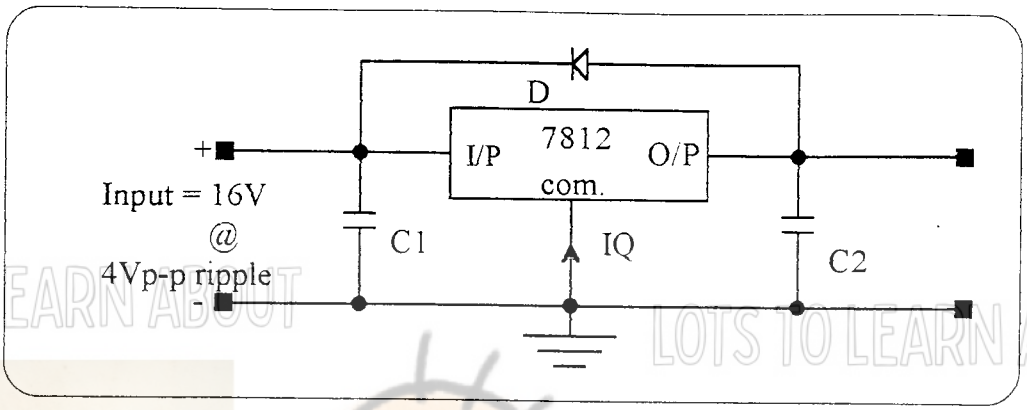
iv) The power dissipated by Q1 at I(limit)

v) The power dissipated by Q1 when the output is short circuited.

Q.2 If the transistor Q1 has a β = 50, determine the current that is supplied to its base by the 723 regulator chip.

PRACTICE PROBLEMS Cont.

Q.3 Refer to the following circuit



i) What is the expected regulated output from this circuit ?

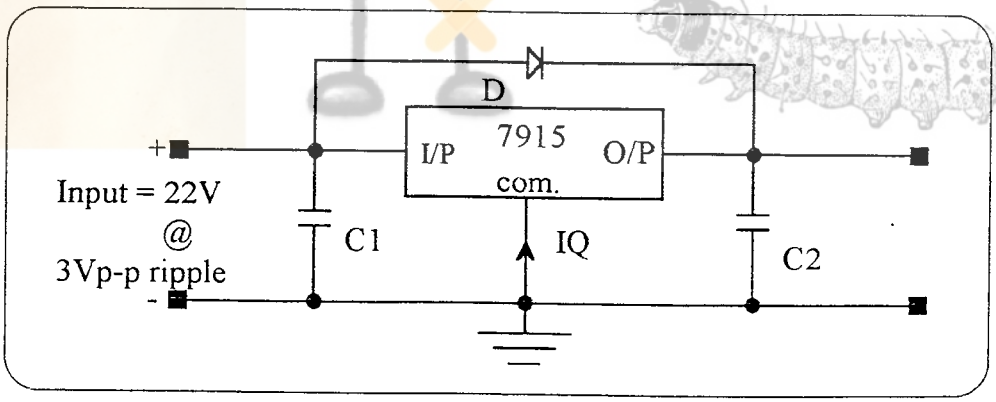
ii) List a typical value for C1 and briefly describe its purpose.

iii) State the purpose of C2 and list a typical value.

iv) State the purpose of diode D.

v) What is a possible problem with the circuit as it is presented ?

Q.4 Refer to the following circuit



i) What is the expected output from this regulator?

ii) Is the diode D connected correctly ?

iii) What is a possible problem with the circuit as it is presented.