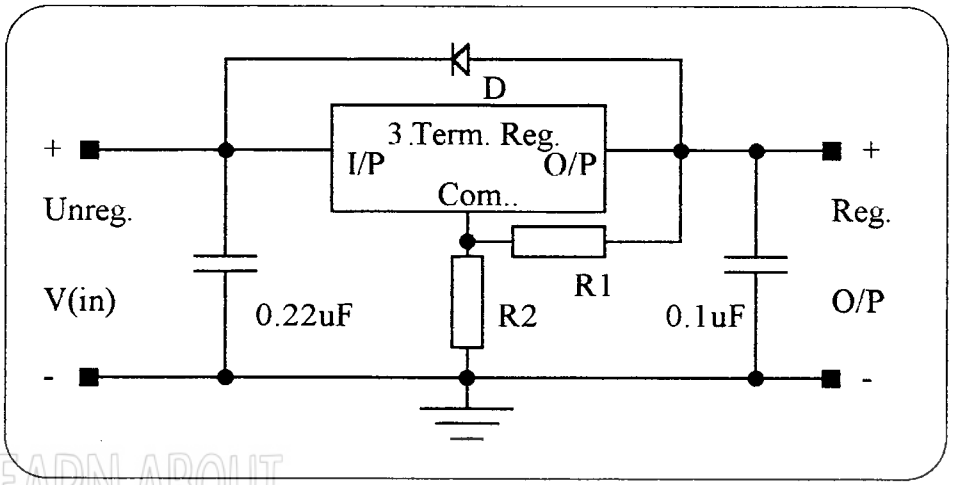
LESSON 5 - INTEGRATED CIRCUIT REGULATORS 2

NON-STANDARD OUTPUT VOLTAGE FROM 3 TERMINAL REGULATORS

The addition of two resistors to the circuit of fixed voltage 3 terminal voltage regulators allows a non-standard output voltage to be obtained. The addition of the two resistors will cause only a slight loss of regulation.



- The output voltage of the regulator is across R1. The current through R1 is selected to be between 3 and 5 times the quiescent current of the regulators common terminal.
- The current through R2 is the current through R1 plus the quiescent current of the regulator. Therefore the voltage dropped across R2 causes the common terminal to be above ground potential by this amount.
- The voltage across R2 plus the regulator output voltage becomes the output voltage of the regulator circuit.
- V(out) can be calculated from

$V(out) = Vxx(1 + R2/R1) + IQ \times R2$ Where: Vxx = Voltage of regulator
IQ = quiescent current

e.g. IQ = 6mA & Vxx = 5V (7805). The output voltage is to be 9V and assume that IR1 = 4 × IQ.

Ans: IR1 = 4 × 6mA = 24 mA. R1 = 5V/24mA = 208Ω. Use 220Ω.
R2 = (Vout - Vxx)/(Vxx/R1 + IQ) = (9-5)/(5/220 + 6mA) = 140Ω.
140Ω is a non-standard value. Use 150//2200

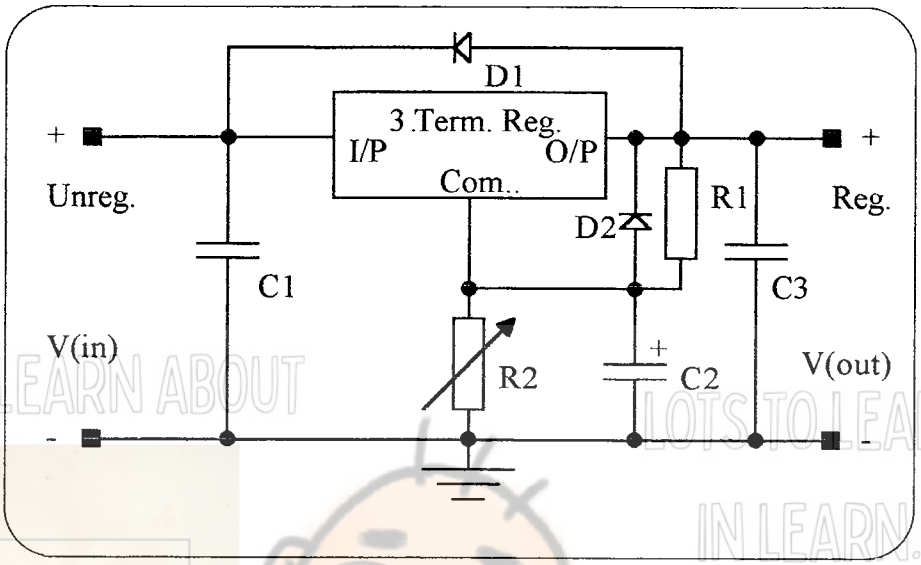
Check, V(out) = 5(1 + 140/220) + (6mA × 140) = 9V

The power dissipated by R1 and R2 is an acceptable loss when the versatility of the circuit considered. The circuit can be made to be continuously variable by making R2 a variable potentiometer but needs to be able to dissipate the power. Special 3 terminal regulators are available for this application.

VARIABLE 3 TERMINAL REGULATORS

The quiescent current in the common terminal of fixed voltage 3 terminal regulators is typically 4.5 to 6 mA and this limits values of the resistors that can be used to produce a continuously variable regulated supply. The common leg current has to be "swamped" by the divider current produced by the resistors and there is also a lower limit to the value of the available output voltage (5V). To overcome the above limitations, a series of 3 terminal regulators have been developed that have reduced the quiescent current to about 0.1mA and have a minimum output voltage of about 1.25V.

LM317 REGULATOR



- The method of producing the quiescent current in the common leg requires that the load current for the output terminal be a minimum of 4 mA else regulation will be lost. R1 is usually selected to be 240Ω, this will produce a current of about 5.2ma and hence cover the above requirement.
- R2 can be the usual sized 1/4 W potentiometer because of the small current required.
- Diode D1 protects the regulator against input short circuits as before. To improve the ripple rejection of the regulator, C2 is often added and becomes more effective at higher voltage outputs. If the output of the regulator shorts for any reason, C2 would attempt to discharge through the common leg of the regulator causing internal damage. By using diode D2 the destructive currents are bypassed around the regulator and therefore protecting it.
- The 317 type regulator is available in a number of package styles with the K (TO3) and T (TO220) styles capable of 1.5A before shutdown occurs if a suitable heatsink is employed.
- Due to the smaller quiescent current the equation for the output voltage is simplified to

$$V(out) = 1.25 \times (1 + R2/R1)$$

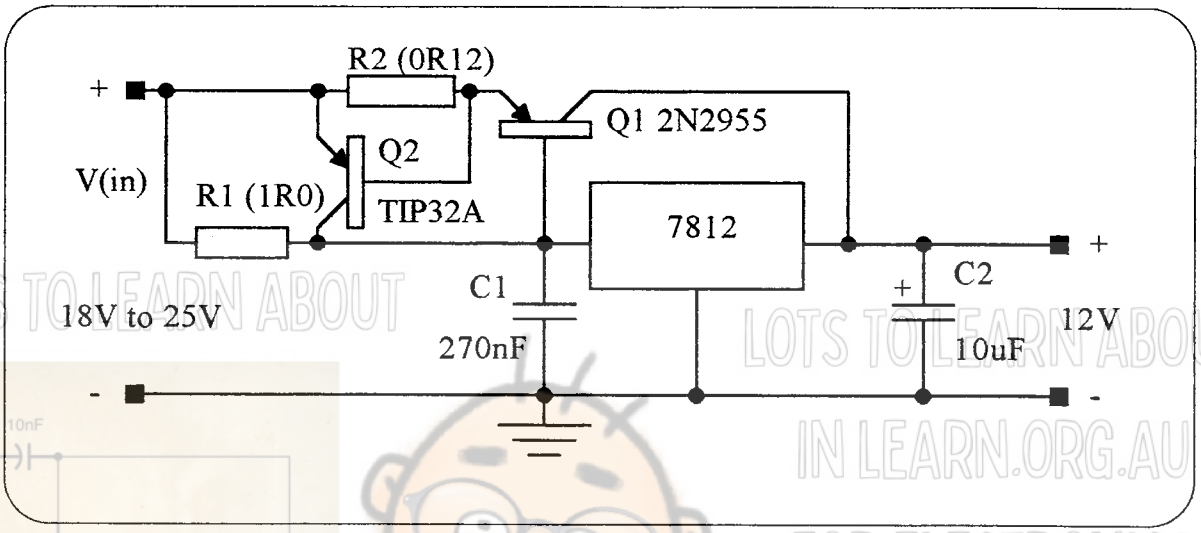
- To obtain a minimum voltage of zero at the output terminals, the common leg needs to be tied to a potential of -1.25V.
- The negative voltage version is designated type 337.

HIGHER RATED THREE TERMINAL REGULATORS .

Beside the examples discussed previously there is a range of 3 terminal regulators that have current ratings such as 3A, 5A and 10A but the cost per unit is considerably higher than the 1 to 1.5A variety. (See supplied list) Higher voltage rating is available in some varieties also should they be needed.

OUTBOARD PASS TRANSISTORS

Although higher current rated 3 terminal regulators are available, frequent use is made of using an external pass transistor with a 1A regulator to increase the current rating. This is often cheaper than using a higher current 3 terminal regulator if the cost of heatsinking and power transistors are taken into account.

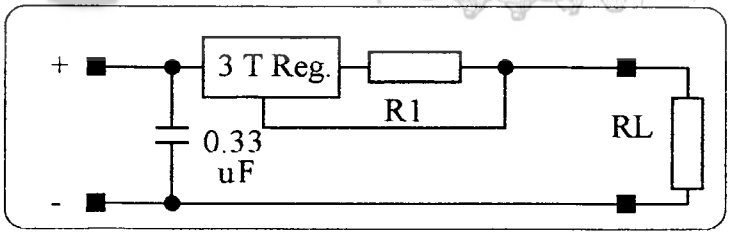


- At low currents, insufficient voltage is developed across R1 to turn transistor Q1 on so all the load current is supplied by the 3 terminal regulator. At around 700mA Q1 is turned on and provides current over this amount.
- At approximately 5A there is sufficient current through R2 to turn on Q2 this robs base current from Q1 and thus causes a constant current mode of operation and hence protecting Q1 from excessive power dissipation.
- The circuit requires a greater differential between V(in) and V(out) than when the regulator is used alone but amounts to no more than perhaps 3.5V.
- Circuits other than the one shown are available and an alternative is discussed in the text book *Understanding dc Power Supplies* by B. DAVIS. - see Chap. 4 Pge 80

3 TERMINAL REGULATOR CONSTANT CURRENT SOURCE

- Iconst = (Vxx/R1) + IQ

- To achieve a constant output current implies a varying load voltage as RL varies.



PRECISION VOLTAGE REGULATOR I.C.'s

Beside the general purpose voltage regulators previously discussed, manufacturers also supply a range of relatively low current regulators that can be set to specified voltages with accuracies of 0.1%. The load and line regulation figures are quoted as being better than 0.1% but the maximum current may be limited to less than 500mA depending on the type.

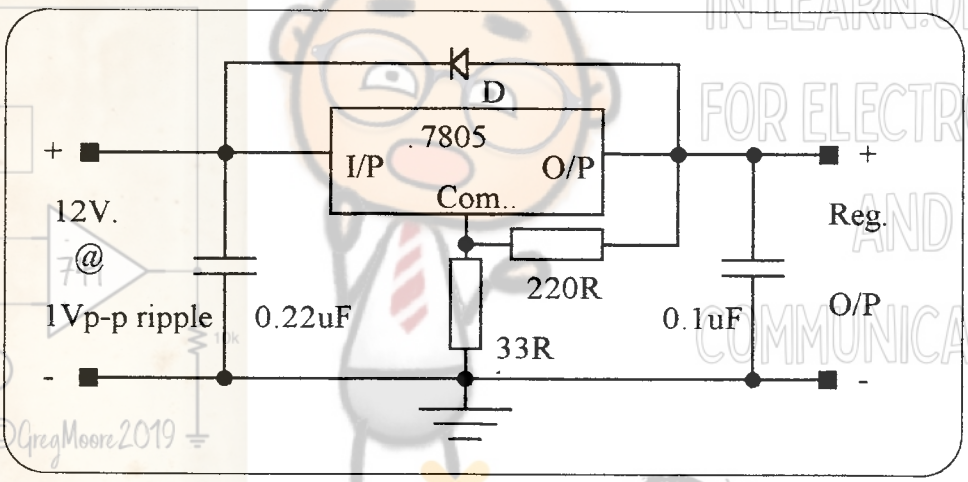
The use of such regulators is found in instrument applications where very accurate reference voltages are required for the processing of electrical input quantities such as voltage or current (DVM's etc).

The NATIONAL SEMICONDUCTOR LH0075 is an example of a precision SERIES regulator that has an internal series of resistors for selected output voltages or it may be provided with a single external resistor to set the output voltage between 0 to 27V. The current limit is adjustable from 0 to 200mA. Line regulation is typically 0.008%/V and load regulation is typically 0.075% with a ripple rejection of 80dB.

The TEXAS INSTRUMENTS TL431 is an example of a SHUNT regulator that can be trimmed to high accuracy by the addition of two 1% resistors. After the setting of the desired output voltage by the two resistors, the circuit is treated as a zener regulator that has a maximum current of 100mA. The device can be made to be continuously variable if desired.

PRACTICE PROBLEMS

Q.1 Refer to the following circuit.



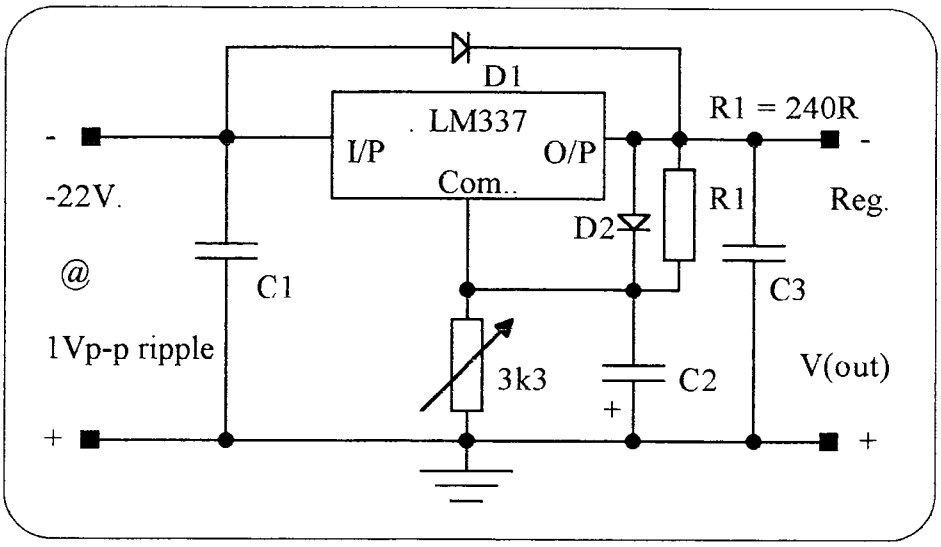
i) Assume IQ = 6mA and determine the regulated output voltage.

ii) Determine the current in the 220Ω resistor.

iii) If RL = 12Ω, calculate the power dissipated by the 7805.

iv) Briefly describe under what conditions the 0.22uF capacitor is essential.

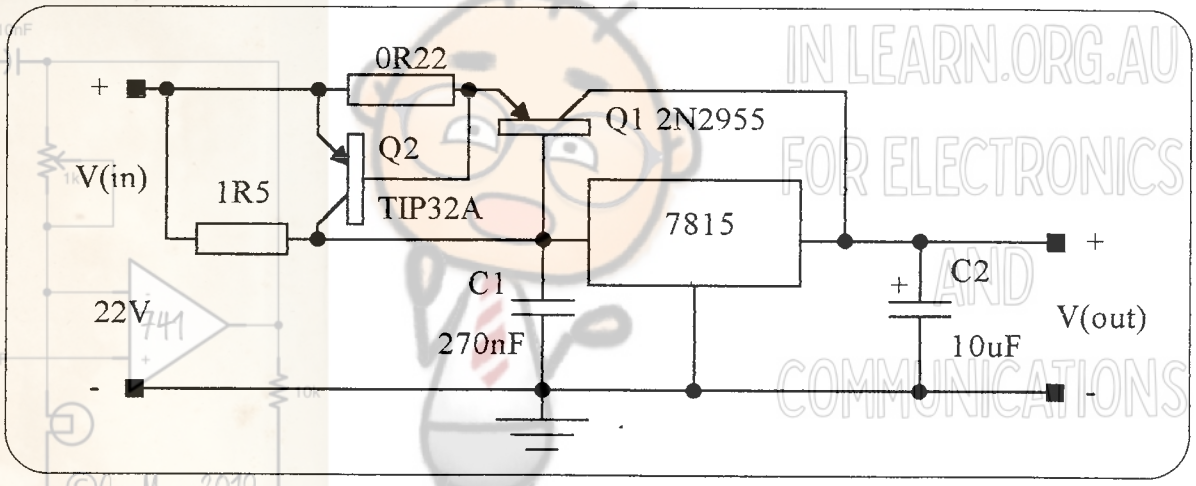
Q.2 Refer to the following circuit



i) Determine the range of output voltage.

ii) Briefly describe the purpose of D2

Q.3 Refer to the following circuit.



i) Estimate the approximate output voltage.

ii) Determine the approximate current that will cause Q1 to conduct.

iii) Calculate the current limit value of the circuit.

iv) Briefly describe why Q2 is necessary.