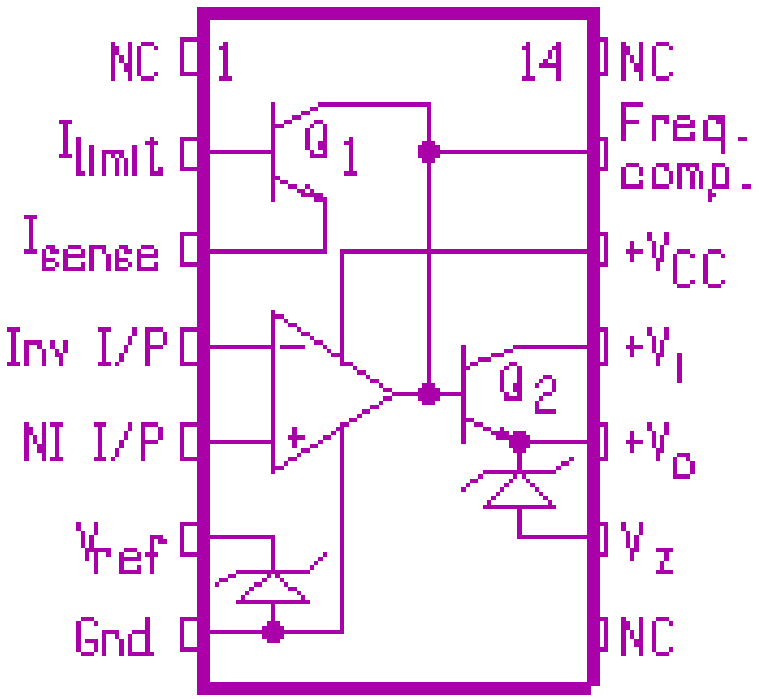
UNIT-V
APPLICATION ICs

IC Voltage Regulators

- There are basically two kinds of IC voltage regulators:
  - Multipin type, e.g. LM723C
  - 3-pin type, e.g. 78/79XX
- Multipin regulators are less popular but they provide the greatest flexibility and produce the highest quality voltage regulation
- 3-pin types make regulator circuit design simple

Multipin IC Voltage Regulator



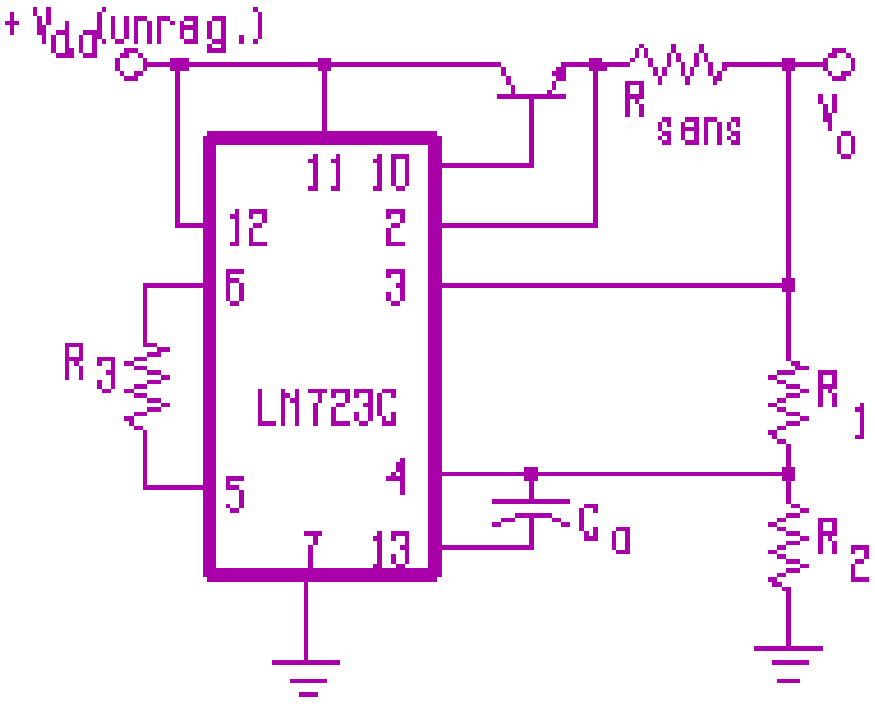
LM 723C Schematic

- The LM723 has an equivalent circuit that contains most of the parts of the op-amp voltage regulator discussed earlier.
- It has an internal voltage reference, error amplifier, pass transistor, and current limiter all in one IC package.

LM723 Voltage Regulator

- Can be either 14-pin DIP or 10-pin TO-100 can
- May be used for either +ve or -ve, variable or fixed regulated voltage output
- Using the internal reference (7.15 V), it can operate as a high-voltage regulator with output from 7.15 V to about 37 V, or as a low-voltage regulator from 2 V to 7.15 V
- Max. output current with heat sink is 150 mA
- Dropout voltage is 3 V (i.e. $V_{CC} > V_{o(max)} + 3$)

LM723 in High-Voltage Configuration



External pass transistor and current sensing added.

Design equations:

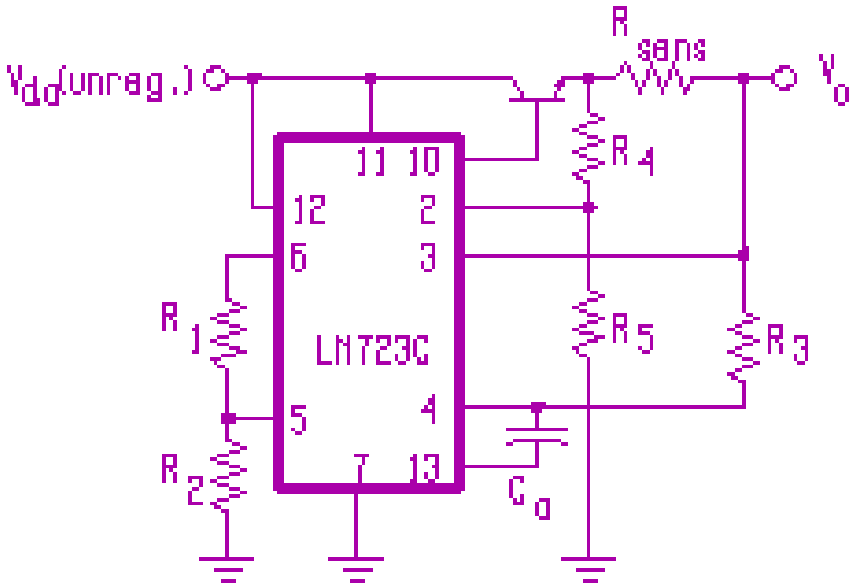
$$V_o = \frac{V_{ref}(R_1 + R_2)}{R_2}$$

$$R_3 = \frac{R_1 R_2}{R_1 + R_2} \qquad R_{sens} = \frac{0.7}{I_{\max}}$$

Choose $R_1 + R_2 = 10\ k\Omega$, and $C_c = 100\ pF$.

To make V_o variable, replace R_1 with a pot.

LM723 in Low-Voltage Configuration



With external pass transistor and foldback current limiting

$$V_o = -\frac{R_2 V_{ref}}{R_1 + R_2}$$

$$I_{L(max)} = \frac{R_4 V_o + 0.7(R_4 + R_5)}{R_5 R_{sens}}$$

$$I_{short} = \frac{0.7(R_4 + R_5)}{R_5 R_{sens}}$$

$$R_{sens} = \frac{0.7 V_o}{I_{short}(V_o + 0.7) - 0.7 I_{L(max)}}$$

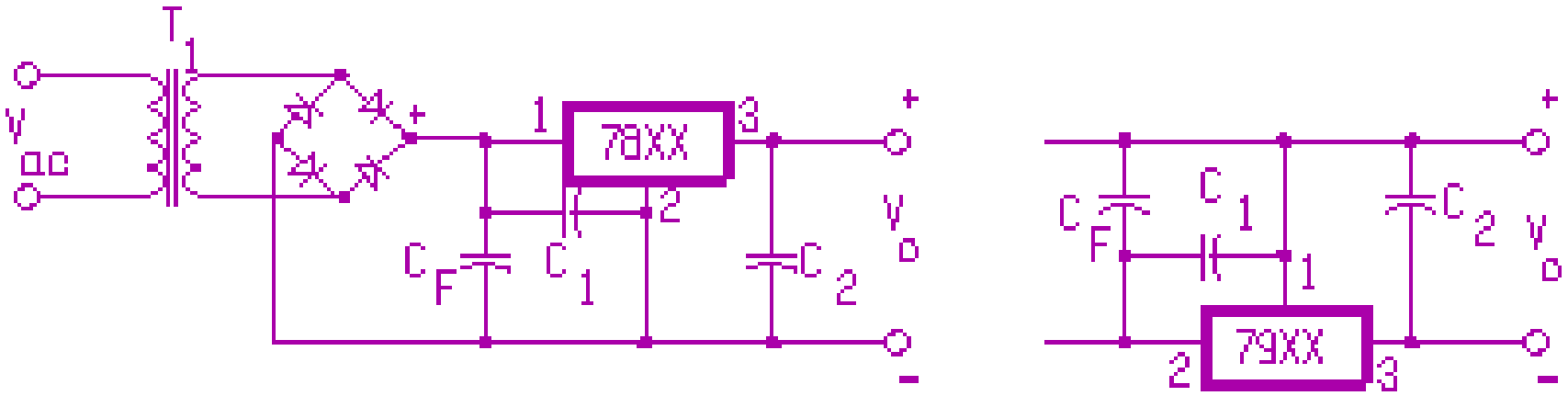
Under foldback condition:

$$V_o' = -\frac{0.7 R_L (R_4 + R_5)}{R_5 R_{sens} - R_4 R_L}$$

Three-Terminal Fixed Voltage Regulators

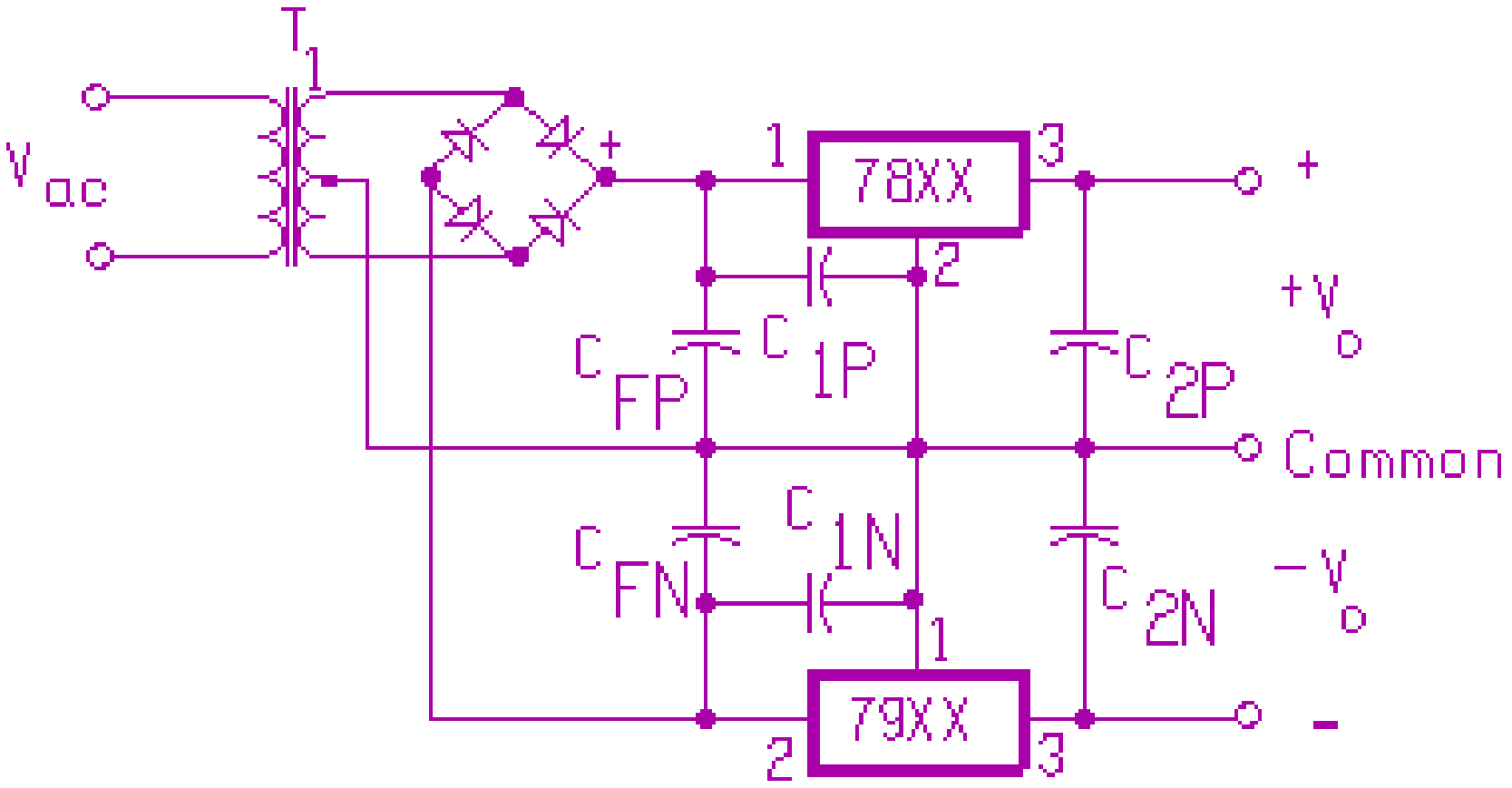
- Less flexible, but simple to use
- Come in standard TO-3 (20 W) or TO-220 (15 W) transistor packages
- 78/79XX series regulators are commonly available with 5, 6, 8, 12, 15, 18, or 24 V output
- Max. output current with heat sink is 1 A
- Built-in thermal shutdown protection
- 3-V dropout voltage; max. input of 37 V
- Regulators with lower dropout, higher in/output, and better regulation are available.

Basic Circuits With 78/79XX Regulators

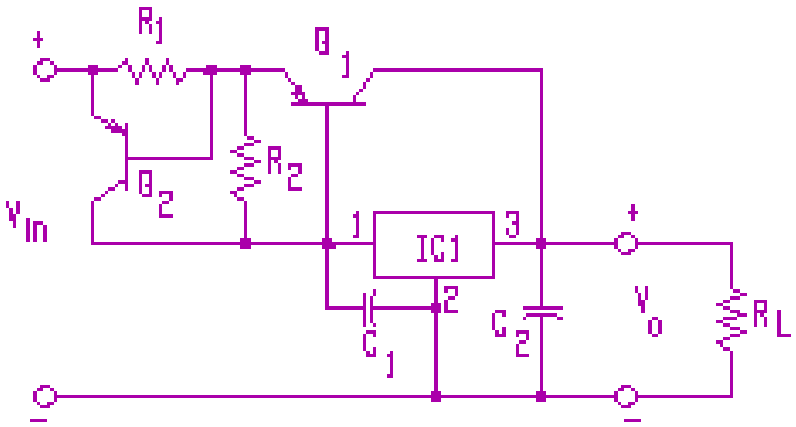


- Both the 78XX and 79XX regulators can be used to provide +ve or -ve output voltages
- C_1 and C_2 are generally optional. C_1 is used to cancel any inductance present, and C_2 improves the transient response. If used, they should preferably be either 1 μF tantalum type or 0.1 μF mica type capacitors.

Dual-Polarity Output with 78/79XX Regulators



78XX Regulator with Pass Transistor

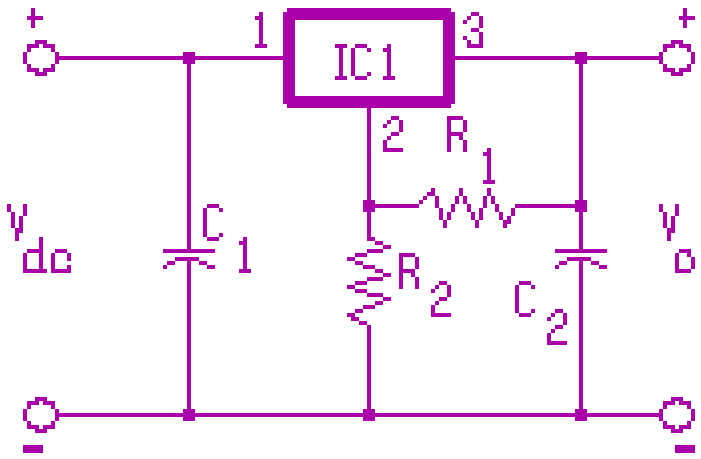


$$R_1 = \frac{0.7}{I_{\max}}$$

$$R_2 = \frac{0.7}{I_{R2}}$$

- Q_1 starts to conduct when $V_{R2} = 0.7$ V.
- R2 is typically chosen so that max. I_{R2} is 0.1 A.
- Power dissipation of Q_1 is $P = (V_i - V_o)I_L$.
- Q_2 is for current limiting protection. It conducts when $V_{R1} = 0.7$ V.
- Q_2 must be able to pass max. 1 A; but note that max. V_{CE2} is only 1.4 V.

78XX Floating Regulator



- It is used to obtain an output > the V_{reg} value up to a max.of 37 V.
- R_1 is chosen so that $R_1 \leq 0.1\ V_{reg}/I_Q$, where I_Q is the

$$V_o = V_{reg} + \left(\frac{V_{reg}}{R_1} + I_Q \right) R_2$$

or

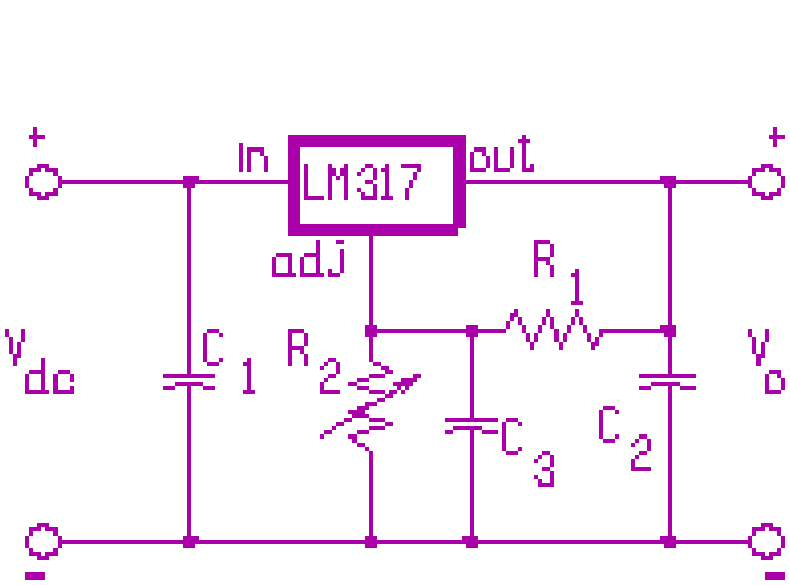
$$R_2 = \frac{R_1 (V_o - V_{reg})}{V_{reg} + I_Q R_1}$$

of

3-Terminal Variable Regulator

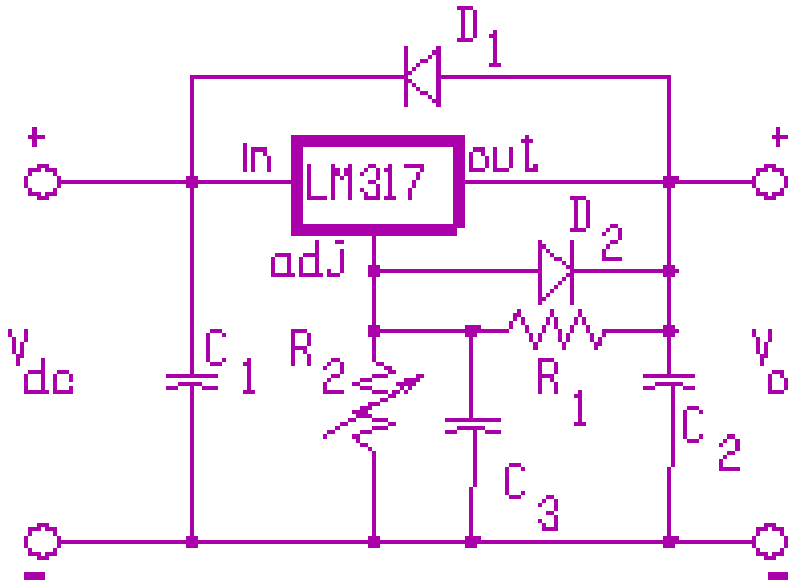
- The floating regulator could be made into a variable regulator by replacing R_2 with a pot. However, there are several disadvantages:
  - Minimum output voltage is V_{reg} instead of 0 V.
  - I_Q is relatively large and varies from chip to chip.
  - Power dissipation in R_2 can in some cases be quite large resulting in bulky and expensive equipment.
- A variety of 3-terminal variable regulators are available, e.g. LM317 (for +ve output) or LM 337 (for -ve output).

Basic LM317 Variable Regulator Circuits



(a)

Circuit with capacitors to improve performance



(b)

Circuit with protective diodes

Notes on Basic LM317 Circuits

- The function of C_1 and C_2 is similar to those used in the 78/79XX fixed regulators.
- C_3 is used to improve ripple rejection.
- Protective diodes in circuit (b) are required for high-current/high-voltage applications.

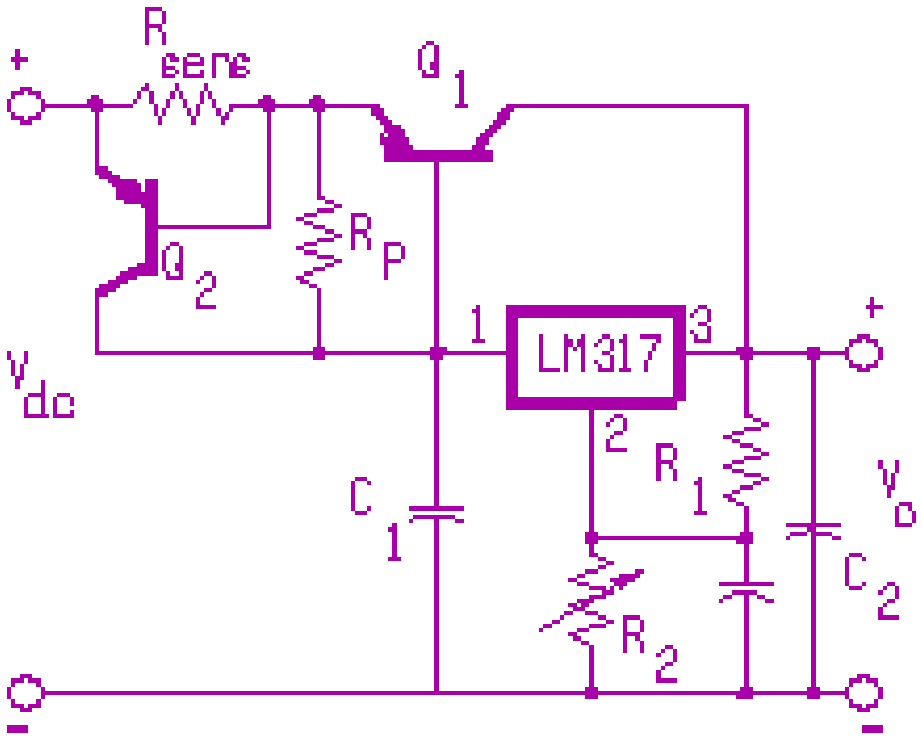
$$V_o = V_{ref} + \left(\frac{V_{ref}}{R_1} + I_{adj} \right) R_2$$

where V_{ref} = 1.25 V, and I_{adj} is the current flowing into the adj. terminal (typically 50 μA).

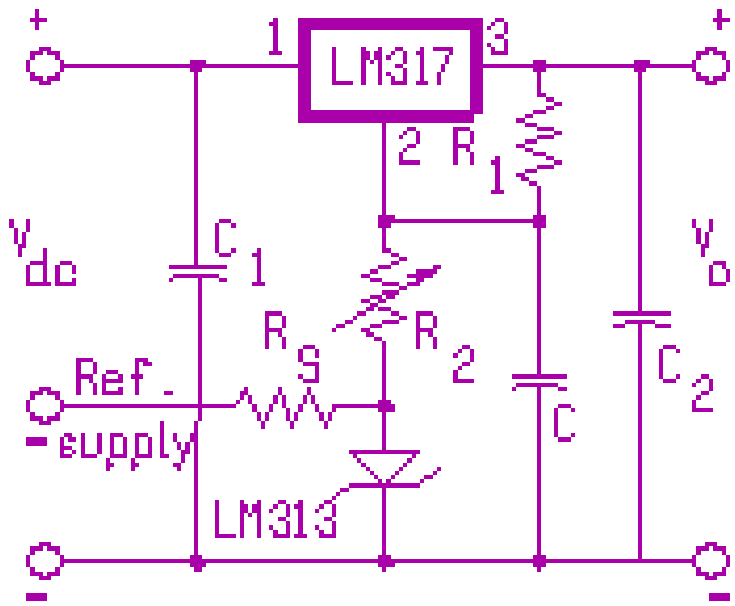
$$R_2 = \frac{R_1 (V_o - V_{ref})}{V_{ref} + I_{adj} R_1}$$

$R_1 = V_{ref} / I_{L(min)}$, where $I_{L(min)}$ is typically 10 mA.

LM317 Regulator Circuits

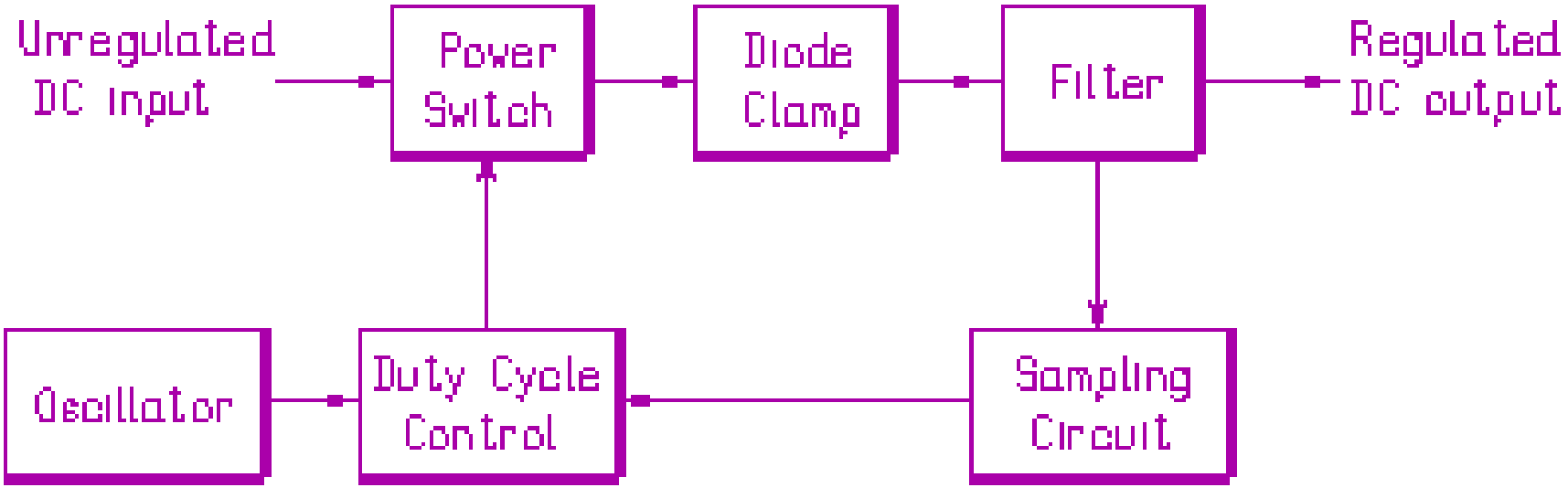


Circuit with pass transistor and current limiting



Circuit to give 0V min. output voltage

Block Diagram of Switch-Mode Regulator



It converts an unregulated dc input to a regulated dc output. Switching regulators are often referred to as dc to dc converters.

Comparing Switch-Mode to Linear Regulators

Advantages:

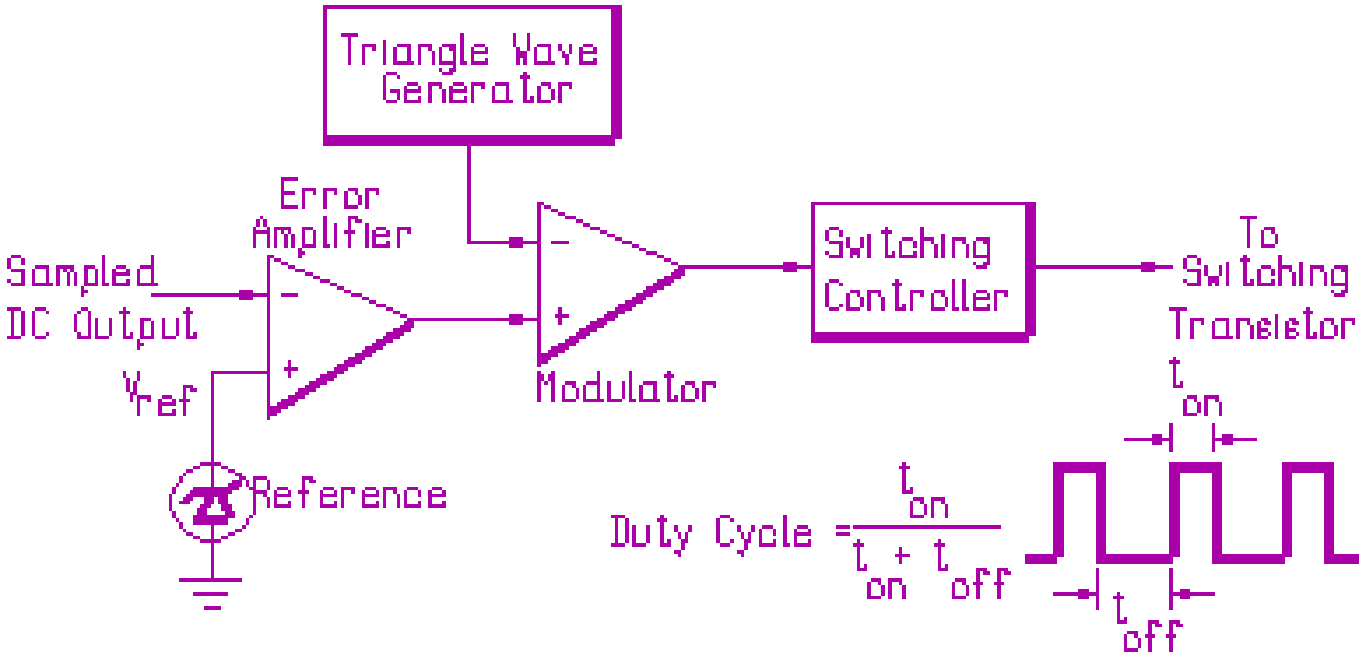
- 70-90% efficiency (about double that of linear ones)
- can make output voltage > input voltage, if desired
- can invert the input voltage
- considerable weight and size reductions, especially at high output power

Disadvantages:

- More complex circuitry
- Potential EMI problems unless good shielding, low-loss ferrite cores and chokes are used

General Notes on Switch-Mode Regulator

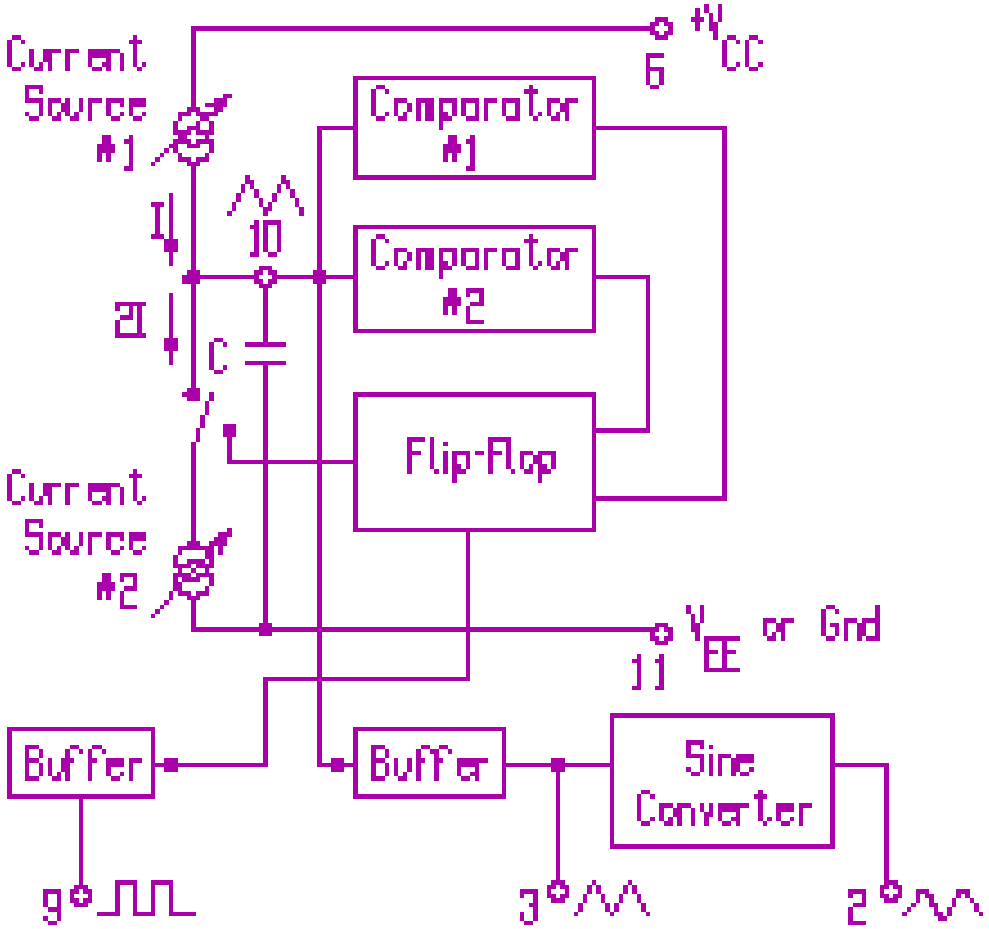
The duty cycle of the series transistor (power switch) determines the average dc output of the regulator. A circuit to control the duty cycle is the *pulse-width modulator* shown below:



General Notes cont'd . . .

- The *error amplifier* compares a sample of the regulator V_o to an internal V_{ref}. The difference or error voltage is amplified and applied to a *modulator* where it is compared to a triangle waveform. The result is an output pulse whose width is proportional to the error voltage.
- Darlington transistors and TMOS FETs with f_T of at least 4 MHz are often used. TMOS FETs are more efficient.
- A fast-recovery rectifier, or a Schottky barrier diode (sometimes referred to as a *catch diode*) is used to direct current into the inductor.
- For proper switch-mode operation, current must always be present in the inductor.

ICL8038 Function Generator IC

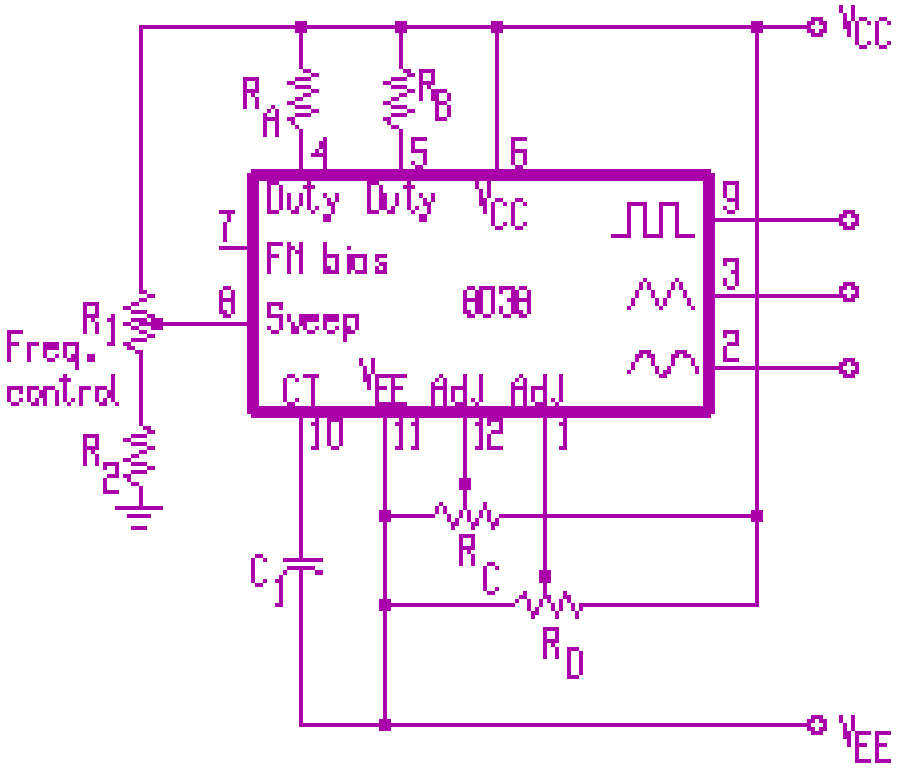


- Triangle wave at pin10 is obtained by linear charge and discharge of C by two current sources.
- Two comparators trigger the flip-flop which provides the square wave and switches the current sources.
- Triangle wave becomes sine wave via the sine converter .

ICL8038 Function Generator IC

- To obtain a square wave output, a pull-up resistor (typically 10 to 15 kΩ) must be connected between pin 9 and V_{CC}.
- Triangle wave has a linearity of 0.1 % or better and an amplitude of approx. $0.3(V_{CC}-V_{EE})$.
- Sine wave can be adjusted to a distortion of < 1% with amplitude of $0.2(V_{CC}-V_{EE})$. The distortion may vary with f (from 0.001 Hz to 200 kHz).
- IC can operate from either single supply of 10 to 30 V or dual supply of ✂5 to ✂15 V.

ICL8038 Function Generator Circuit



$$f_o = \frac{3(V_{CC} - V_{sweep})}{2RC_1V_{total}}$$

where $R = R_A = R_B$

If pin 7 is tied to pin 8,

$$f_o = \frac{3}{5R_AC_1\left(1+\frac{R_A}{2R_A - R_B}\right)}$$

For 50 % duty cycle,

$$f_o \approx \frac{0.3}{RC_1}$$

$+V_{CC} > V_{sweep} > \text{ß}V_{total} + V_{EE} + 2$

where $V_{total} = V_{CC} + |V_{EE}|$

Isolation Amplifier

- Provides a way to link a fixed ground to a floating ground.
- Isolates the DSP from the high voltage associated with the power amplifier.

ISOLATION AMPLIFIER

Purposes

- To break ground to permit incompatible circuits
- to be interfaced together while reducing noise
- To amplify signals while passing only low leakage current to prevent shock to people or damage to equipment
- To withstand high voltage to protect people, circuits, and equipment

Methods

- Power Supply Isolation : battery, isolated power
- Signal Isolation : opto-isolation, capacitive

OPTOCOUPLER

- The optocouplers provide protection and high-speed switching

- An optocoupler, also known as an opto-isolator, is an integral part of the opto electronics arena. It has fast proven its utility as an electrical isolator or a high-speed switch, and can be used in a variety of applications.

- The basic design for optocouplers involves use of an LED that produces a light signal to be received by a photodiode to detect the signal. In this way, the output current or current allowed to pass can be varied by the intensity of light.

OPTOCOUPLER

- A very common application for the opto coupler is a FAX machine or MODEM, isolating the device from the telephone line to prevent the potentially destructive spike in voltage that would accompany a lightning strike. This protective tool has other uses in the opto electronic area. It can be used as a guard against EMI, removing ground loops and reducing noise.

- This makes the optocoupler ideal for use in switching power supply and motor control applications. Today as semiconductors are being designed to handle more and more power, isolation protection has become more important than ever before.

Optoelectronic Integrated Circuits

Applications

- Inter- and intra-chip optical interconnect and clock distribution
- Fiber transceivers
- Intelligent sensors
- Smart pixel array parallel processors

Optoelectronic Integrated Circuits

Approaches

- Conventional hybrid assembly: multi-chip modules
- Total monolithic process development
- Modular integration on ICs:
- epitaxy-on-electronics
- flip-chip bump bonding w. substrate removal
- self-assembly

LM380 Power Amplifier

General Description

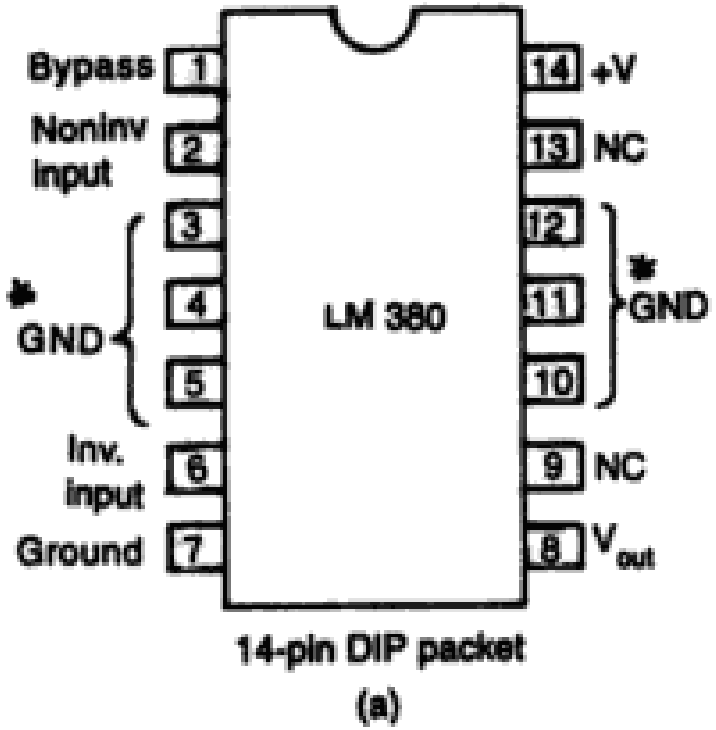
- The LM380 is a power audio amplifier for consumer application. In order to hold system cost to a minimum, gain is internally fixed at 34 dB. A unique input stage allows inputs to be ground referenced. The output is automatically self centering to one half the supply voltage. The output is short circuit proof with internal thermal limiting.

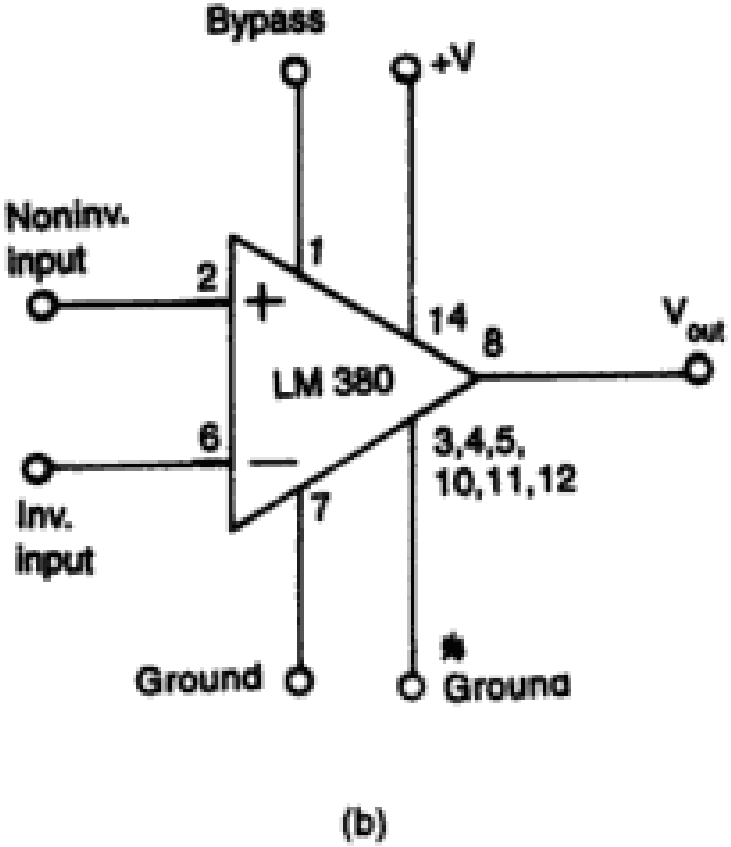
- The package outline is standard dual-in-line. A copper lead frame is used with the center three pins on either side comprising a heat sink. This makes the device easy to use in standard p-c layout.

Features

- Wide supply voltage range
- Low quiescent power drain
- Voltage gain fixed at 50
- High peak current capability
- Input referenced to GND
- High input impedance
- Low distortion
- Quiescent output voltage is at one-half of the supply
- voltage
- Standard dual-in-line package

PIN DIAGRAM AND BLOCK DIAGRAM OF LM380





Circuit Diagram for a Simple LM380-Based Power Amplifier