"When you give joy to other people, you get more joy in return. You should give a good thought to happiness that you can give out."

- Eleanor Roosevelt

11

Applications

11.1 Multiplexing Displays

- The decimal outputs of digital instruments such as digital voltmeters (DVMs) and frequency counters are often displayed using seven-segment indicators.
- Such indicators are often constructed using LED bar for each segment because of its direct compatibility with TTL and do not require higher voltages.
- Multiplexing of these LED are employed in the circuit so as to reduce the indicator power requirements.

In common anode LED type 7-segment indicator

- A segment is illuminated whenever an output of 7447 goes LOW (essentially to ground).
- If we assume a 2-V dc drop across an illuminated segment (LED), a current $I =$

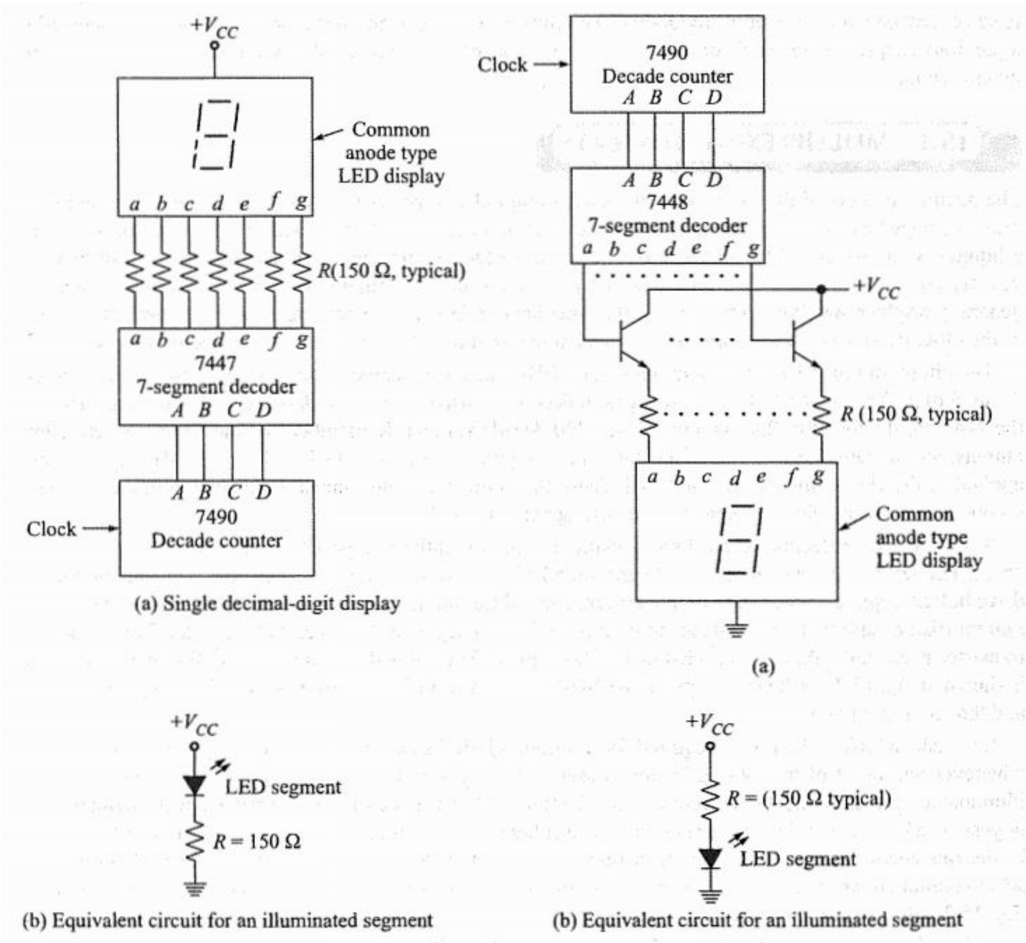

Figure 11.1: Decimal digit display.

$(5-2)/150 = 20mA$ is required to illuminate each segment.

- To illuminate all segment, we require $7 \times 20 = 140mA$.

- The 7447 will also required about 64 mA, so a maximum of around 200 mA is required for this single digital display.

- A digital instrument that has a four-digital decimal display will require four of circuits in figure 11.1 and thus has a current requirement of 4 x 200 = 800 mA.
- A six-digital instrument would require 1200 mA, or 1.2 A, just for display.
- Clearly these current requirements are much too large for small instruments, but they can be greatly reduced using multiplexing technique.

Multiplexing Display

- Basically multiplexing is accomplished by applying current to each display digit in short, repeated puses rather than continuously.

- If the pulse repeation rate is sufficiently high (i.e $\geq$ 60 Hz), our eyes will perceive a steady illumination without any flicker.

- In figure 11.2, a single digit display is shown. +5 V DC is applied through a pnp transistor that acts like a switch.

- When DIGIT = 1, the transistor is OFF, and the indicator current is zero.

- When DIGIT = 0, the transistor is ON, and the number is displayed.

- If waveform in used as DIGIT as shown in 11.2 b, when transistor is ON, the segment will be displayed a number for only 1 out of every 4 ms.

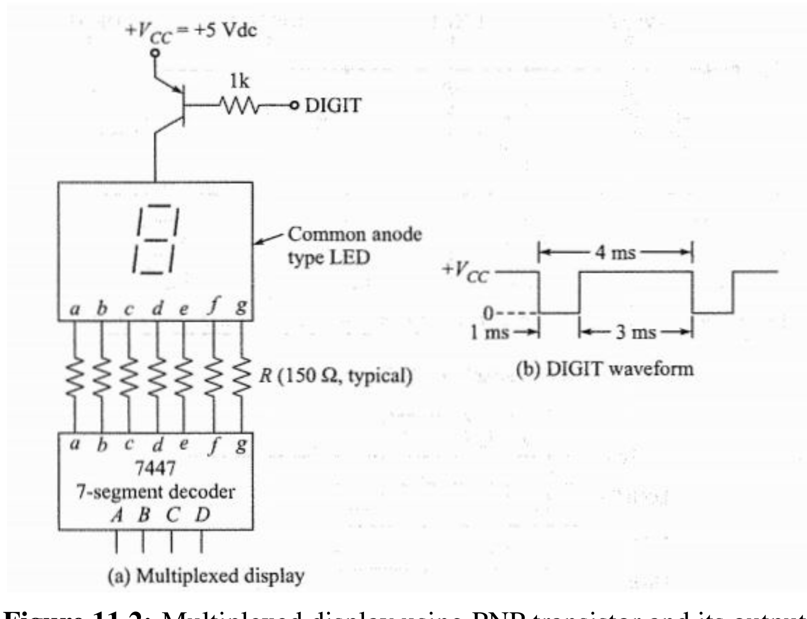

Figure 11.2: Multiplexed display using PNP transistor and its output.

- Even though the display is not illuminated for 3 out of 4 ms, the illumination will appear to eyes as if it is continuous.

- The repetition rate (RR) is given by 1/0.004 = 250 Hz(> 60 Hz).

- That is, this single digit display requires only one-fourth the current of a continuously illuminated display.

Multiplexing four-digit display

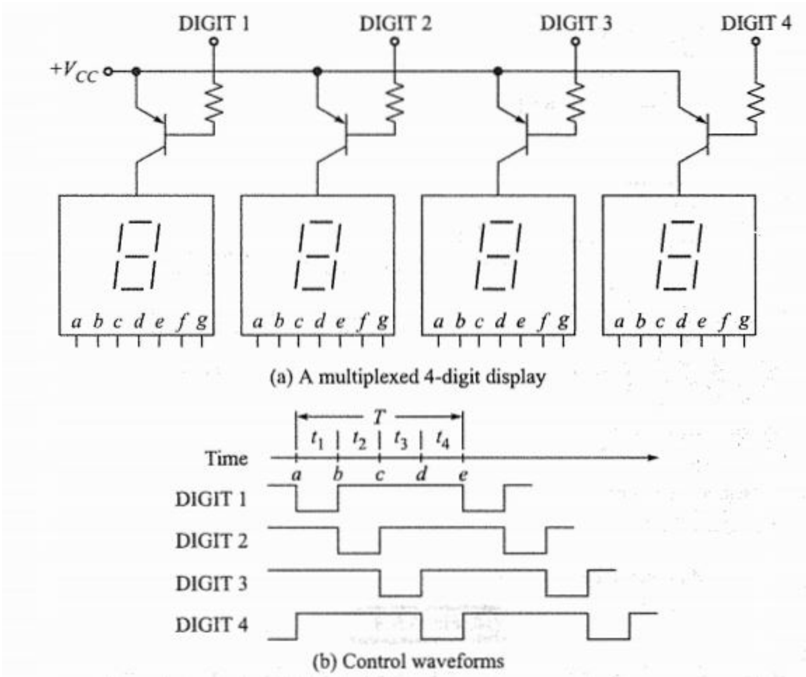

Figure 11.3: Multiplexing four digit display.

- Assume, a digit 1 is illuminated during time t_1, digit 2 at t_2 and so on.
- Each digit will be illuminated one fourth of time.

- If $t_1 = t_2 = t_3 = t_4 = T/4$
- If t_1 = 1 ms, T = 4 ms, the RR = 250 Hz.

- In fact, in multiplexing displays in this way, teh power supply current is simply the current required for a single display no matter how many displays are being multiplexed.

11.2 Frequency Counters

- A frequency counter is a digital instrument that can be used to measure the frequency of any periodic waveform.
- A GATE ENABLE singal that has known period t, and is applied to one leg of an NAD gate.
- The unknown signal is applied to the other leg of the AND gate and act as the clock for the counter.

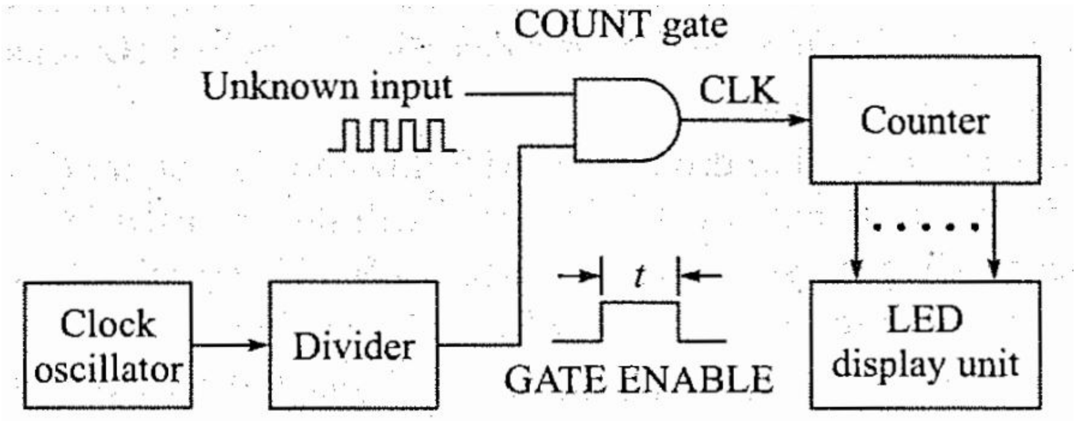

Figure 11.4: Basic frequency counter.

- The counter will advance for one count for each transition of the unknown signal, and at the end of the known time period, the contents of the counter will equal the number of periods of the unknown signal that have occurred during t.
- In other word, the counter contents will be proportion to the frequency of the unknown signal.

For example:
- Suppose the gate signal is 1s and the unknown input signal is a 750-Hz square wave.
- At the end of 1s, the counter will have counted up to 750, which is the exactly the frequency of the input signal.

11.3 Time Measurement

- With slight modification, the frequency counter can be changed into the instrument for measuring the time.

The unknown voltage is passed through a conditioning amplifier to produce a periodic waveform that is compatible with TTL circuit and is then applied to a JK flip-flop.
- The output of this flip-flop is used as the ENABLE gate input; since it is high for a time period t that is exactly equal to the time period of the unknown input voltage.
- The oscillator and divider provides a series of pulses that are passed through the count gate and serve as the clock for the counter.
- The contents of the counter and display unit will then be proportional to the time pe-

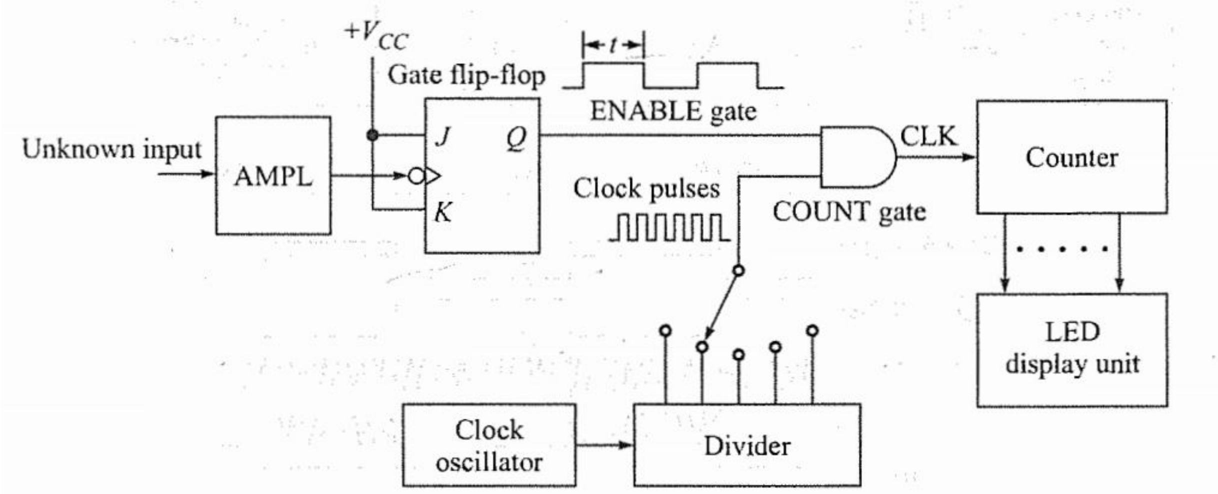

Figure 11.5: Instrument to measure time period.

riod of the unknown input signal.

For example:

- If the unknown input signal is a 5-KHz sine wave and the clock pulses from the divider are 0.1 μs in width and are spaced every 0.1 μs, the counter and display will read 200.

Suppose:

Display unit have 5-decimal digit capacity

Unknown input = 200 Hz square wave.

Divider switch = 100 KHz square wave

Now,

ENABLE gate time, t = 1/200 = 5000 μs,

100 KHz square wave used as the clock produces a series of pulses of 10 μs.

Therefore, during the gate time t, the counter will advance by,

$$\frac{5000}{10} = 500 \quad counts$$

This will be displayed.

Since, each clock pulse represents 10 μs, the time period of unknown input = 500 x 10 μs = 5000 μs.