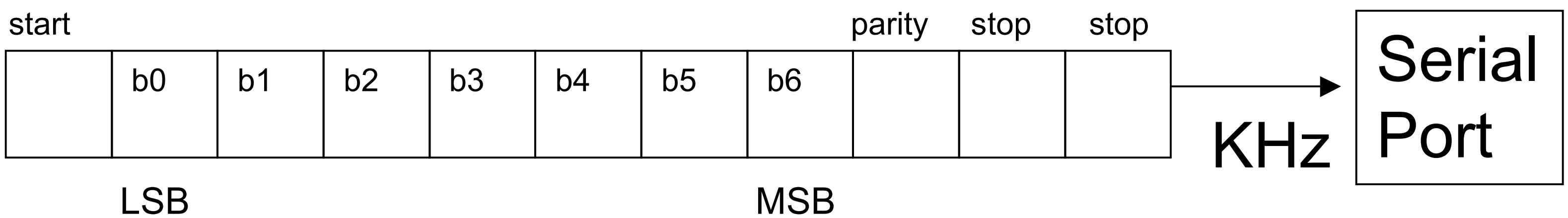
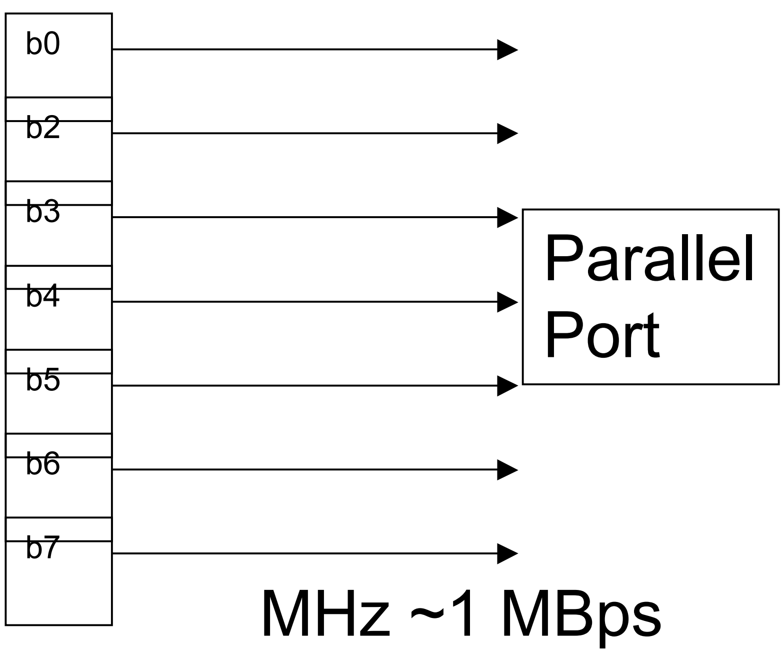
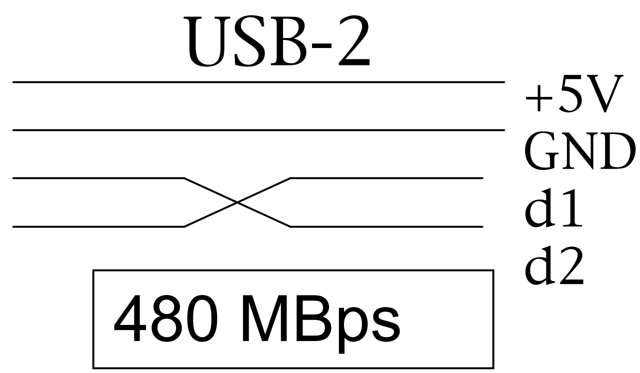
Chapter-14 Digital and Analogue I/O

Serial Transmission (RS232) (lower cost)



Parallel Transmission



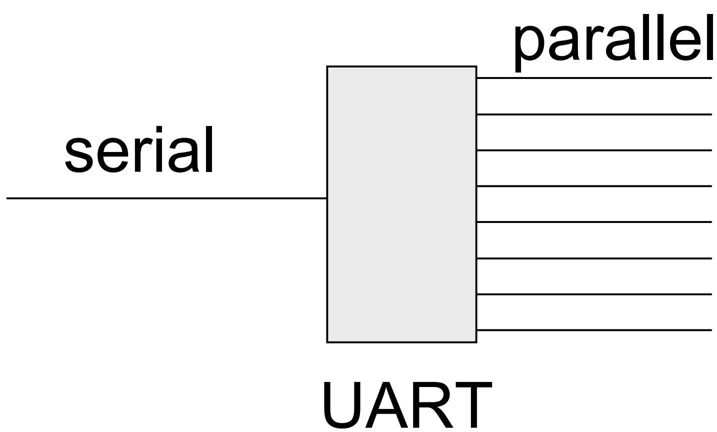


Serial -to- Parallel Conversion

Serial ports, also called **communication (COM) ports**, are **bi-directional**. Bi-directional communication allows each device to receive data as well as transmit it. Serial devices use different pins to receive and transmit data -- using the same pins would limit communication to **half-duplex**, meaning that information could only travel in one direction at a time. Using different pins allows for **full-duplex** communication, in which information can travel in both directions at once.

This 40-pin Dual Inline Package (DIP) chip is a variation of the National Semiconductor NS16550D UART chip.

Serial ports rely on a special controller chip, the **Universal Asynchronous Receiver/Transmitter (UART)**, to function properly. The UART chip takes the parallel output of the computer's system bus and transforms it into serial form for transmission through the serial port. In order to function faster, most UART chips have a built-in buffer of anywhere from 16 to 64 kilobytes. This buffer allows the chip to cache data coming in from the system bus while it is processing data going out to the serial port. While most standard serial ports have a maximum transfer rate of 115 Kbps (kilobits per second), high speed serial ports, such as **Enhanced Serial Port (ESP)** and **Super Enhanced Serial Port (Super ESP)**, can reach data transfer rates of 460 Kbps.



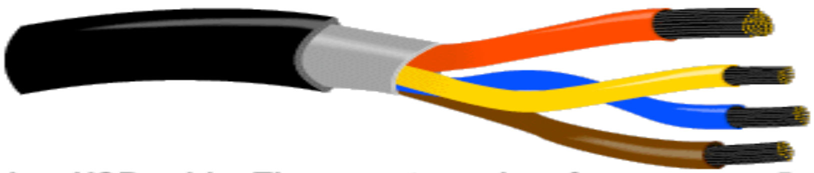
The USB Process

When the host powers up, it queries all of the devices connected to the bus and assigns each one an address. This process is called **enumeration** -- devices are also enumerated when they connect to the bus. The host also finds out from each device what type of data transfer it wishes to perform:

- **Interrupt** - A device like a mouse or a keyboard, which will be sending very little data, would choose the interrupt mode.
- **Bulk** - A device like a printer, which receives data in one big packet, uses the bulk transfer mode. A block of data is sent to the printer (in 64-byte chunks) and verified to make sure it is correct.
- **Isochronous** - A streaming device (such as speakers) uses the isochronous mode. Data streams between the device and the host in real-time, and there is no error correction.

The host can also send commands or query parameters with **control packets**.

The devices connected to a USB port rely on the USB cable to carry power and data.



Inside a USB cable: There are two wires for power -- +5 volts (red) and ground (brown) -- and a twisted pair (yellow and blue) of wires to carry the data. The cable is also shielded.

USB Features

The Universal Serial Bus has the following features:

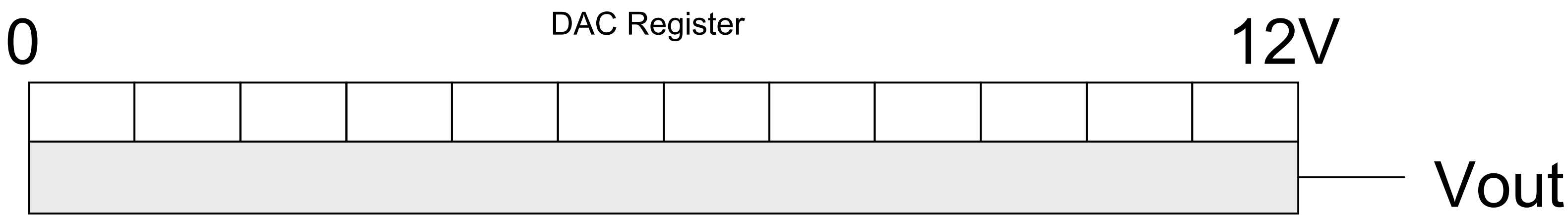
- The computer acts as the **host**.
- Up to **127 devices** can connect to the host, either directly or by way of USB hubs.
- Individual USB cables can run as long as 5 meters; with hubs, devices can be up to 30 meters (six cables' worth) away from the host.
- With USB 2.,the bus has a maximum data rate of **480 megabits per second**.
- A USB cable has two wires for power (+5 volts and ground) and a twisted pair of wires to carry the data.
- On the power wires, the computer can supply up to 500 milliamps of power at 5 volts.
- Low-power devices (such as mice) can draw their power directly from the bus. High-power devices (such as printers) have their own power supplies and draw minimal power from the bus. Hubs can have their own power supplies to provide power to devices connected to the hub.
- USB devices are **hot-swappable**, meaning you can plug them into the bus and unplug them any time.
- Many USB devices can be put to **sleep** by the host computer when the computer enters a power-saving mode.

DAC - Digital to Analogue Conversion

A DAC converts a digital number to an analogue voltage level. For example I show a 12-bit DAC with a dynamic range of 0-12V. Each bit then represents

$$\Delta V = 1/2^{12} = 1/4096 \times 12V = 2.93mV$$

Thus the DAC resolution ΔV is about 3 mV. The Analogue signal will occur in these 3mV steps.

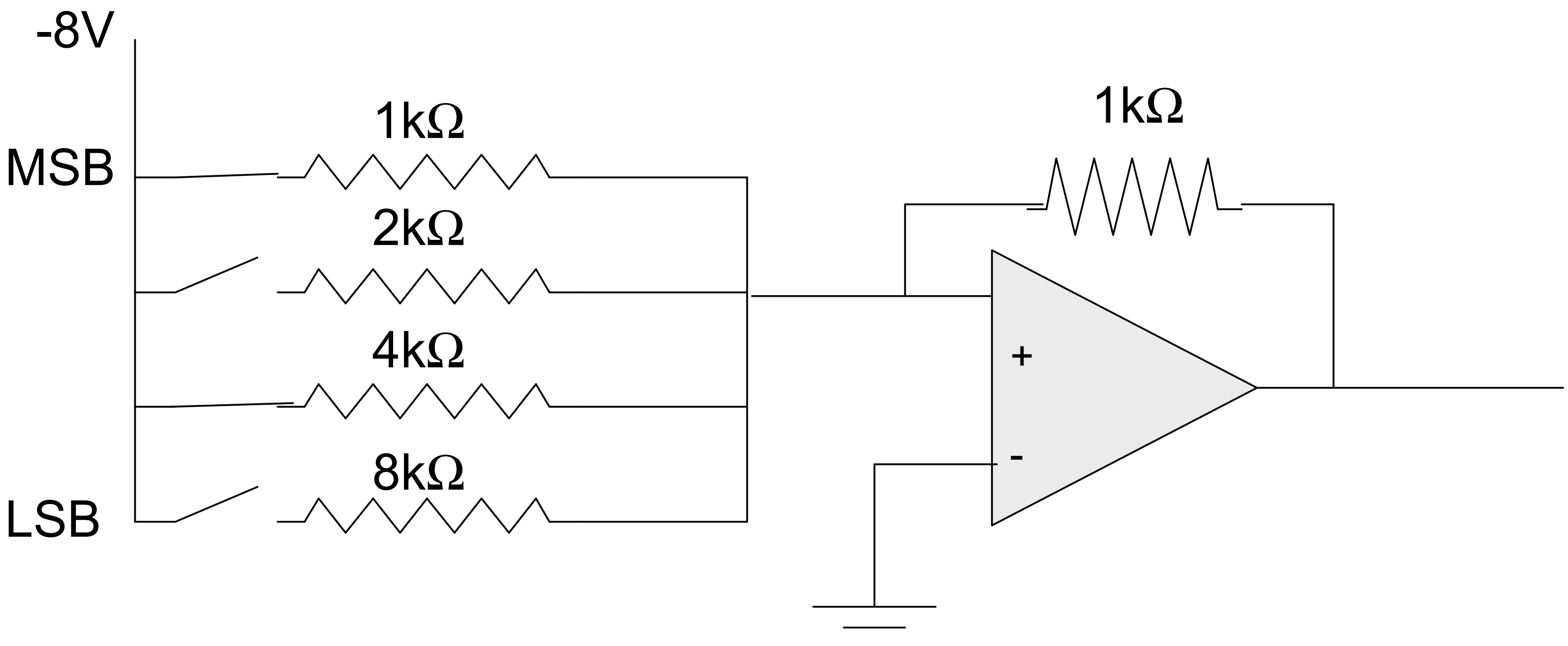


If the hexidecimel number 2F5 is loaded in to the DAC register what voltage comes out?

$2F5 = 0010\ 1010\ 0101 = 1x2^9 + 1x2^7 + 1x2^5 + 1x2^2 + 1x2^0 = 677$

Vout = $(677/4096)12V = 677 \times 2.93mV =$ **1.98V**

4-BIT DAC CIRCUIT w OP-AMP



1111_{LSB} --> Vout = [1(1/8)+1(1/4) +1(1/2) +1(1/1)] 8V = 15V

0001_{LSB} --> Vout = [1(1/8)+0(1/4) +0(1/2) +0(1/1)] 8V = 1V

Wilkinson ADC

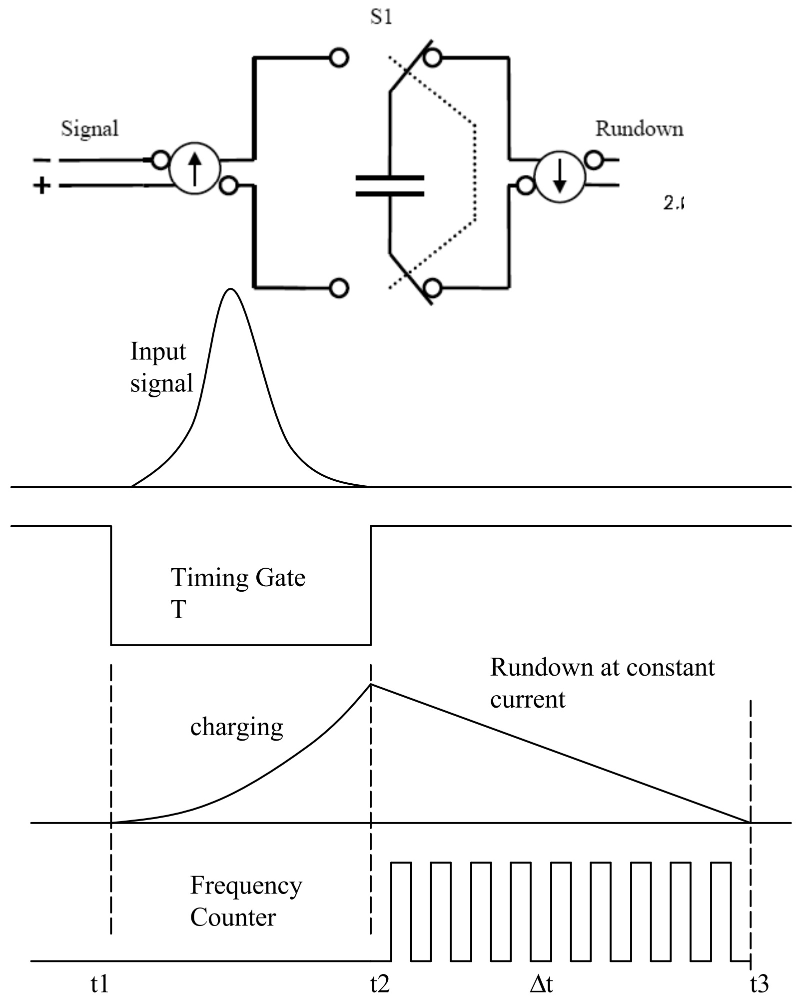
$I.\ Charge-up$

$$q_T = \frac{1}{R_{in}} \int_0^T V(t)\,dt \quad charge\ collected$$

$$R_{in} = ADC\ input\ impedance\ (\ 50\Omega)$$

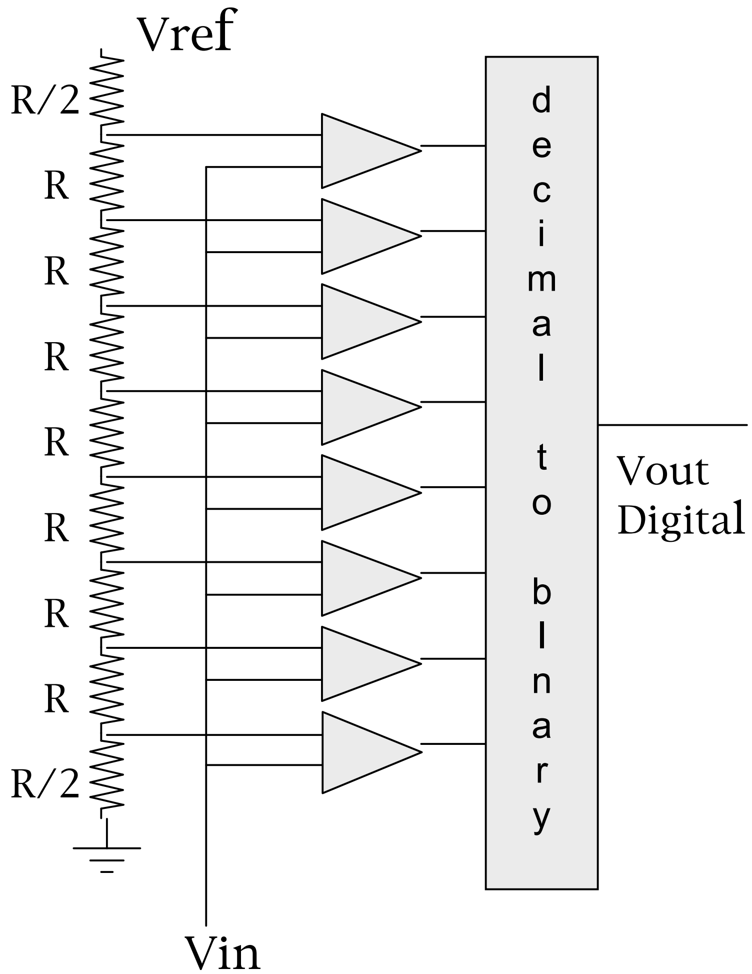
$II.\ Linear\ Run-down\ at\ constant$
$current\ I_0$

$$q_T = I_0 N \Delta t$$

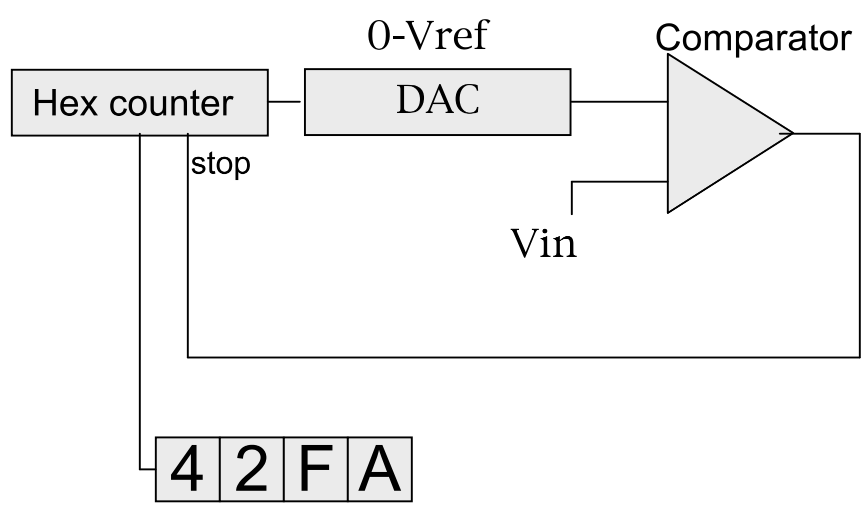


Analogue-to-Digital Conversion

Parallel conversion ADC



Successive Approximation ADC



Parallel Conversion ADC