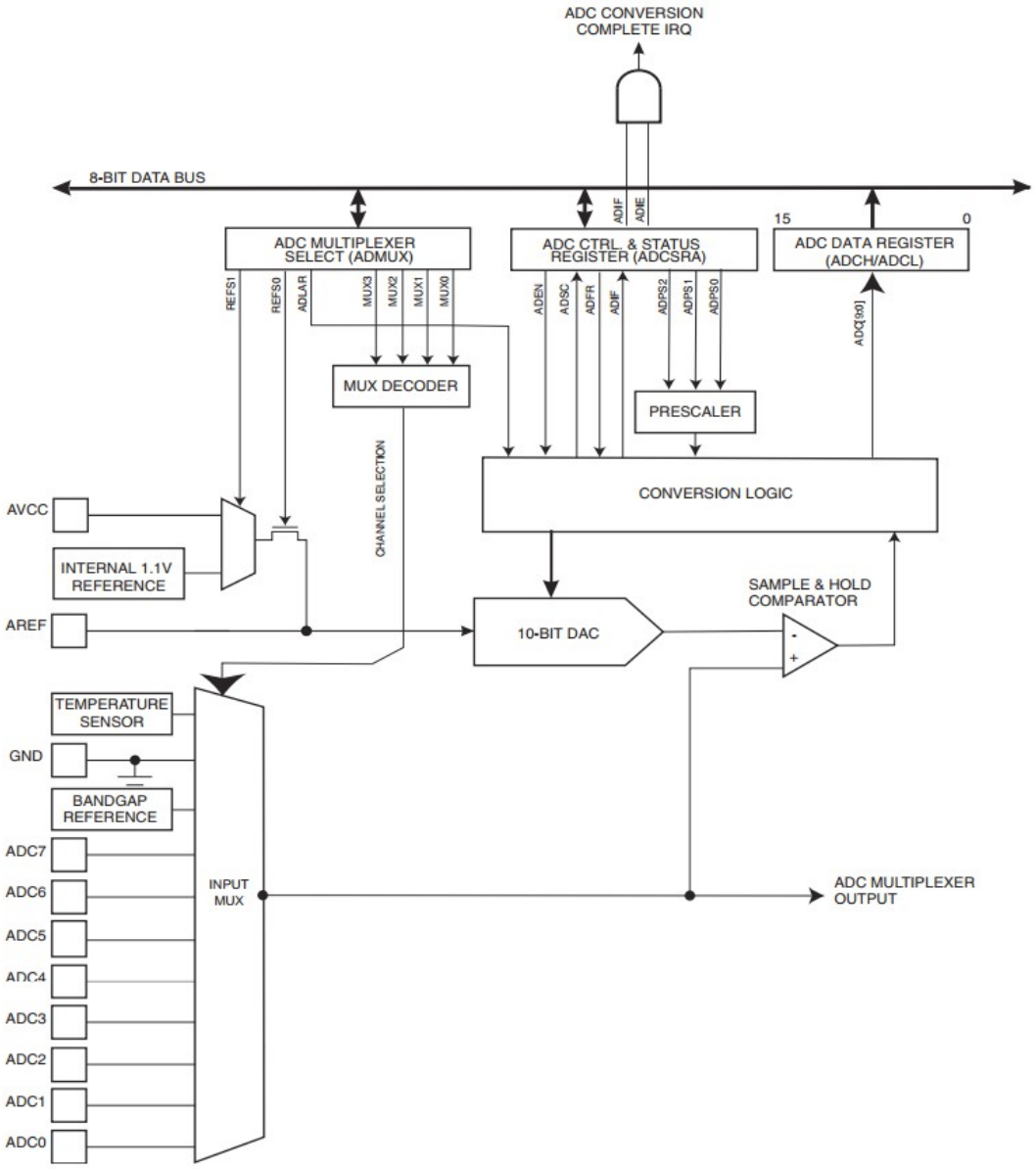
Figure 24-1. Analog to Digital Converter Block Schematic Operation,



Computing the number received from the ADC:

When the input to the ADC is at a voltage, Vin (between 0 and Aref), the number that will be returned by the ADC, N (0 to 1023), can be computed by the following formula.

$$N = 1024 * \frac{Vin}{Aref}$$

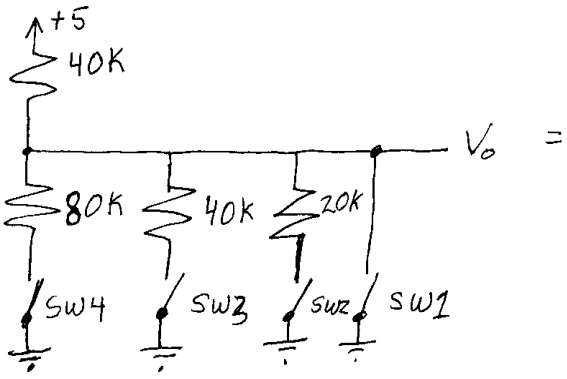
or if you had an ADC reading of N, you would compute the voltage as

$$V = Aref * \frac{N}{1024}$$

Appendix A: Default Reference assumed as 5 volts.

```
// Software Timer sending data
// out every 0.5 seconds.
unsigned long Timer;
#define INTERVAL 500

// put your setup code here, to run once:
void setup()
{
       Serial.begin(38400); // Set up Serial port.
       Timer = millis();      // Timer setup.
} // End of setup

// put your main code here, to run repeatedly:
void loop()
{
       float Voltage;
       // Check time
       if (millis() - Timer >= INTERVAL)
       {
              // if 500 milliseconds, compute voltage
              // based on assumed reference.
              Voltage = 5.0*analogRead(0) / 1024.0;
              Serial.println(Voltage);
              // Update timer
              Timer += INTERVAL;

       } // End of Timer

} // End of loop
```

Application that does not need an exact reference.



Sw1 -> $Vo = 0$

Sw2 -> $Vo = \frac{20K}{40K + 20K} * 5 = 1.666$

Sw3 -> $Vo = \frac{40K}{40K + 40K} * 5 = 2.5$

Sw4 -> $Vo = \frac{80K}{40K + 80K} * 5 = 3.33$

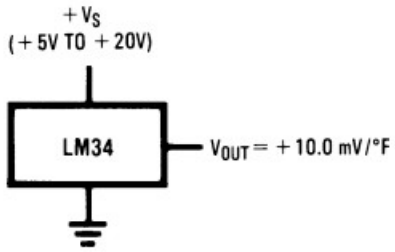
Appendix B: External Reference of 3.5 volts.

```
// Software Timer sending data
// out every 0.5 seconds.
unsigned long Timer;
#define INTERVAL 500

// put your setup code here, to run once:
void setup()
{
       Serial.begin(38400); // Set up Serial port.
       Timer = millis();      // Timer setup.
       analogReference(EXTERNAL); // set reference to the external supply.
} // End of setup

// put your main code here, to run repeatedly:
void loop()
{
       float Voltage;
       // Check time
       if (millis() - Timer >= INTERVAL)
       {
              // if 500 milliseconds, compute voltage
              // based on external reference.
              Voltage = 3.5*analogRead(0) / 1024.0;
              Serial.println(Voltage);
              // Update timer
              Timer += INTERVAL;

       } // End of Timer

} // End of loop
```

Application needing a better reference:

Temperature sensor LM34

Basic Fahrenheit Temperature Sensor (5°F to 300°F)



If Aref is 3.5 volts, the precision is 3.5 V / 1024 = 3.42 x 10^{-3} M = 3.42 mV. This means that we can measure 3.42mV / 10mV or 0.342 degree F per bit.

Temperature Range 0 - 350 degrees

Appendix C: Internal Reference of 1.1 Volts.

```
// Software Timer sending data
// out every 0.5 seconds.
unsigned long Timer;
#define INTERVAL 500

// put your setup code here, to run once:
void setup()
{
	Serial.begin(38400); // Set up Serial port.
	Timer = millis();	// Timer setup.
	analogReference(INTERNAL); // set reference to the external supply.
} // End of setup

// put your main code here, to run repeatedly:
void loop()
{
	float Voltage;
	// Check time
	if (millis() - Timer >= INTERVAL)
	{
		// if 500 milliseconds, compute voltage
		// based on external reference.
		Voltage = 1.1*analogRead(0) / 1024.0;
		Serial.println(Voltage);
		// Update timer
		Timer += INTERVAL;

	} // End of Timer

} // End of loop
```

If we do the same computation on reading the LM34, we get.

If Aref is 1.1 volts, the precision is 1.1 V / 1024 = 1.075 x 10^{-3} M = 1.075 mV. This means that we can measure 1.075mV / 10mV or 0.1075 degree F per bit.

Temperature Range 0 - 110 degrees

This precision and range are very sufficient for room/ambient temperatures.