Embedded Systems Interfacing

Lecture one

Digital Input Output Part 1

Digital To Analog Converter
(DAC)

When talking about signals, they can be broadly classified into analog signals and digital signals.

All dgital Electronics like Logic Gates, Flip-Flops, Microcontroller, Microprocessor etc work with Digital Signals, while the Analog Electronics are like Op-Amp, Power switches etc.

In a typical electronics design, these two signals often have to be converted from one form to another.

We already know how Analog to Digital Converter (ADC) is used to convert analog signals to digital value.

Here we will learn how Digital signals can be converted to Analog voltages using DACs.

Note that the ADC (Analog to Digital Converter) performs the opposite function of the DAC, it converts the analog signal to digital.

Digital Signal Processing (DSP)
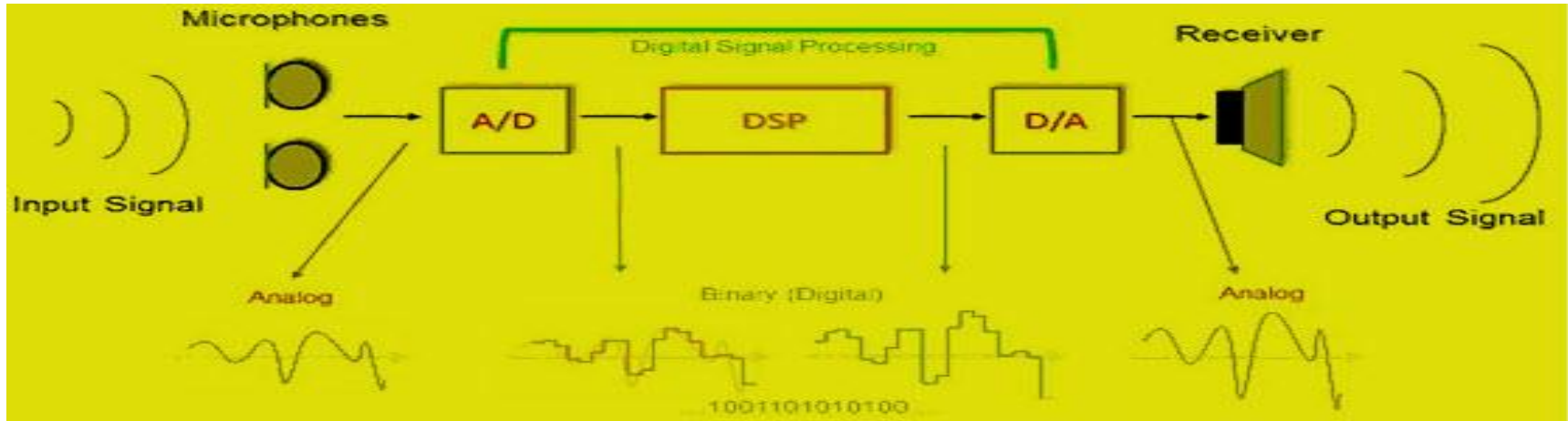
an ADC converts the analog data collected by audio input equipment such as a microphone (sensor), into a digital signal that can be processed by a computer or a microcontroller.

The microcontroller may add sound effects like amplification. Now a DAC will process the amplified digital sound signal back into the analog signal that is used by audio output equipment such as a speaker.

Digital Signal Processing
(DSP)

This process can be broken down into these steps:

1. During the recording process, an artist lays down a track. Microphones pick up the sounds of voices and instruments as analog audio signals.

2. Recording engineers store the analog signals as digital. Recording equipment uses analog-to-digital converters to transform the analog signals to digital signals for storage. Nowadays, this usually means storing them as digital signals as a digital audio file.

3. During playback, a DAC decodes the stored digital signals. In doing so, the DAC converts those signals back into analog audio.

4. A DAC sends the converted analog signals to an amplifier. The amplifier, in turn, sends music through your headphones or stereo speakers.

DAC Operation
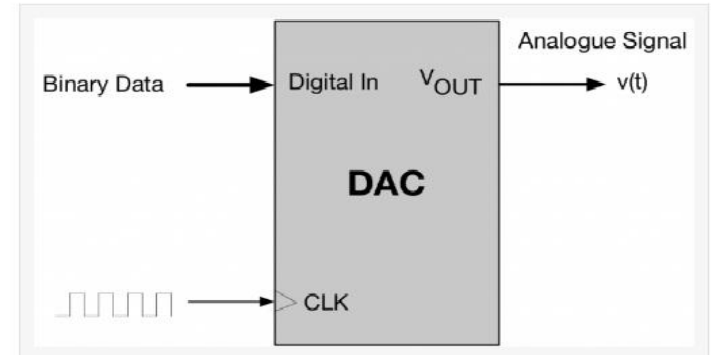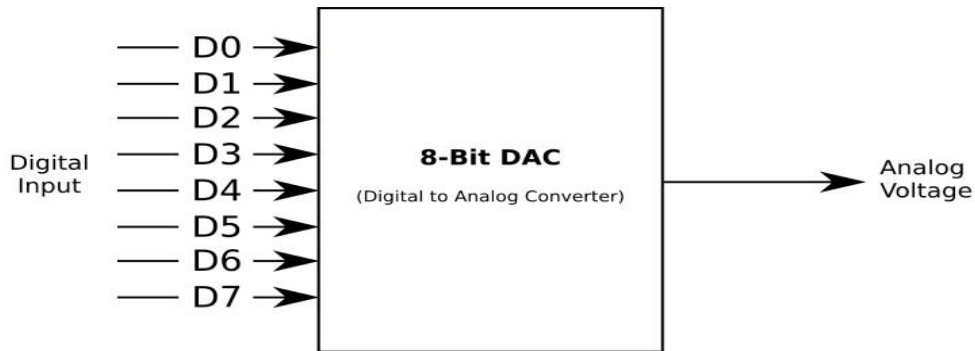
the DAC device may have the input represented in several data inputs, which is called parallel DAC, or it may have 1 input pin only where each bit of the data word is sent in sequence, this is called serial DAC.

The digital data may be produced from a microprocessor, Application Specific Integrated Circuit (ASIC), or Field Programmable Gate Array (FPGA),then the data requires the conversion to an analog signal in order to interact with the real world.

Our microcontroller stm32f103c8 doesn't have an internal DAC peripheral so we will implement our DAC ourselves.

There are two methods commonly used for digital to analog conversion: **Weighted Resistors** method and the other one is using the **R-2R ladder network** method.

The weighted resistor DAC has a very simple idea but its implementation is a bit hard as it requires a large range of resistor values, this range increases dramatically with increasing number of bits in the digital input voltage and accordingly the accuracy becomes poor.

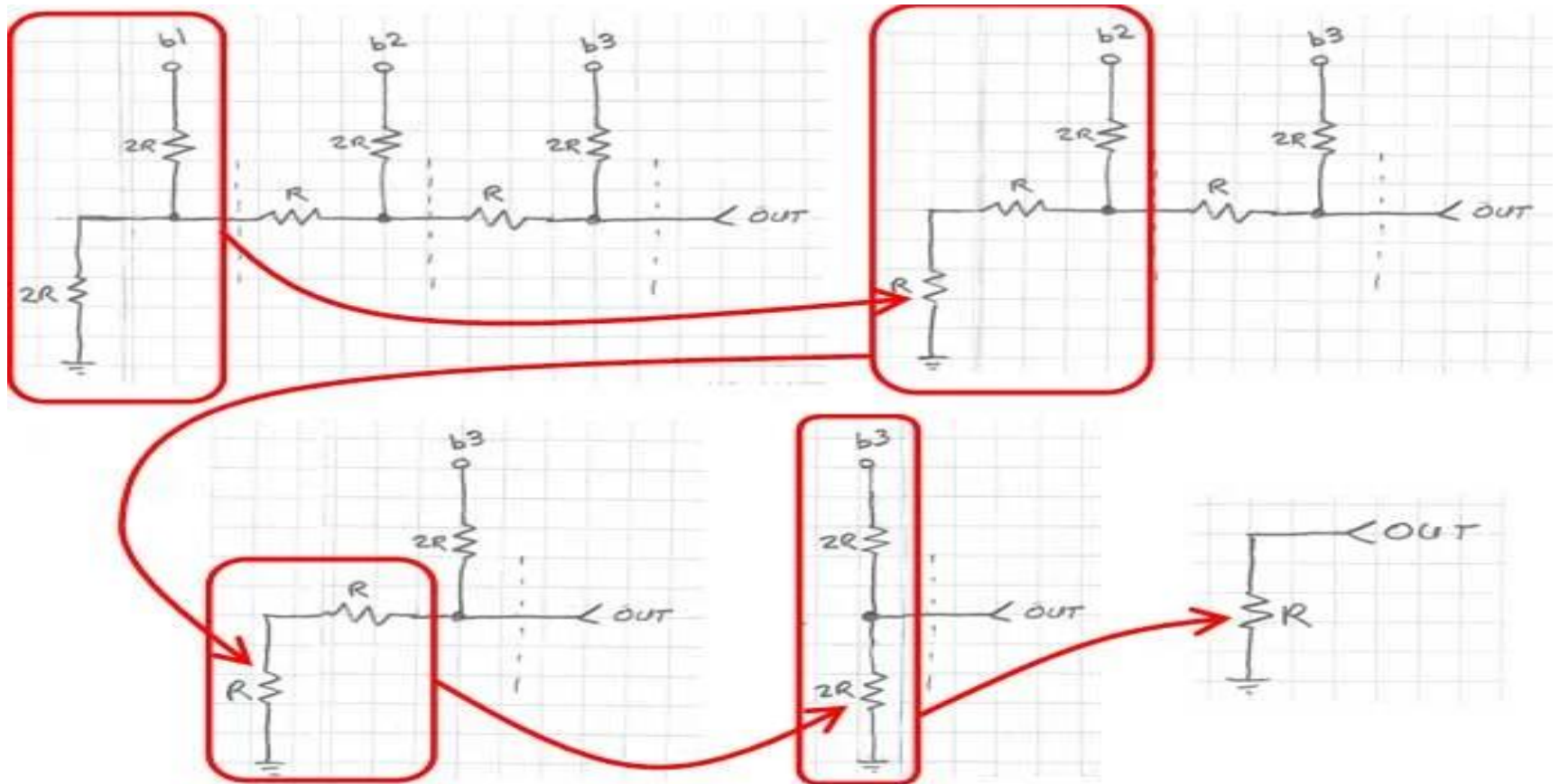For these reasons, IMT has chosen the R2R ladder network method to implement its on-board DAC.
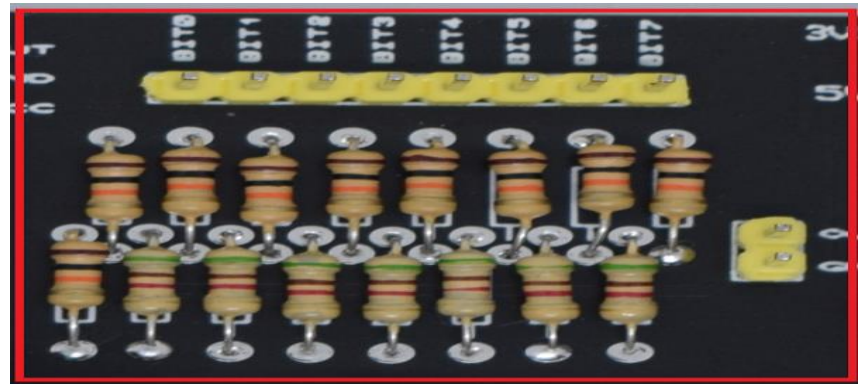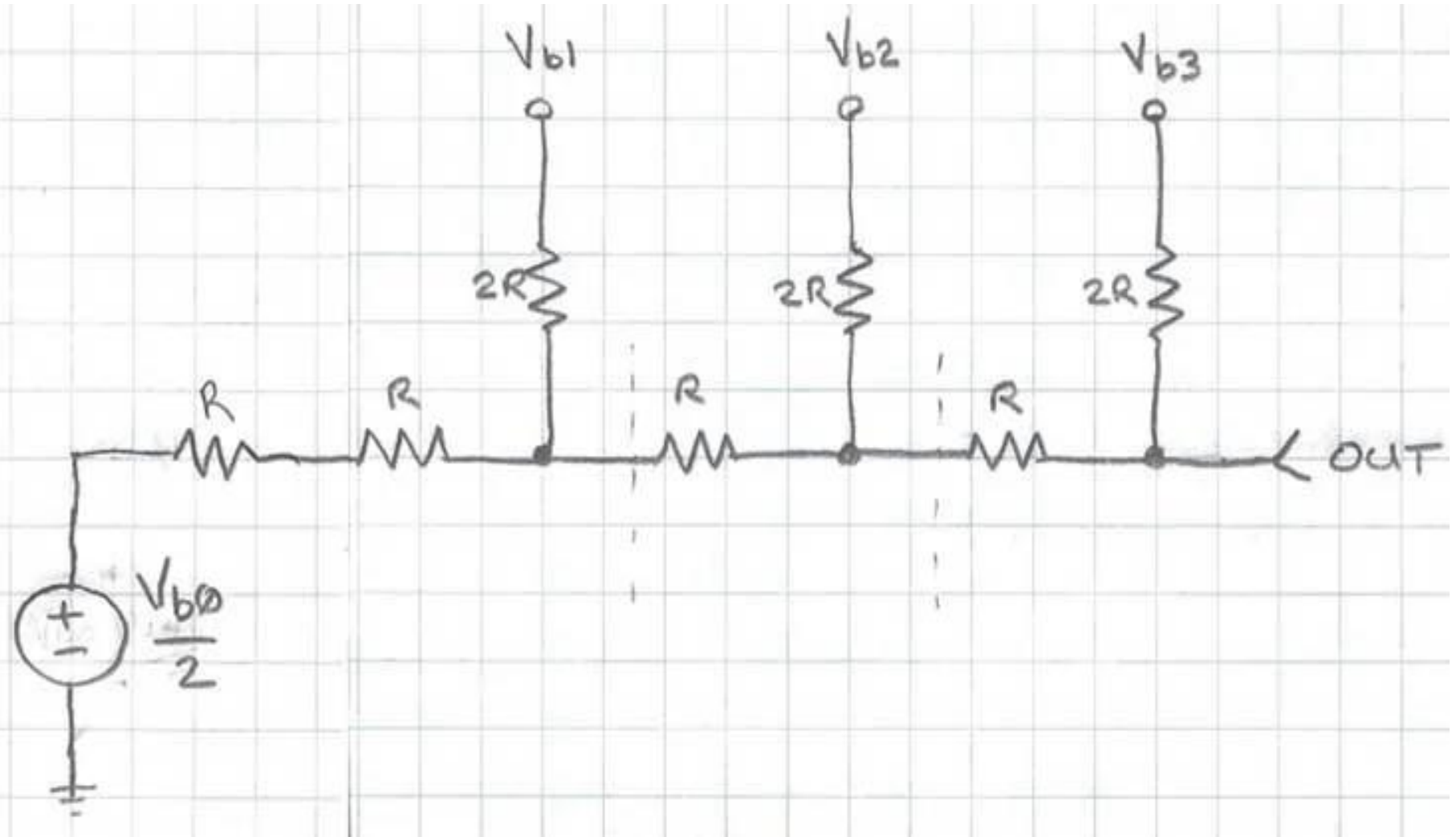
R2R Resistor Ladder DAC

An R–2R ladder is a simple and inexpensive way to perform digital-to-analog conversion, using repetitive arrangements of precise resistor networks in a ladder-like configuration
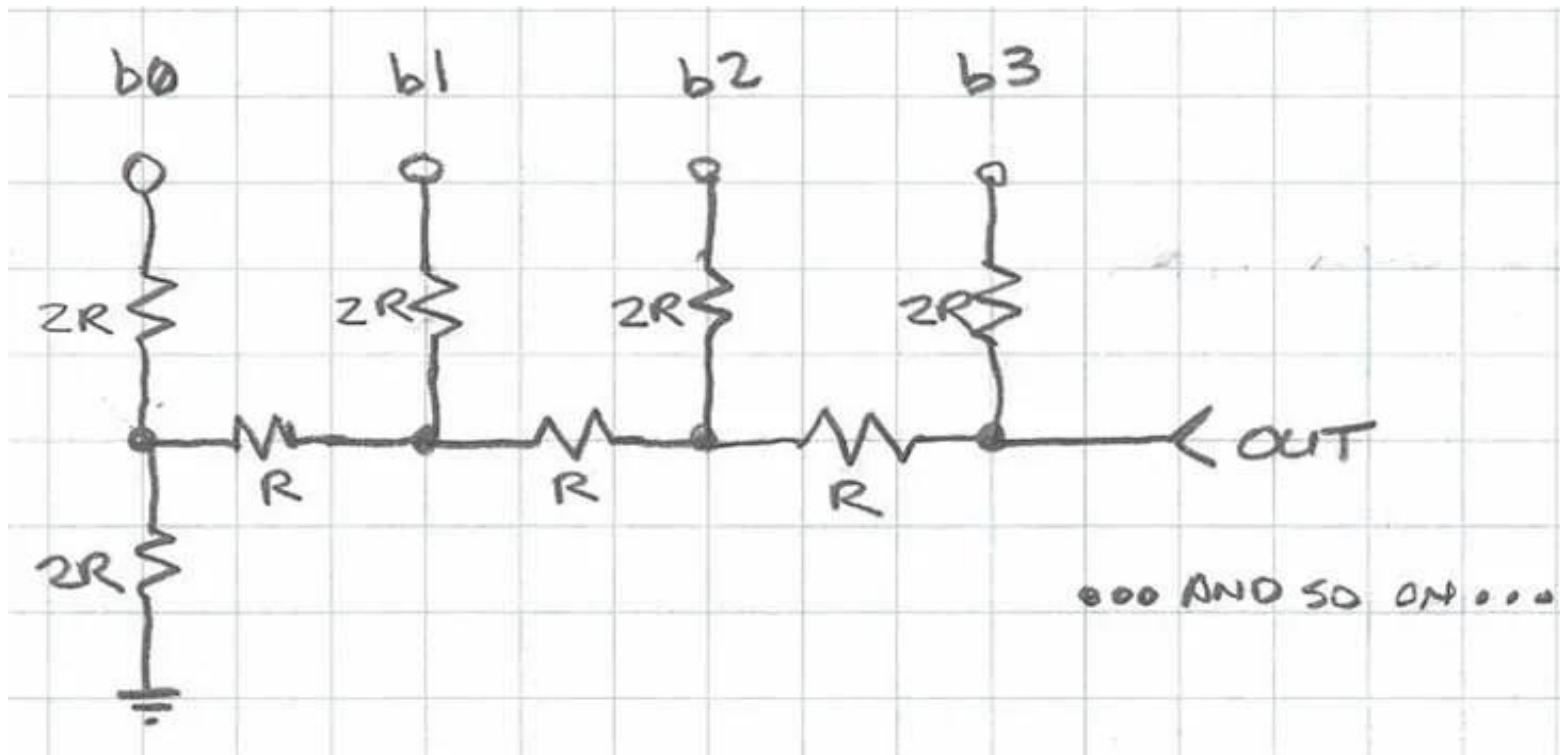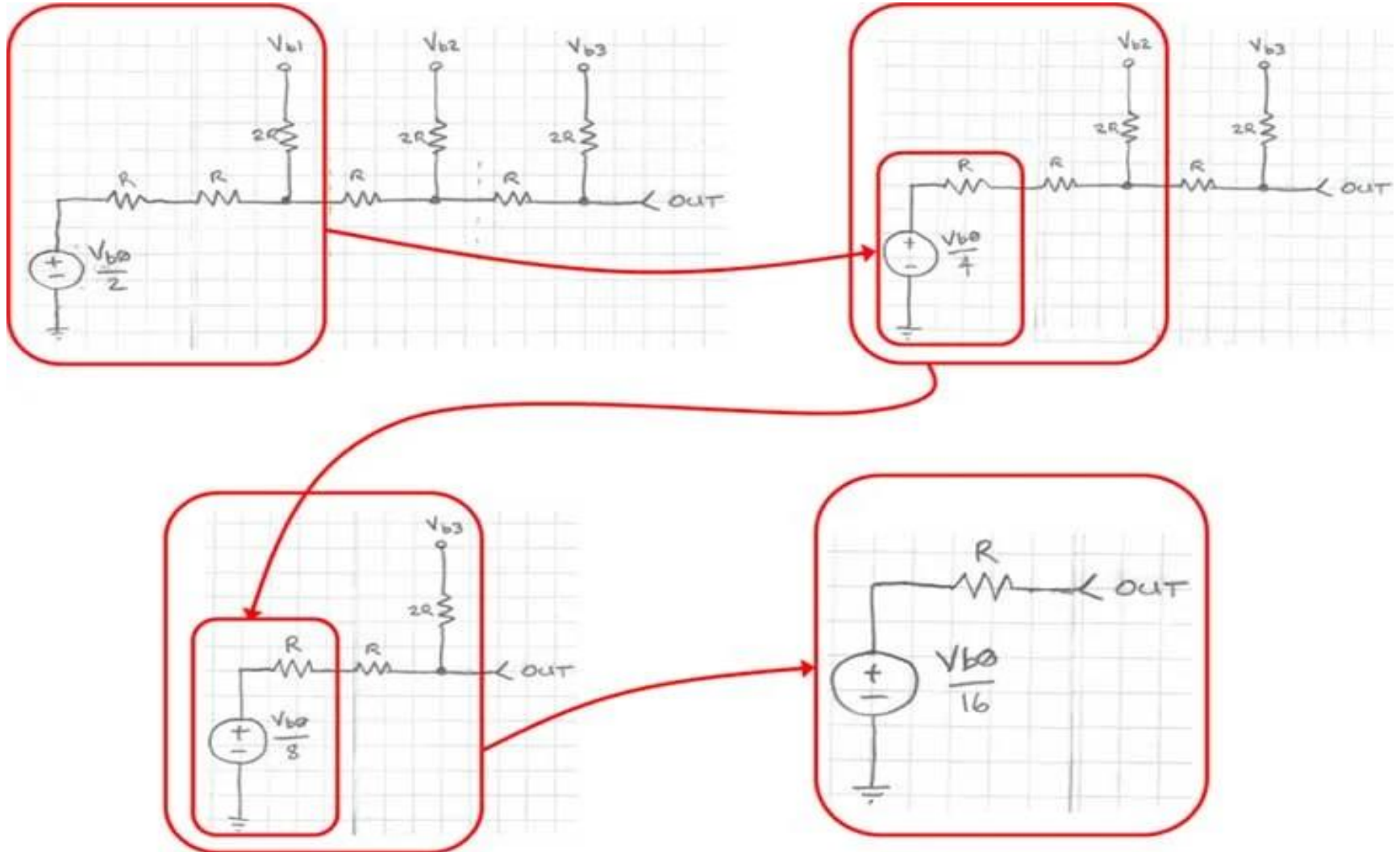
R2R Resistor Ladder DAC

R2R Resistor Ladder DAC

R2R Resistor Ladder DAC

R2R Resistor Ladder DAC

In a more general sense, the contribution of each bit to the output is a simple binary weighting function of each bit.

As you work back from the MSB to the LSB, the voltage contribution each bit is cut in half. Thus, the general form of the equation to calculate the output voltage :

$$Vout = Vb0 / 16 + Vb1 / 8 + Vb2 / 4 + Vb3 / 2 .$$

The R-2R resistor ladder based digital-to-analog converter (DAC) is a simple, effective, accurate and inexpensive way to create analog voltages from digital values.

IMT has provided an 8-bit DAC on its kit using a series of 5k, 10k ohms,

Any questions . . . ?

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