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17/ENG04/023
Elect/Elect Engineering EEE 471

1. Signal Processing Techniques

a) The Fourier Transform

This is the signal processing technique utilized in neurofeedback (the EEG being intensely non-periodic). The Fourier transform is one of the most commonly used methods of signal analysis. It is simply a mathematical transformation that changes a signal from a time domain representation to a frequency domain representation thereby allowing one to observe and analyze its frequency content.

b) Filters

Remember that the Fourier transform shows the frequency contents of a signal. Filtering is the process of removing certain portions of the input signal in order to create a new signal. A familiar example would be the bass and treble controls on a CD player or electric guitar. There are 4 basic filter types:

The low pass filter
The High pass filter
Bandpass filter
Notch filter

So how does a filter actually "remove" unwanted frequencies? This is accomplished by sending the input signal through a system function H(s) which determines the degree of amplification for each frequency in the signal. The required frequencies are boosted by the instrument gain while the unwanted frequencies are ~~boosted~~ by ~~the~~ a gain of zero.

c) Phase Response:

Ideally, a filter should have "linear" phase response. This means that there is a constant time delay difference from the input for all input frequencies - If the phase response is not

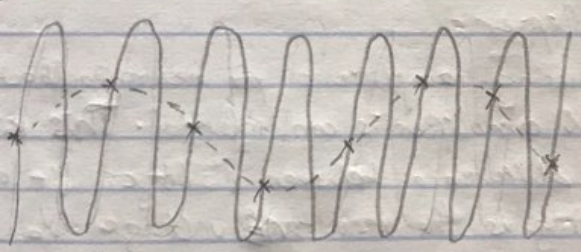
linear, then different frequencies would be delayed by different amounts. For example; When opera music is put through a filter, a cymbal crash might be heard over the singer's voice instead of after.

d) Sampling

Sampling is the process of taking a continuous time signal and representing it by a series of discrete data points. Sampling theory makes our life easier by efficiently converting a signal from analog to digital and vice versa with virtually no loss of information provided that the samples are equally spaced and are ~~close er~~ et close enough together in time

e) Aliasing

An "alias" is a spurious signal that is obtained when the digital sampling of an analog signal occurs at too slow a rate. When a high frequency signal is sampled too slowly the high frequency signal will alias (look a whole lot like) low frequency activity upon analog reconstruction



Example: A high frequency signal that is sampled too slowly

f) Amplifiers and Voltage Laws

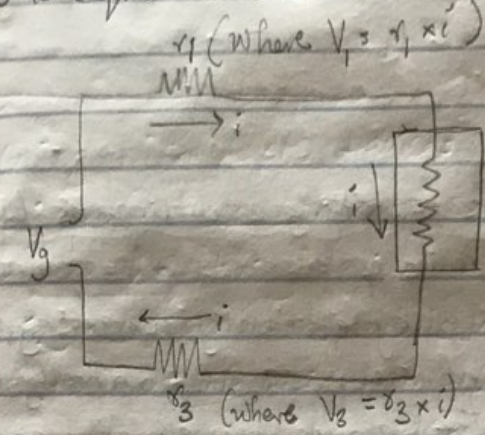
i) Ohms law:

Voltage is equal to the product of the current and ~~resis~~ resistance:

$V = IR$

ii) Kirchoff's Voltage law:

Kirchoff's voltage law states that the sum of the voltage drops (resistance) and rises around a closed loop within a circuit is equal to zero.



The voltage drop across the measuring instrument V_2 must be very close to V_g. Thus V_1 and V_3 across r_1 and r_3 must be minimal. Since, according to Kirchoff's law, $V_g = V_1 + V_2 + V_3$, we want V_1 and V_3 to be negligible in order for V_2 to be as close to V_g as possible. This can be accomplished by controlling the impedance such that r_1 and r_3 have very low contact resistance and r_2 has very high instrument input impedance.

iii) Differential Amplifiers

In the case of using amplifiers for neurofeedback purposes the differential amplifier is considered. This kind of amplifier amplifies the difference between voltages V_+ and V_- by a gain (A) giving us the resultant voltage V_o

g) Electric fields

Given all the preceding information, it is clear that the measuring instrument itself needs to be taken into consideration as a source of signal corruption in biofeedback or any other for of measurement.

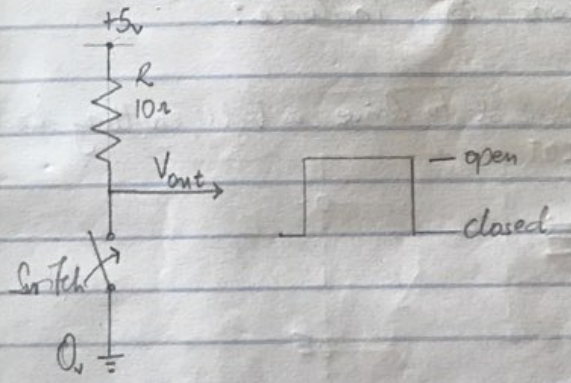
Signal Interfacing Techniques

Interfacing is the method of connecting or linking together one device, especially a computer or micro-controller with another allowing us to design or adapt the output and ~~processes to control something~~ input configurations of the two electronic devices so that they can work together.

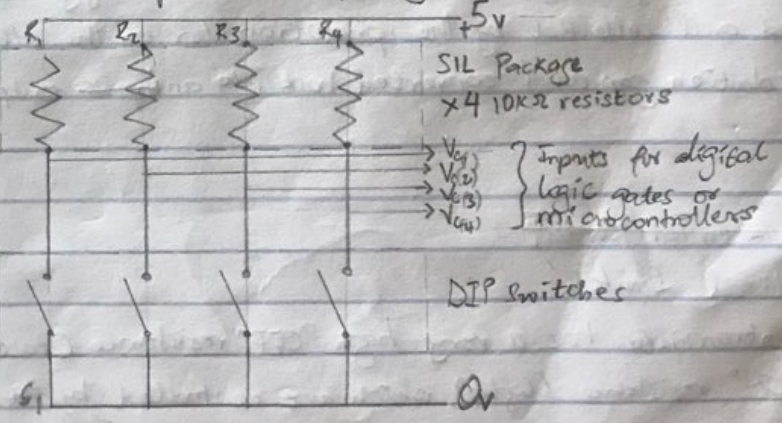
Input interfacing Circuits

i Input interfacing A single Switch

The most common way of input interfacing a switch (or push button) to an electronic circuit is via a pull-up resistor to the supply voltage as shown below. When the switch is open, 5 volts or a logic "1" is ~~ope~~ given as the output signal. When the switch is closed the output is grounded and 0v, or a logic "0" is given as the output



ii DIP Switch Input Interfacing



DIP or Dual-in-line Package switches are individual switches that are ~~four~~ grouped together as for 4 or 8 switches within a single package.

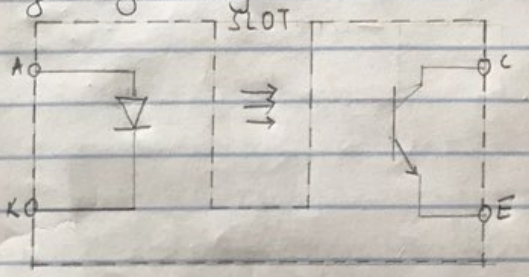
~~ii Switch Bounce Waveform~~

iii Interfacing with Opto Devices

Optical switches (or opto-switches) are another type of optical (photo) switching devices which can be used for input interfacing. The advantage here is that the optical switch can be used for input interfacing harmful voltage levels onto the input pins of microcontrollers, PICs and other such digital circuits or for detecting objects using light as the two components are electrically separate but optically coupled providing a high degree of isolation (typically 2-5kV). Optical switches come in a variety of different types and designs for use in a whole range of interfacing applications; some include:

i Slotted Optical Switch

A DC voltage is generally used to drive a light emitting diode



SCHEMATIC DIAGRAM

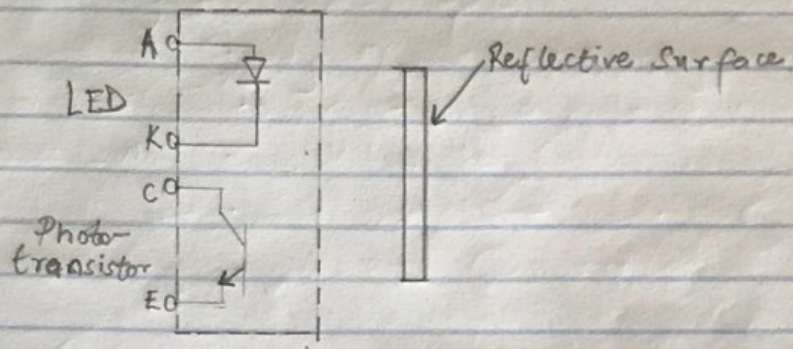
which converts the input signal into infrared light energy. This light is reflected and collected by the phototransistor on the other side of the isolation gap and converted back into an ~~input~~ output signal

~~ii Slotted opto-switch circuit~~

ii Reflected Optical Switch

The phototransistor has a very high "OFF" resistance (dark) and a low "ON" resistance (light), which are controlled by ~~the~~ the

amount of light striking its base from the LED. If there is no object in front of the sensor then the LEDs infrared light will shine foward as a single beam. When there is an object in close proximity to the sensor the LEDs light is repleted back and detected by the phototransistor. The amount of repleded light sensed by the phototransistor and the degree of transistor saturation will depend on how close or reflective the object is.



(2) Expert System Instrumentation

Expert system is a part of the Artificial intelligence, a solution sopeware for complicated problems, which solving the problems need experience and knowledge. By using ~~Expo~~ application of expert system, the system can do health monitoring, automatic trouble tracing and gives advice towards the trouble