

Stuff

HW # 1 due M, 1/13 by 5:00 pm in a yet-to-be-determined locker

Ch. 1: 3 (Problem 1.3 on p.49).

Ex1.3 (Exercises 1.3 on p.6) You do not have to mathematically verify that the two approaches are equivalent, as long as you get percentages that approach 100%.

Ch. 1: 9 Hint: use N=3 see if the expressions work.

Ch. 1: 10

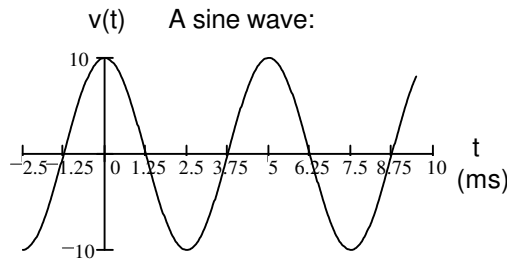
Answers: 3c) $0.1 \cdot V \cdot \sin(1000 \cdot t)$ 3d) $100 \cdot \text{mV} \cdot \sin(6283 \cdot t)$ 9c) 10 bits, 4.89 mV

The following paragraph should have been part of the syllabus:

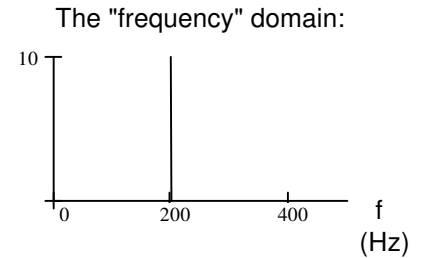
If you want any deviations from the normal class requirements (say credit for labs, if you're taking the class for a second time) you will need to see me before the work would normally be due and get an agreement in writing. You'll need to turn in your copy of the agreement with your final, so I'll remember to grade you properly.

Graduate students who are here to meet their proficiency requirement (Proficiency Students) MUST talk to me, please come up after class.

Sine waves

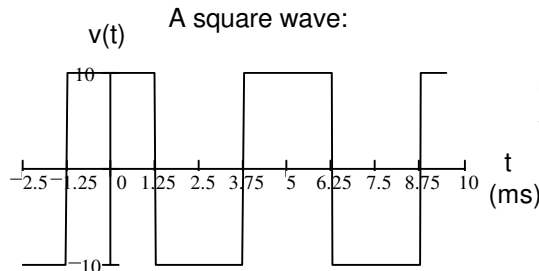


amplitude := 10·V
 $V_{\text{RMS}} := \frac{10 \cdot V}{\sqrt{2}}$
 $T := 5 \cdot \text{ms}$
 $f := \frac{1}{T} \quad f = 200 \cdot \text{Hz}$
 $\omega := 2 \cdot \pi \cdot f \quad \omega = 1257 \cdot \frac{\text{rad}}{\text{sec}}$

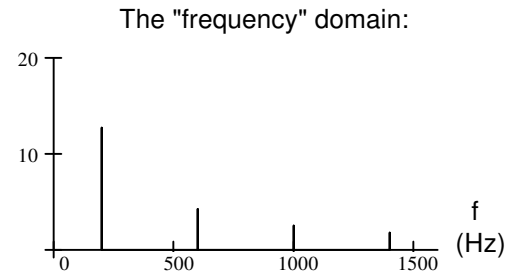


Periodic waves

Recall Fourier series: Any periodic waveform can be represented by a series of sinewaves of different frequencies.

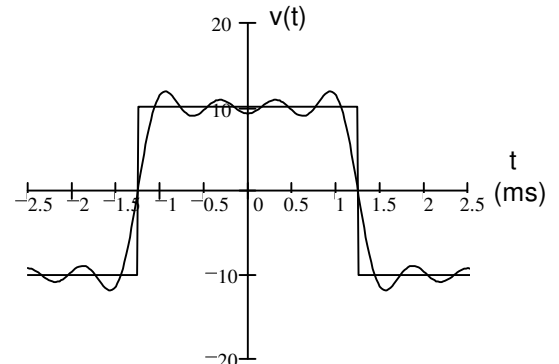
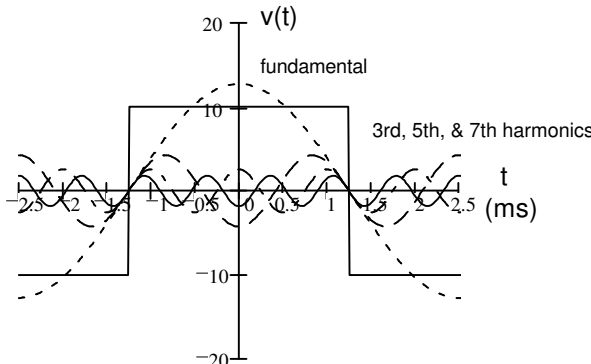


amplitude := 10·V
 $V_{\text{RMS}} := 10 \cdot V$



$$v(t) = \frac{4}{\pi} \cdot \cos(\omega \cdot t) - \frac{4}{3 \cdot \pi} \cdot \cos(3 \cdot \omega \cdot t) + \frac{4}{5 \cdot \pi} \cdot \cos(5 \cdot \omega \cdot t) - \frac{4}{7 \cdot \pi} \cdot \cos(7 \cdot \omega \cdot t) + \dots$$

Notice that the frequency spectrum shows the amplitudes of the harmonics, but not the phases.



Signals

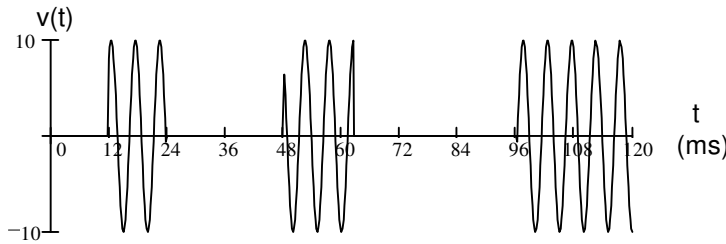
For us: A time-varying voltage or current that carries information.

In some unpredictable fashion
 DC is not a signal, Neither is a pure sine wave. If you can predict it, what information can it provide?
 Neither DC nor pure sine wave have any "bandwidth".
 In fact, no periodic waveform is a signal & no periodic waveform has bandwidth.

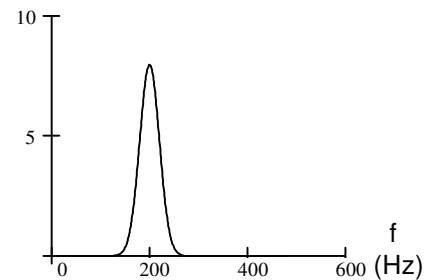
You need bandwidth to transmit information

However, if we change the waveform in any non-periodic way, then the spectrum will no longer be just lines, and we'll have bandwidth.

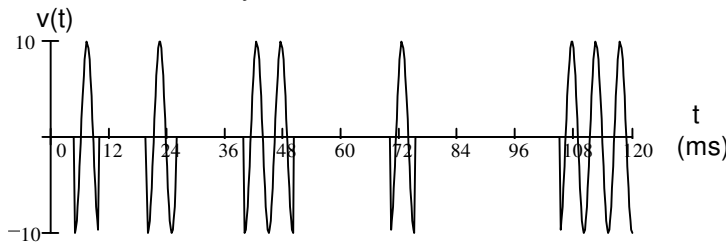
Just turning the sine wave on and off in some unpredictable way,



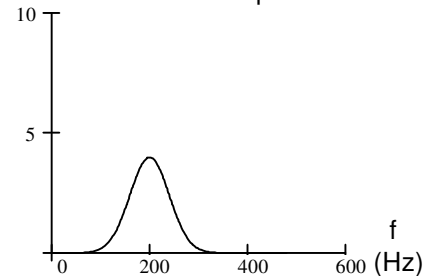
Makes the spectrum widen



The faster you turn it on and off,



the wider the spectrum.



The faster things happen, the wider the bandwidth. The sharper the edges, the higher the frequencies. Obviously these two phenomena are related.

To get the spectrum of a "random" waveform you must take the Fourier Transform instead of the Fourier series.

Signal sources

Microphone
 Camera
 Thermistor or other thermal sensor
 Potentiometer
 LVDT (Linear Variable Differential Transformer)
 Light sensor
 Computer
 switch
 etc...

A transducer is a device which transforms one form of energy to another. Some sensors are transducers, many are not

Most often a signal comes from some other system.

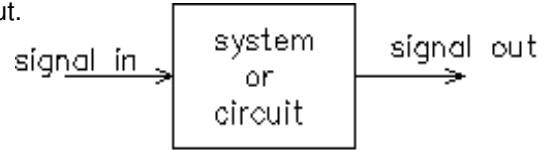
Sine waves are "pretend" signals

Although sine waves are not really signals, we use them to simulate signals all the time, both in calculations and in the lab. This makes sense because all signals can be thought of as being made up of a spectrum of sine waves.

Frequency response

The "response" of a system or circuit is the output for a given input.

A "transfer function" is a mathematical description of how the output is related to the input.



"Block diagram"

$$\text{output} = \text{Transfer function} \times \text{input}$$

$$\text{or... Transfer function} = \frac{\text{output}}{\text{input}}$$

No real system or circuit treats all frequencies the same, so all real transfer functions are functions of frequency.

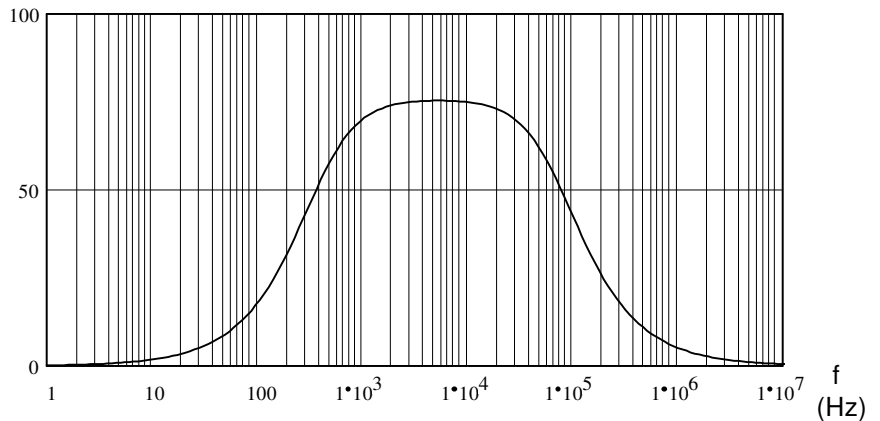
$$\text{Transfer function} = H(\omega) \text{ or } H(f) \text{ or, Transfer function} = H(s)$$

The transfer function can be used to describe the "frequency response" of a circuit. That is, how does the circuit respond to inputs of different frequencies.

A typical frequency response curve for a circuit we might work with:

Magnitude plot

$$|H(f)|$$

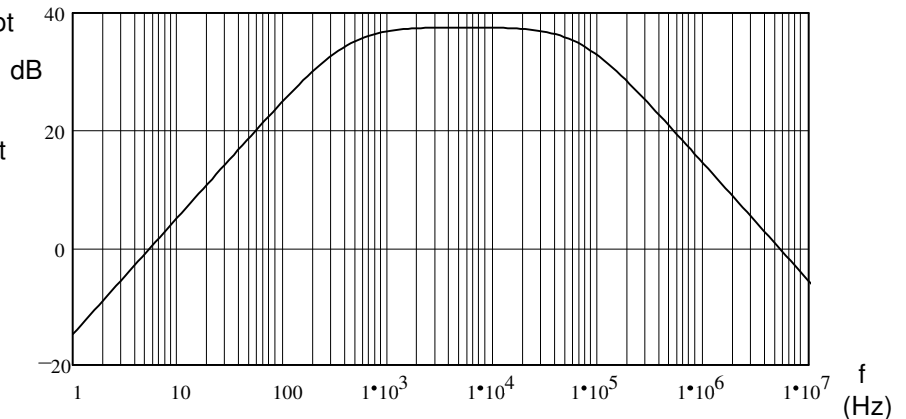


More commonly, the magnitude plot will be expressed in terms of "decibels" (dB)

Magnitude plot

$$|H(f)|$$

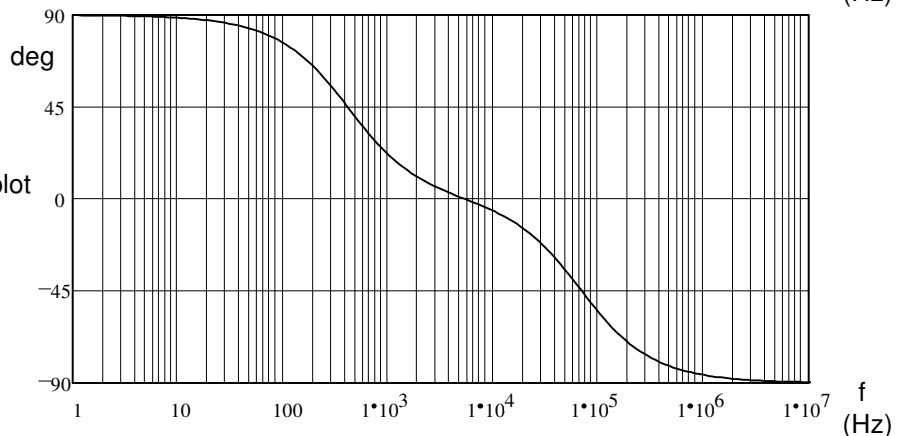
dB will be explained later



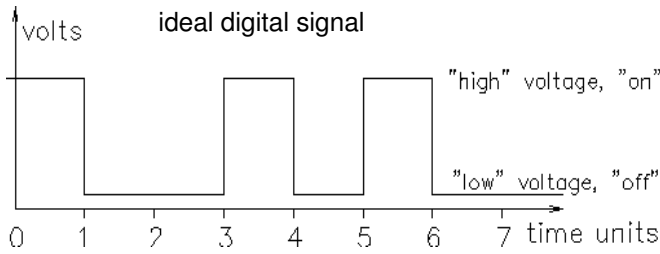
Phase angle is also part of the frequency response

Phase angle plot

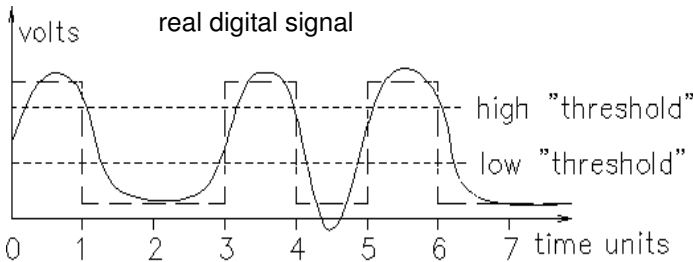
$$\angle H(f)$$



Digital Signals



But now we know that sharp edges = high frequencies and no system has a perfect frequency response.



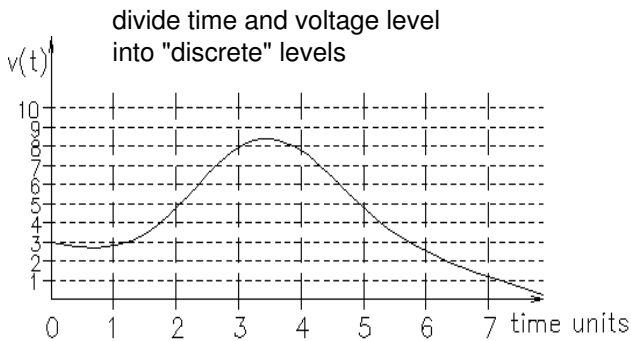
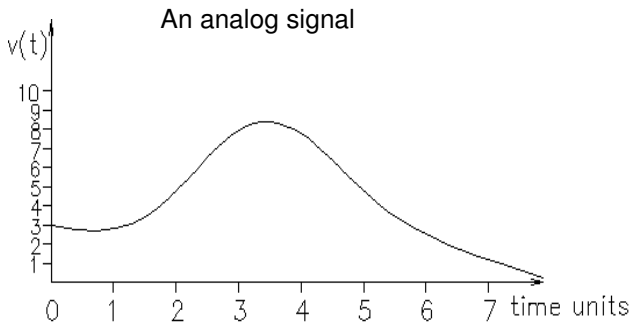
digital circuits use thresholds to tell a "high" from a "low". Some levels may not be defined either way.

Behind all digital signals there are really analog signals.

Analog - to - digital conversion (ADC or A/D converter or A to D converter)

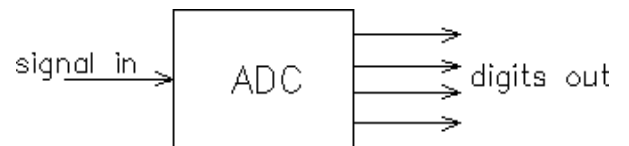
Neglecting the underlying analog nature of digital signals for the moment...

An analog signal can be represented by numbers.



<u>time</u>	<u>level</u>	<u>binary representation</u>
0	3	0011
1	3	0011
2	5	0101
often you can't fit to an exact level, this is called "quantization error"		
3	8	1000
4	8	1000
5	5	0101
6	3	0011
7	1	0001

Digital



usually contains a filter and a sample & hold as well as an ADC

Digital - to - analog conversion (DAC or D/A converter or D to A converter)

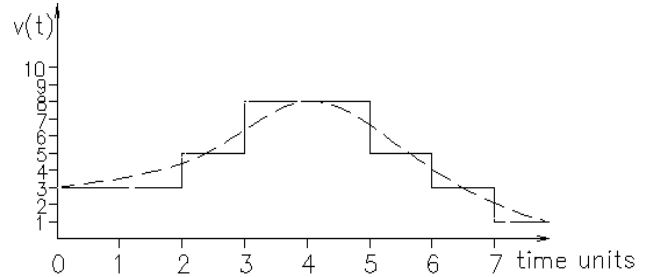
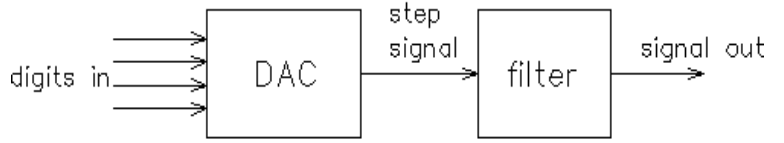
Take those digits and turn them back into voltage levels.

Filter the result to get a close representation to what you started with.

In fact, if the sampling rate is at least twice the highest frequency found in the input signal and the filter is a perfect low-pass filter, then the output can be exactly the same as the input (\pm the quantization error). This is the "Nyquist" theorem.

More "bits" = less quantization error, less "noise"

Faster sampling rate = higher frequency response



Signal Processing

ADC, DAC

Filtering low-pass, high-pass, band-pass, band-reject, notch, etc...

Modulation, demodulation AM, FM, phase

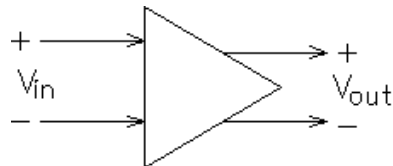
Multiplexing, frequency, time

Etc...

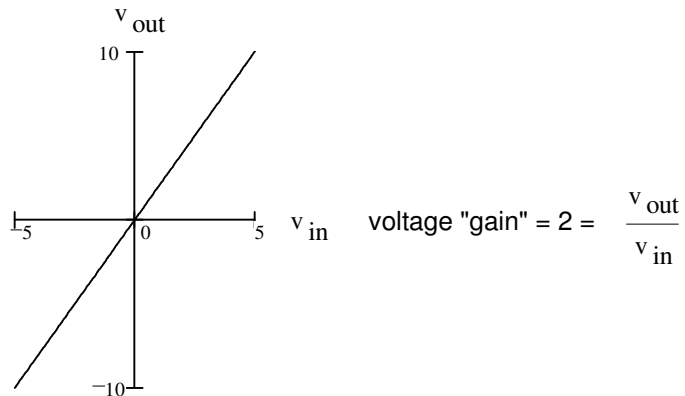
And.. the most important for us in this class... Amplification, creating a duplicate of a signal which has more power than the original.

Amplification

General symbol:



Transfer Characteristic:



We can talk about voltage gain, current gain, and power gain.
 All amplifiers must have the potential for power gain (will depend on the "load")
 Of course this means that all amplifiers must be connected to a power supply!