CSN08704

Telecommunications

2. Signals

Data, Audio, Video and Images

http://asecuritysite.com/comms

Prof Bill Buchanan

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2. Signals: Electrical Signals

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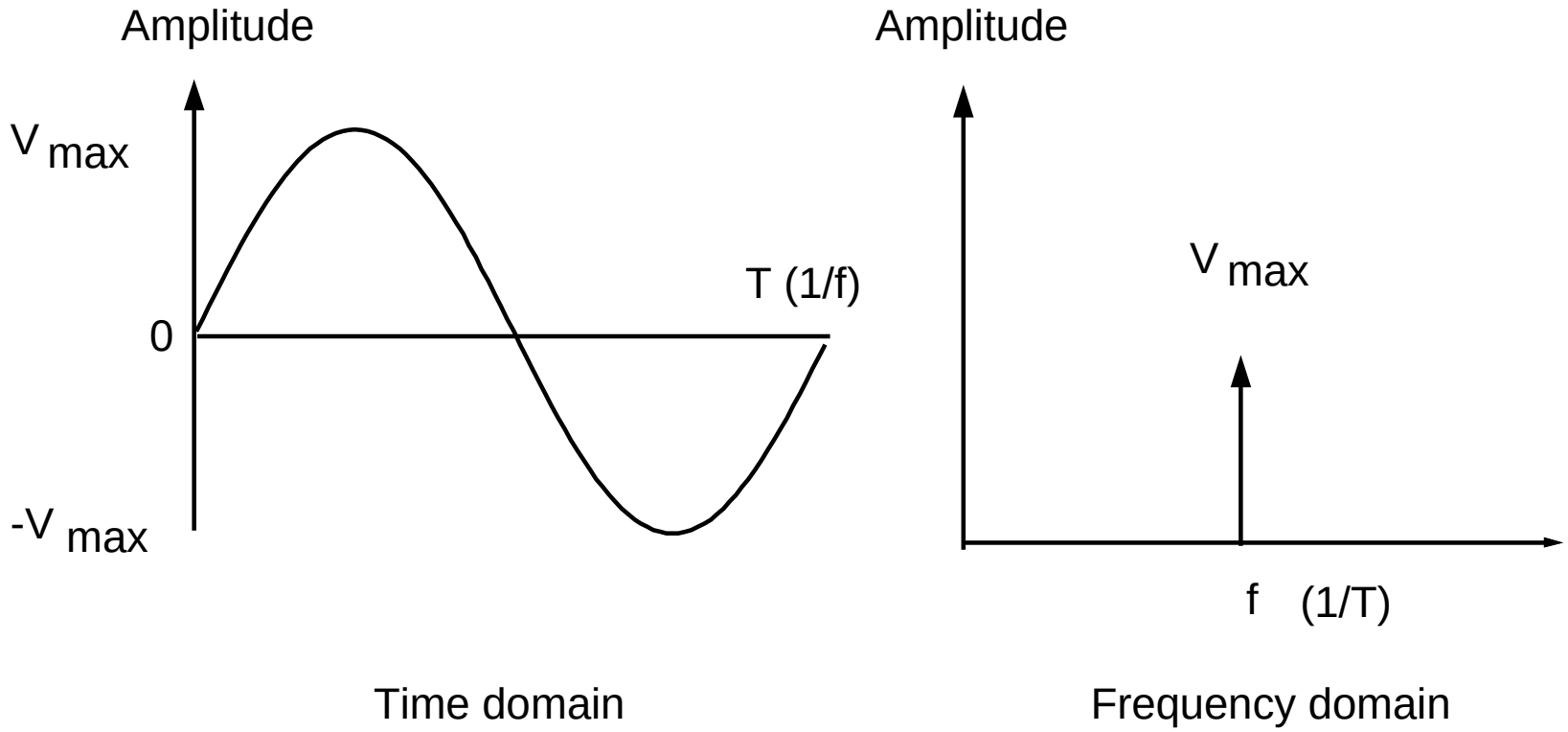
Note frequencies

	Octave 1	Octave 2	Octave 3	Octave 4	Octave 5	Octave 6	Octave 7
C	32.70	65.41	130.81	261.63	523.25	1046.50	2093.00
C#,Db	34.65	69.30	138.59	277.18	554.36	1100.73	2217.46
D	36.71	73.42	146.83	293.66	587.33	1174.66	2349.32
D#,Eb	38.89	77.78	155.56	311.13	622.25	1244.51	2489.02
E	41.20	82.41	164.81	329.63	659.26	1318.51	2367.02
F	43.65	87.31	174.61	349.23	698.46	1396.91	2637.02
F#,Gb	46.25	92.45	185.00	369.99	739.99	1474.98	2959.96
G	49.00	98.00	196.00	392.00	783.99	1567.98	3135.96
G#,Ab	51.91	103.83	207.65	415.30	830.61	1661.22	3322.44
A	**55.00**	**110.00**	**220.00**	**440.00**	**880.00**	**1760.00**	**3520.00**
A#,Bb	58.27	116.54	233.08	466.16	932.33	1664.66	3729.31
B	61.74	123.47	246.94	493.88	987.77	1975.53	3951.07

Time and Frequency domain



Time domain

Frequency domain

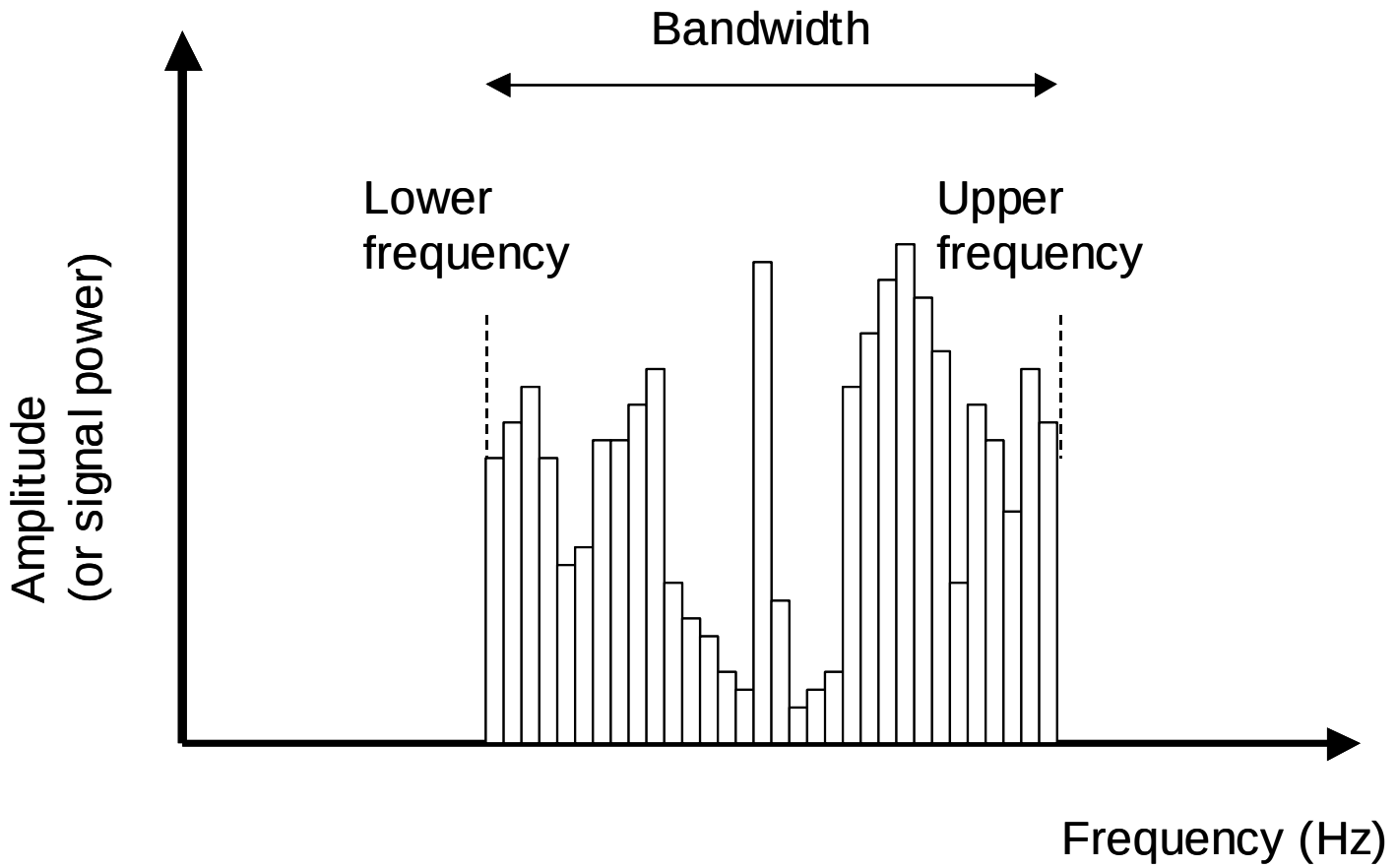
$$V(t) = V\sin(2\pi ft + \theta)$$

Signals

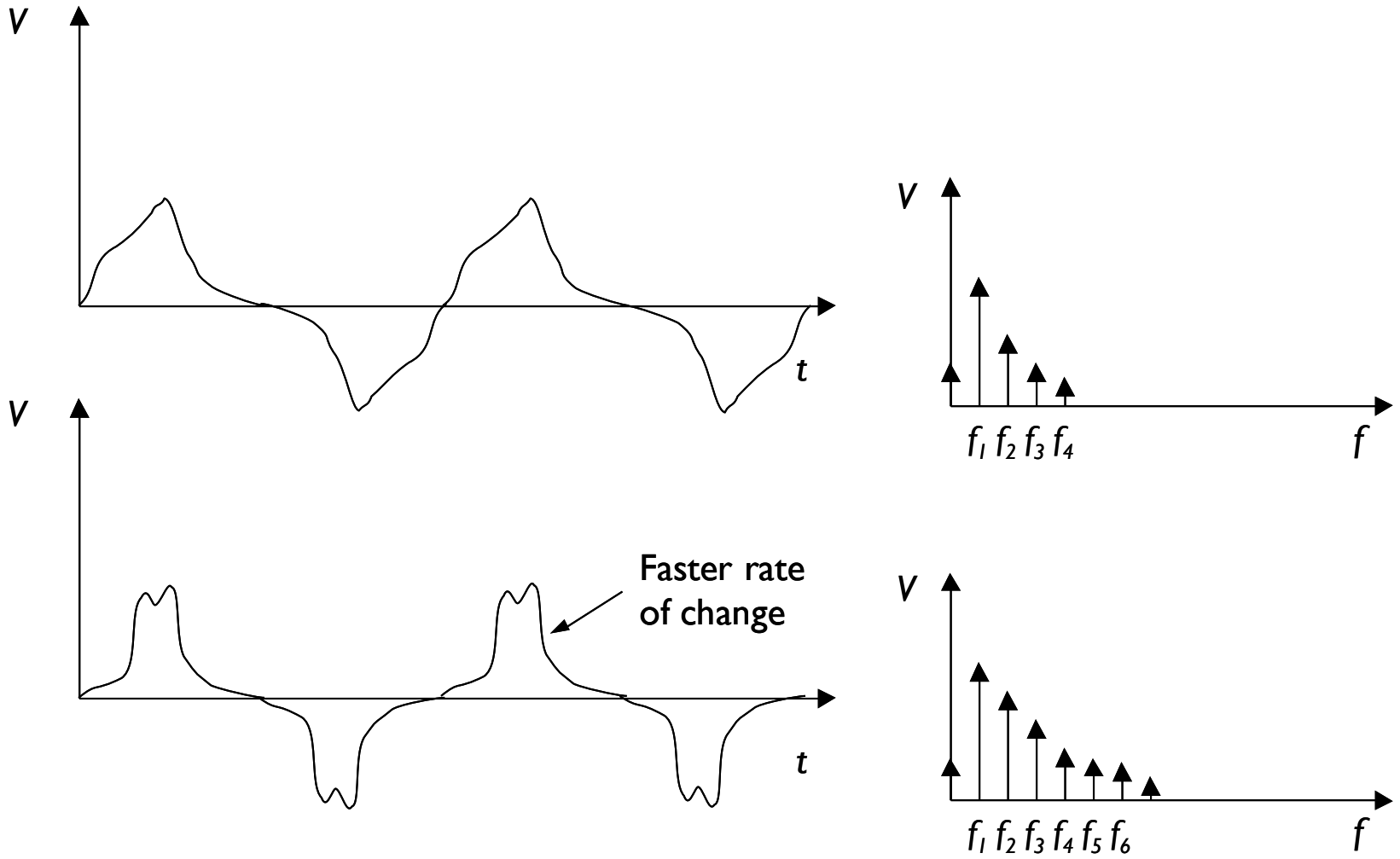
http://www.asecuritysite.com/comms/plot01

Bandwidth

Application	*Bandwidth*
Telephone speech	4 kHz
Hi-fi audio	20 kHz
FM radio	200 kHz
TV signals	6 MHz
Satellite comms	500 MHz

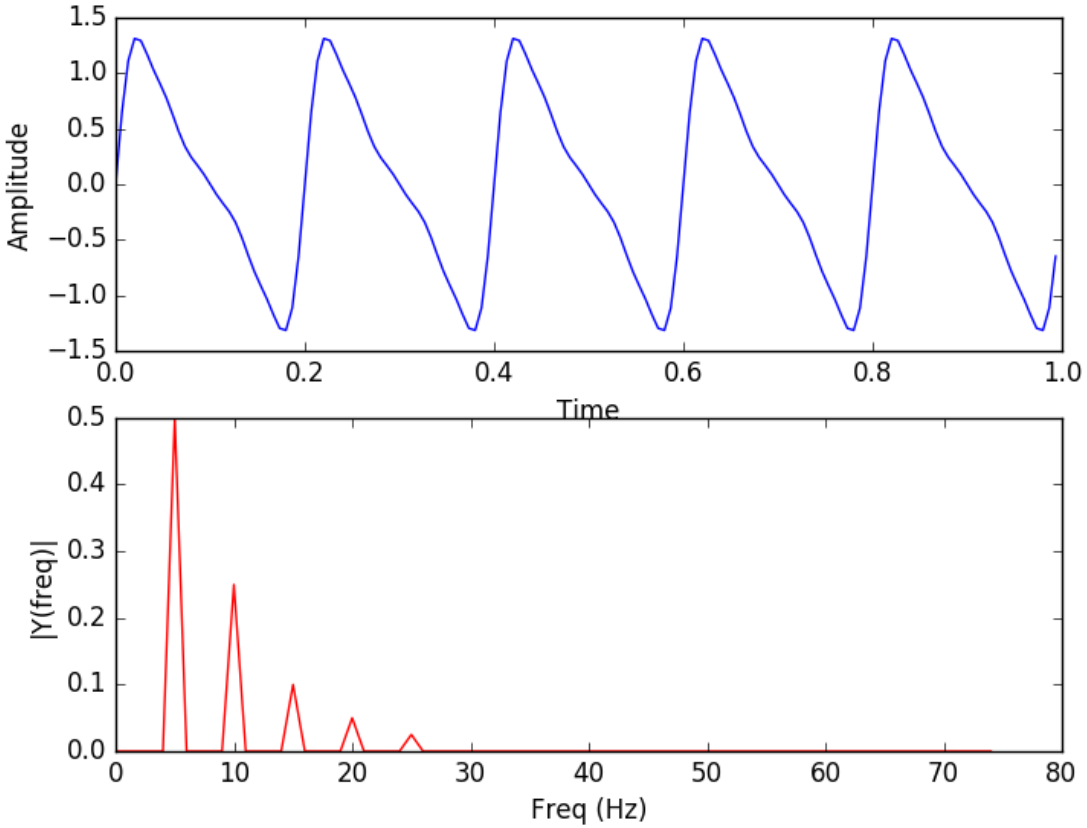


Frequency content of repetitive signals



Signals with harmonics

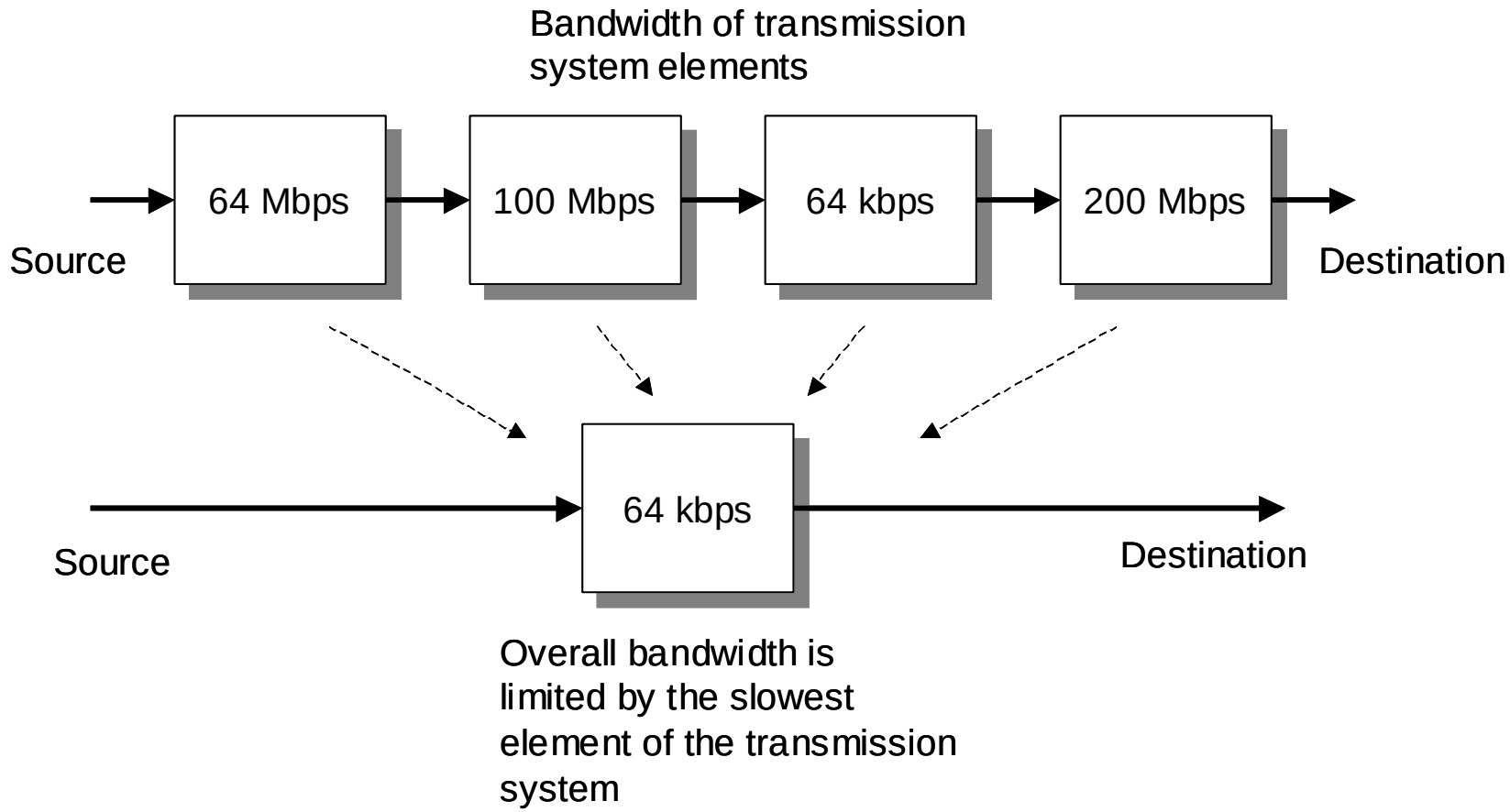
- Link



$$v(t) = A_1 \sin(2\pi f_1 t) + A_2 \sin(2\pi f_2 t) + A_3 \sin(2\pi f_3 t) +$$

$f_1 = fundamental\ frequency$
$f_2 = 2nd\ harmonic\ (2.f_1)$

Overall bandwidth



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2. Signals: Noise and Distortion

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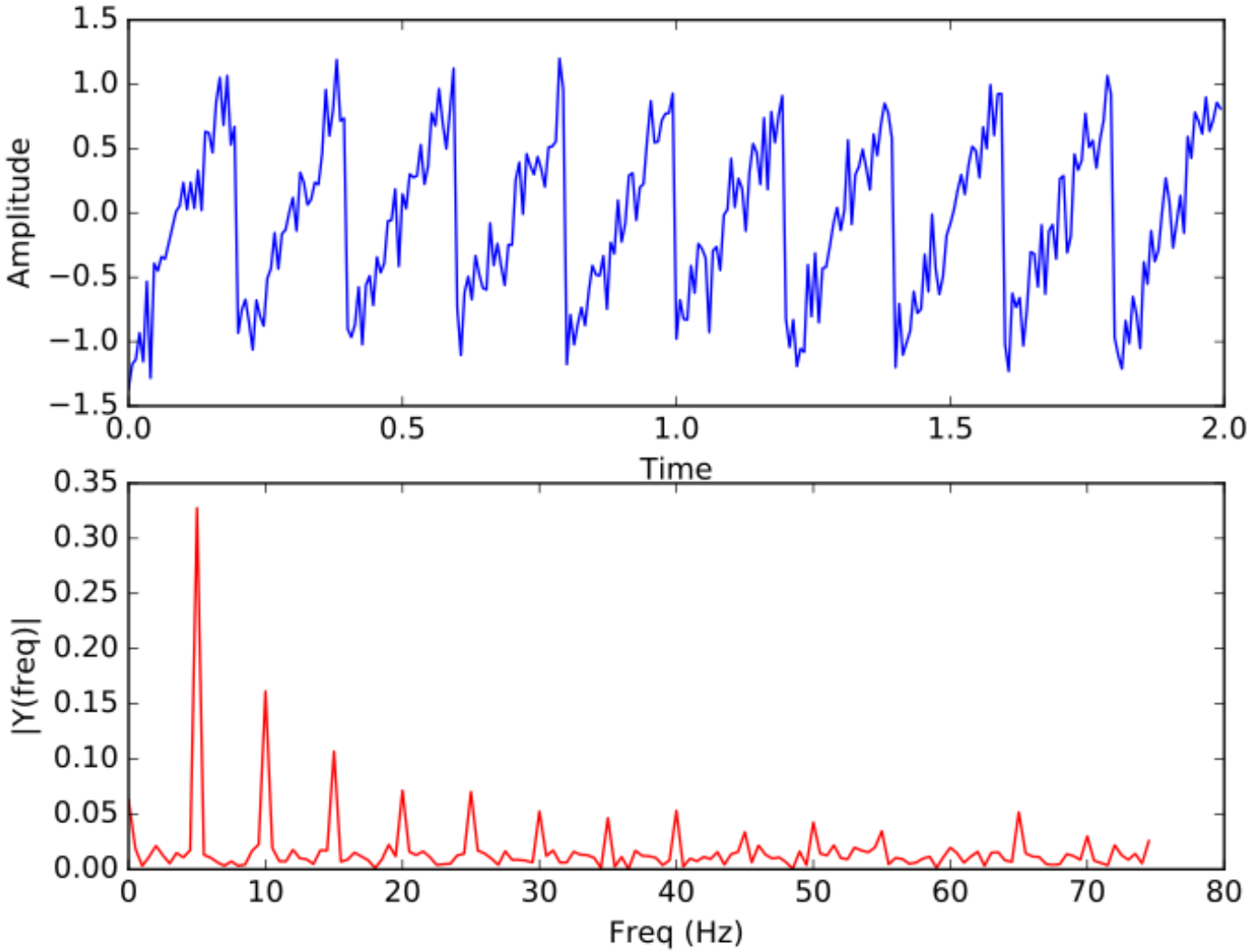
Noise

- Thermal N = k T B
- Cross-talk.
- Impulse noise.

N is the noise power in watts, *k* is Boltzman's constant (1.38×10^{-23} J/K), *T* is the temperature (in K) and *B* the bandwidth of channel (Hz).

Signals with noise

- Saw tooth with 0.2 V amplitude for Gaussian (normal distribution) noise.
- Link.



Signal-to-noise ratio

$$\frac{S}{N}(dB) = 10\log_{10}\frac{SignalPower}{NoisePower}$$

$$\frac{S}{N}(dB) = 10\log_{10}\frac{100\times10^{-3}}{20\times10^{-9}}\,\mathrm{dB}$$

$$\frac{S}{N}(dB) = 10\times\log_{10}\left[5\times10^{6}\right]\mathrm{dB}$$

$$\frac{S}{N}(dB) = 6.7\,\mathrm{dB}$$

Capacity

$$\log_x(y) = \frac{\log_{10}(y)}{\log_{10}(x)}$$

$$Capacity = B.\log_2\left[1+\frac{S}{N}\right] \quad \text{bits/sec}$$

$$Capacity = 10^5.\log_2\left(1+10^4\right) \text{ bits/sec}$$

$$\approx 10^5.\frac{\log_{10}\left(10^4\right)}{\log_{10}(2)} \text{ bits/sec}$$

$$= 13.3\times 10^5 \text{ bits/sec}$$

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