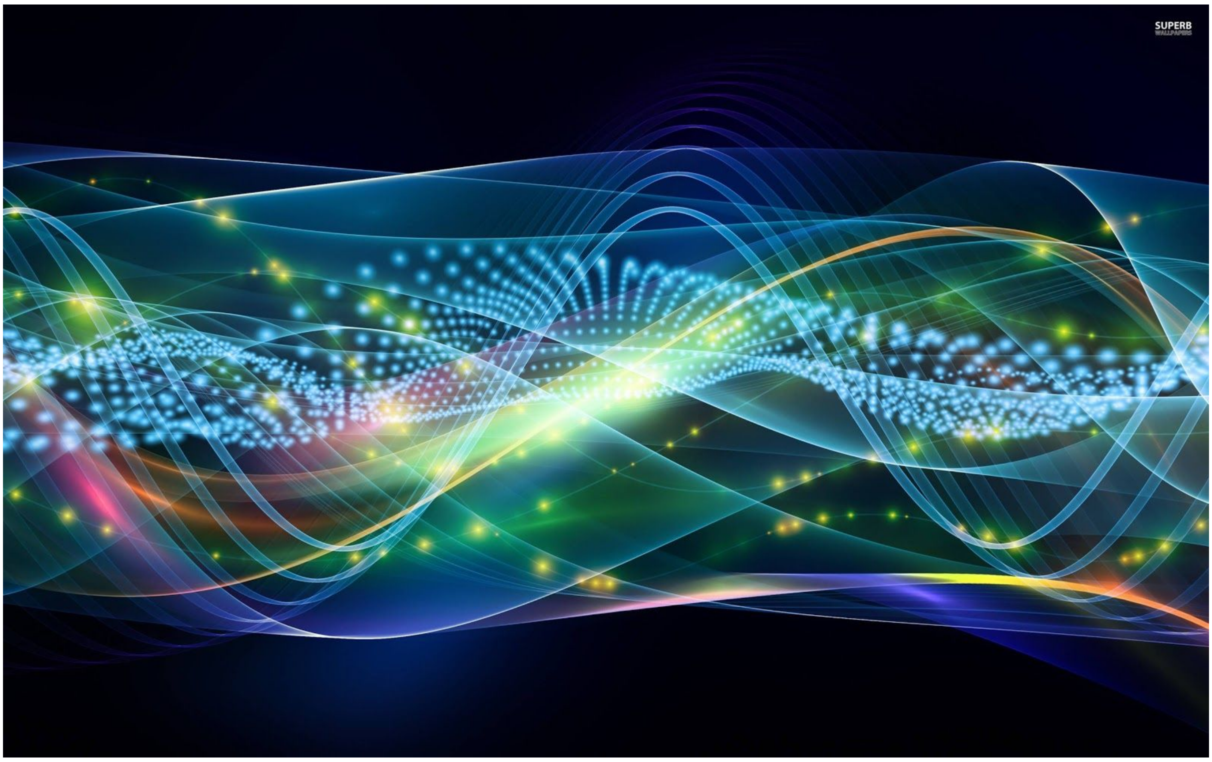
SIGNAL
AND
SYSTEMS

ENERGY AND POWER SIGNALS



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THEORY

A signal is a function that conveys information about a phenomenon (or) A signal is an electrical or electromagnetic current that is used for carrying data from one device or network to another.

A signal may also be defined as an observable change in a quantity.

In ECE, it refers to any time varying voltage, current.

There are two types of signals:-

1) *Digital signal*
2) *Analog signal*

In experiment, signals are classified by two sections.

1) *Power signal*
2) *Energy signal*

ENERGY SIGNAL

A signal which satisfies the condition 0<E< ∞ is energy signal. The energy in continuous time signals is given as,

$$E = \int_{-\infty}^{\infty} |x(t)|^2 dt$$

The energy in discrete time signals is given as,

$$E = \sum_{-\infty}^{\infty} |x[n]|^2$$

POWER SIGNAL

A Power signal will satisfy the condition 0<P< ∞. The equation for power in continuous time signals is

$$P = \underset{T\to\infty}{Lt} \frac{1}{2T} \int_{-T}^{T} \left|x(t)\right|^2 dt$$

The power equation in discrete time signals is

$$P = \underset{N\to\infty}{Lt} \frac{1}{2N+1} \sum_{-N}^{N} \left|x[n]\right|^2$$

In this experiment, we need to find if a signal is a power or an energy signal.

The given signals are :

1) *Sine wave*
2) *Saw-tooth wave*
3) *Square wave*
4) *Triangular wave*
5) *Impulse wave*
6) *Unit step wave*
7) *And pulse wave signals.*

NOTE

- *Signals cannot be both energy and power energy.*
- *Signals can be neither energy nor power.*
- *Most periodic signals are power signals.*

DISCUSSION

Sine wave

Periodic signals are classified by 3 important characteristics:

1) *Amplitude*
2) *Frequency*
3) *Phase.*

The signal sine wave is a periodic function. Its value may be determined at any point of time as it repeats itself at regular intervals.

As most of the periodic signals are power signals. so.

Sine wave is a power signal.

Saw - tooth wave

The sawtooth wave is a kind of non-sinusoidal waveform. based on the floor function of time t is an example of a sawtooth wave with period 1. This sawtooth function has the same phase as the sine function.

A sawtooth wave is a non-sinusoidal wave and it is continuous.

Mostly, sawtooth wave is a power signal.

Square wave

A square wave is a non-sinusoidal function.

The square wave is a special case of a pulse wave which allows arbitrary durations at minimum and maximum.

Square wave is an energy signal.

Triangular wave

A triangle wave is a non-sinusoidal waveform named for its triangular shape. It is a periodic, piecewise linear, continuous real function.

As it is a periodic function, triangular wave is a power signal.

Impulse wave

It is also known as a dirac delta function.

An impulse wave function is not a periodic function, it just has one high value at zero. Impulse trains are useful in sampling and thus the time period of your impulse train decides the sampling rate of your signal.

As it is aperiodic signal, Impulse signal is an energy signal.

Unit step wave

Unit step wave function is a periodic function with no particular period.

It is also called as a Heaviside step function, and it is a discontinuous function.

As it is a periodic function, unit step function is a power signal.

Pulse wave

A pulse wave is a non-sinusoidal periodic waveform in which the amplitude alternates at a steady frequency between fixed minimum and maximum values, with the same duration at minimum and maximum.

As it is a periodic signal, pulse wave is a power signal.

RESULTS

SIN WAVE

Power = 0.5

Energy = Infinity

SAW-TOOTH WAVE

T = 1, A = 1

Power = 0.3333

Energy = Infinity

SQUARE WAVE

T = 1, A = 1

Power = 0

Energy = 1

TRIANGULAR WAVE

T = 1, A = 1

Power = 1/12

Energy = Infinity

IMPULSE WAVE

Power = 0

Energy = Infinity

UNIT STEP WAVE

A = 1

Power = 0.5

Energy = Infinity

PULSE WAVE

T = 1, A = 1, Beta = 0.5

Power = 0.5   Energy = Infinity

CONCLUSION

→ *A periodic signal is always a power signal if its Fourier transform is a set of discrete components comprising of a fundamental and its harmonics. In case of sinusoid it has only the fundamental component.*

→ *An aperiodic signal is an energy signal if its Fourier transform is continuous.*

APPENDIX

SIN

```
function y = fn_sin(t);


    y = sin(t);
```

SAW TOOTH

```
function y = fn_sawtooth(T, A, t);


    y = zeros(size(t, 1), size(t, 2));
    for i = 1:length(t)
        t(i) = rem(t(i), T);
        if (t(i) < 0)
            t(i) = T + t(i);
        end


        if (t(i) < T)
            y(i) = A*t(i);
        end
   end
```

SQUARE WAVE

```
function y = fn_square(T, A, t);

    T = T/2;
    y = zeros(size(t, 1), size(t, 2));
    for i = 1:length(t)
        if (-T < t(i) && t(i) < T)
            y(i) = A;
        end
    end
```

TRIANGULAR WAVE

```
function y = fn_triangular(T, A, t)

    y = zeros(size(t, 1), size(t, 2));
    for i = 1:length(t)
        t(i) = rem(t(i), T);
        if (t(i) < 0)
            t(i) = T + t(i);
        end
```

```
        if (t(i) < T/2)
            y(i) =  A*t(i);

        else
            y(i) = A*(T-t(i));
        end

    end
```

IMPULSE WAVE

```
function y = fn_impulse(t)

    y = zeros(size(t, 1), size(t, 2));
    for i = 1:length(t)
        if (-1/2 < t(i) && t(i) < 1/2)
            y(i) = 1;
        else
            y(i) = 0;
        end
    end
```

UNIT STEP WAVE

```
function y = fn_step(A, t)

    y = zeros(size(t, 1), size(t, 2));

    for i = 1:length(t)
        if (0 <= t(i))
            y(i) = A;
        end
    end
```

PULSE WAVE

```
function y = fn_pulse(T, A, beta, t);

    y = zeros(size(t, 1), size(t, 2));
    for i = 1:length(t)
        y(i) = 0;
        t(i) = rem(t(i), T);
        if (t(i) < 0)
            t(i) = T + t(i);
```

```
        end

        if (t(i) < T*beta)
            y(i) =  A ;
        end
    end
```

ENERGY

```
function ene = energy(fun)

  fun = @(t) (fun(t)).^2;
  ene = integral(fun, -10^2, 10^2);
```

POWER

```
function pow = power(f, T)

    fprintf('The signal is periodic, so its power will be equals to
    the power over one period.\n')
    f = @(t) (f(t)).^2;
    ene = integral(f, -T, T);
    pow = ene / (2*T);
```