# Vector Algebra

## Vector Calculation

|  |  |
| --- | --- |
| Name | Operator |
| Dot product |  |
| Cross product |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
| Del – Gradient vector |  |

## System Coordinates Conversion

### Cylindrical Coordinate Systems

|  |  |
| --- | --- |
| Coordinate conversion | Vector conversion |
|  |  |

Differential vector:

### Spherical Coordinate Systems

|  |  |
| --- | --- |
| Coordinate conversion | Vector conversion |
|  |  |

Differential vector:

## Direction Line

|  |  |  |
| --- | --- | --- |
| Coordinate | | |
| Rectangular | Cylindrical | Spherical |
|  |  |  |

## Electromagnetic Field

|  |  |
| --- | --- |
| Point charge | Current element |
|  |  |
| Long line charge | Long line current |
|  |  |
| Sheet of charge | Sheet of current |
|  |  |

Where: .

## Differential Force

|  |  |  |
| --- | --- | --- |
|  |  |  |

## Lorentz Force Equation

|  |  |  |
| --- | --- | --- |
|  |  |  |

(Newton’s second law **F** = m**a** may be useful in some cases)

## Curl and Divergence

**i. Curl/Stoke’s Theorem**

|  |  |  |
| --- | --- | --- |
|  |  |  |

**ii. Gradient Vectors**

|  |  |  |  |
| --- | --- | --- | --- |
|  | Rectangular | Cylindrical | Spherical |
|  |  |  |  |

### Divergence Theorem

|  |  |  |
| --- | --- | --- |
|  |  |  |

# Maxwell’s Equations

Note that:

|  |  |
| --- | --- |
|  |  |

## Line, Surface Integral

|  |  |
| --- | --- |
| Voltage – line integral | Magnetic flux – surface integral |
|  |  |

## Law Maxwell’s Equations

|  |  |  |
| --- | --- | --- |
| Law | Integral form | Differential form |
| Faraday |  |  |
| Ampère |  |  |
| Gauss | For the electric field | |
|  |  |
| For the magnetic field | |
|  |  |
| Conservation of charge |  |  |

Given that:

|  |  |
| --- | --- |
|  |  |

# Uniform Plane Waves in Free Space

**Note:**

|  |  |
| --- | --- |
|  |  |
|  |  |

## Wave Equation

|  |  |
| --- | --- |
| Wave equation | |
|  |  |
| Solution of wave equation | |
|  |  |

## Sinusoidally Time-varying Uniform Plane Waves in Free Space

In the case of , the solution of wave equation becomes:

|  |  |
| --- | --- |
|  |  |

Parameters

|  |  |  |
| --- | --- | --- |
| Phase constant |  |  |
| Frequency |  |  |
| Wavelength |  |  |
| Poynting vector |  |  |

## Polarization Sinusoidally Time-varying Vector Field

Given that:

1) is called as linear polarization in either of two following cases:

* or
* .

2) is called as circular polarization if it satisfies all 3 below conditions:

* . (lệch pha 90)
* . ( vuông góc)
* . (biên độ thành phần bằng nhau)

3) Elliptical polarization

* If 1) and 2) are not satisfy, therefore, the polarization must be elliptical

(Nếu xét 1) và 2) không thõa mãn vậy kết luận là “Elliptical polarization”)

# Fields and Waves in Material Media

## Material Media

|  |  |
| --- | --- |
| Conductor – Semiconductor:  (vật liệu dẫn điện bán dẫn)  Where: | Dielectric:  Where:  permittivity  polarization vector |
| Magnetic material:  Where:  permeability.  Magnetization vector |

## Waves in Material Media

Propagation constant

|  |  |  |
| --- | --- | --- |
|  |  |  |

Intrinsic impedance

|  |  |  |
| --- | --- | --- |
|  |  |  |

Where:

* : Attenuation constant.
* Phase constant.
* : Ratio between and .
* Phase different between electric field and magnetic field.

Relationship

|  |  |  |
| --- | --- | --- |
|  |  |  |

Note that:

**Wave equation**

|  |  |  |
| --- | --- | --- |
|  |  |  |
|  |  |  |

Poyting vector: Average power:

Special cases:

|  |  |  |  |
| --- | --- | --- | --- |
| Material media | | | |
| Perfect dielectric | Imperfect dielectric | Good conductor | Perfect conductor |
|  |  |  | (No field inside) |

## Boundary Condition

Given that: there are two medium (1) and (2) which have its identities and respectively and normal vector points from medium (2) to (1). The boundary condition is given by:

|  |  |  |
| --- | --- | --- |
|  | or |  |
|  | or |  |
|  | or |  |
|  | or |  |

Special cases:

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Medium (2) is perfect conductor:  (   |  |  |  | | --- | --- | --- | |  | or |  | |  | or |  | |  | or |  | |  | or |  | | Medium (1) and (2) are dielectric:  ((1) can be free space, )   |  |  |  | | --- | --- | --- | |  | or |  | |  | or |  | |  | or |  | |  | or |  | |

## Reflection and transmission of uniform plane waves

Given that: there are two medium (1) and (2) which has its identities and respectively.

|  |  |
| --- | --- |
| Reflection coefficient | |
|  |  |
| Transmission coefficient | |
|  |  |

# Transmission Line Essentials for Digital Electronics

## Transmission Line

|  |  |
| --- | --- |
|  |  |

For lossless line ():

|  |  |
| --- | --- |
|  |  |

Where:

|  |  |  |
| --- | --- | --- |
|  |  |  |

Special case:

|  |  |
| --- | --- |
| 1. Parallel-Plate Line: |  |
| 2. Coaxial Cable: |  |
| 3. Parallel wire line: |  |

## Terminated by Resistor

|  |  |  |  |
| --- | --- | --- | --- |
|  |  |  |  |

For Line with/without load resistor:

|  |  |
| --- | --- |
|  |  |

Reflection coefficients:

|  |  |  |
| --- | --- | --- |
|  | Voltage | Current |
| At load |  |  |
| At source |  |  |

Steady state of transmission:

|  |  |  |  |
| --- | --- | --- | --- |
|  | |  | |
|  | |  | |  | |

## Transmission Line Discontinuity

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  |  |  |  |  |

In this case reflection coefficient becomes

|  |  |  |
| --- | --- | --- |
|  |  |  |

Define Transmission Coefficient:

|  |  |
| --- | --- |
| Voltage | Current |
|  |  |

Power transfer

|  |  |  |
| --- | --- | --- |
|  |  |  |

## Terminated by Reactive Components

|  |  |
| --- | --- |
| Inductor | Capacitor |
|  |  |