Important Digital Communication Formulas PDF

Formulas
Examples
with Units

List of 25
Important Digital Communication Formulas

1) Modulation Parameters Formulas

1.1) Attenuation given Power of 2 Signals Formula

Evaluate Formula

Formula

$$dB = 10 \cdot \left(\log10\left(\frac{P_2}{P_1} \right) \right)$$

Example with Units

$$-10.8884\,\text{dB} = 10 \cdot \left(\log10\left(\frac{14.67\,\text{W}}{180\,\text{W}} \right) \right)$$

1.2) Attenuation given Voltage of 2 Signals Formula

Evaluate Formula

Formula

$$dB = 20 \cdot \left(\log10\left(\frac{V2}{V1} \right) \right)$$

Example with Units

$$-10.8814\,\text{dB} = 20 \cdot \left(\log10\left(\frac{20\,\text{v}}{70\,\text{v}} \right) \right)$$

1.3) Bit Rate Formula

Evaluate Formula

Formula

$$R = f_s \cdot BitDepth$$

Example with Units

$$360\,\text{kb/s} = 0.3\,\text{kHz} \cdot 1200$$

1.4) Bit Rate of Raised Cosine Filter given Time Period Formula

Evaluate Formula

Formula

$$R_s = \frac{1}{T}$$

Example with Units

$$142.8571\,\text{kb/s} = \frac{1}{7\,\mu\text{s}}$$

1.5) Bit Rate of Raised Cosine Filter using Rolloff Factor Formula

Evaluate Formula

Formula

$$R_s = \frac{2 \cdot f_b}{1 + \alpha}$$

Example with Units

$$142.8533\,\text{kb/s} = \frac{2 \cdot 107.14\,\text{kb/s}}{1 + 0.5}$$

1.6) Bit Rate using Bit Duration Formula

Evaluate Formula

Formula

$$R = \frac{1}{T_b}$$

Example with Units

$$360.036\,\text{kb/s} = \frac{1}{2.7775\,\mu\text{s}}$$

1.7) Number of Quantization Levels Formula

Evaluate Formula

Formula

$$N_{lvl} = 2^{N_{res}}$$

Example with Units

$$4 = 2^{0.002\,\text{kb}}$$

1.8) Number of Samples Formula

Evaluate Formula

Formula

$$N_s = \frac{f_m}{f_s}$$

Example with Units

$$0.51 = \frac{0.153\,\text{kHz}}{0.3\,\text{kHz}}$$

1.9) Nyquist Sampling Frequency Formula

Evaluate Formula

Formula

$$f_s = 2 \cdot F_m$$

Example with Units

$$0.3\,\text{kHz} = 2 \cdot 0.15\,\text{kHz}$$

1.10) Quantization Step Size Formula

Evaluate Formula

Formula

$$\Delta = \frac{V_{max} - V_{min}}{N_{lvl}}$$

Example with Units

$$0.9\,\text{v} = \frac{5\,\text{v} - 1.4\,\text{v}}{4}$$

1.11) Signal to Noise Ratio Formula

Evaluate Formula

Formula

$$SNR = \left(6.02 \cdot N_{res}\right) + 1.76$$

Example with Units

$$13.8 = \left(6.02 \cdot 0.002\,\text{kb}\right) + 1.76$$

2) Modulation Techniques Formulas

2.1) Bandwidth Efficiency in Digital Communication Formula

Evaluate Formula

Formula

$$S = \frac{R}{BW}$$

Example with Units

$$9 = \frac{360\,\text{kb/s}}{40\,\text{kHz}}$$

2.2) Bandwidth of ASK given Bit Rate Formula

Evaluate Formula

Formula

$$BW_{ASK} = \left(1 + \alpha\right) \cdot \left(\frac{R}{n_b}\right)$$

Example with Units

$$33.75\,\text{kHz} = \left(1 + 0.5\right) \cdot \left(\frac{360\,\text{kb/s}}{16}\right)$$

2.3) Bandwidth of FSK Formula

Evaluate Formula

Formula

$$BW_{FSK} = R \cdot (1 + \alpha) + (2 \cdot \Delta f)$$

Example with Units

$$545.98\,\text{kHz} = 360\,\text{kb/s} \cdot (1 + 0.5) + (2 \cdot 2.99\,\text{kHz})$$

2.4) Bandwidth of Multilevel FSK Formula

Evaluate Formula

Formula

$$BW_{MFSK} = R \cdot (1 + \alpha) + (2 \cdot \Delta f \cdot (L - 1))$$

Example with Units

$$551.96\,\text{kHz} = 360\,\text{kb/s} \cdot (1 + 0.5) + (2 \cdot 2.99\,\text{kHz} \cdot (3 - 1))$$

2.5) Bandwidth of Multilevel PSK Formula

Evaluate Formula

Formula

$$BW_{MPSK} = R \cdot \left(\frac{1 + \alpha}{\log2(L)}\right)$$

Example with Units

$$340.7021\,\text{kHz} = 360\,\text{kb/s} \cdot \left(\frac{1 + 0.5}{\log2(3)}\right)$$

2.6) Bandwidth of Raised Cosine Filter Formula

Evaluate Formula

Formula

$$f_b = \frac{1 + \alpha}{2 \cdot T}$$

Example with Units

$$107.1429\,\text{kb/s} = \frac{1 + 0.5}{2 \cdot 7\,\mu\text{s}}$$

2.7) Baud Rate Formula

Evaluate Formula

Formula

$$r = \frac{R}{n_b}$$

Example with Units

$$22.5\,\text{kbps} = \frac{360\,\text{kb/s}}{16}$$

2.8) Probability Error of BPSK for Raised Cosine Filter Formula

Evaluate Formula

Formula

$$e_{BPSK} = \left(\frac{1}{2}\right) \cdot erfc\left(\sqrt{\frac{\varepsilon_s}{N_0}}\right)$$

Example with Units

$$0.5 = \left(\frac{1}{2}\right) \cdot erfc\left(\sqrt{\frac{1.2\text{e-}11\,\text{J}}{10}}\right)$$

2.9) Probability Error of DPSK Formula

Evaluate Formula

Formula

$$e_{DPSK} = \left(\frac{1}{2}\right) \cdot e^{-\left(\frac{\varepsilon_b}{N_0}\right)}$$

Example with Units

$$0.5 = \left(\frac{1}{2}\right) \cdot e^{-\left(\frac{55e\text{-}12\,\text{J}}{10}\right)}$$

2.10) Rolloff Factor Formula

Evaluate Formula

Formula

$$\alpha = \left(\frac{BW_{ASK} \cdot n_b}{R}\right) - 1$$

Example with Units

$$0.5 = \left(\frac{33.75\,\text{kHz} \cdot 16}{360\,\text{kb/s}}\right) - 1$$

2.11) Sampling Period Formula

Evaluate Formula

Formula

$$T_s = \frac{1}{f_s}$$

Example with Units

$$3333.3333\,\mu\text{s} = \frac{1}{0.3\,\text{kHz}}$$

2.12) Sampling Theorem Formula

Evaluate Formula

Formula

$$f_s = 2 \cdot f_m$$

Example with Units

$$0.306\,\text{kHz} = 2 \cdot 0.153\,\text{kHz}$$

2.13) Signal Time Period Formula

Evaluate Formula

Formula

$$T = \frac{1 + \alpha}{2 \cdot f_b}$$

Example with Units

$$7.0002\,\mu\text{s} = \frac{1 + 0.5}{2 \cdot 107.14\,\text{kb/s}}$$

2.14) Symbol Time Formula

Evaluate Formula

Formula

$$T_{syb} = \frac{R}{N}$$

Example with Units

$$40000\,\mu\text{s} = \frac{360\,\text{kb/s}}{9000\,\text{kb}}$$

Variables used in list of Digital Communication Formulas above

- **BitDepth** Bit Depth
- **BW** Signal Bandwidth *(Kilohertz)*
- BW_{ASK} Bandwidth of ASK *(Kilohertz)*
- BW_{FSK} Bandwidth of FSK *(Kilohertz)*
- BW_{MFSK} Bandwidth of Multilevel FSK *(Kilohertz)*
- BW_{MPSK} Bandwidth of Multilevel PSK *(Kilohertz)*
- **dB** Attenuation *(Decibel)*
- e_{BPSK} Probability Error of BPSK
- e_{DPSK} Probability Error of DPSK
- f_b Bandwidth of Raised Cosine Filter *(Kilobit per Second)*
- f_m Maximum Frequency *(Kilohertz)*
- F_m Message Signal Frequency *(Kilohertz)*
- f_s Sampling Frequency *(Kilohertz)*
- **L** Number of Level
- **N** Bits Conveyed Per Symbol *(Kilobit)*
- N_0 Noise Density
- n_b Number of Bits
- N_{lvl} Number of Quantisation Levels
- N_{res} Resolution of ADC *(Kilobit)*
- N_s Number of Samples
- P_1 Power 1 *(Watt)*
- P_2 Power 2 *(Watt)*
- **r** Baud Rate *(Kilobit per Second)*
- **R** Bit Rate *(Kilobit per Second)*
- R_s Bit Rate of Raised Cosine Filter *(Kilobit per Second)*
- **S** Bandwidth Efficiency
- **SNR** Signal to Noise Ratio
- **T** Signal Time Period *(Microsecond)*
- T_b Bit Duration *(Microsecond)*

Constants, Functions, Measurements used in list of Digital Communication Formulas above

- constant(s): **e**, 2.71828182845904523536028747135266249
  Napier's constant
- Functions: **erfc**, erfc(Number)
  The error function is defined as the integral of the normal distribution from 0 to x scaled such that erf(±∞) = ±1. It is an entire function defined for real- and complex-valued numbers.
- Functions: **log10**, log10(Number)
  The common logarithm, also known as the base-10 logarithm or the decimal logarithm, is a mathematical function that is the inverse of the exponential function.
- Functions: **log2**, log2(Number)
  The binary logarithm (or log base 2) is the power to which the number 2 must be raised to obtain the value n.
- Functions: **sqrt**, sqrt(Number)
  A square root function is a function that takes a non-negative number as an input and returns the square root of the given input number.
- Measurement: **Time** in Microsecond (µs)
  Time Unit Conversion
- Measurement: **Energy** in Joule (J)
  Energy Unit Conversion
- Measurement: **Power** in Watt (W)
  Power Unit Conversion
- Measurement: **Frequency** in Kilohertz (kHz)
  Frequency Unit Conversion
- Measurement: **Data Storage** in Kilobit (kb)
  Data Storage Unit Conversion
- Measurement: **Data Transfer** in Kilobit per Second (kbps)
  Data Transfer Unit Conversion
- Measurement: **Electric Potential** in Volt (V)
  Electric Potential Unit Conversion
- Measurement: **Sound** in Decibel (dB)
  Sound Unit Conversion
- Measurement: **Bandwidth** in Kilobit per Second (kb/s)
  Bandwidth Unit Conversion

- T_s Sampling Period *(Microsecond)*
- T_{syb} Symbol Time *(Microsecond)*
- V_{max} Maximum Voltage *(Volt)*
- V_{min} Minimum Voltage *(Volt)*
- **V1** Voltage 1 *(Volt)*
- **V2** Voltage 2 *(Volt)*
- **α** Rolloff Factor
- **Δ** Quantization Step Size *(Volt)*
- **Δf** Difference in Frequency *(Kilohertz)*
- ε_b Energy per Bit *(Joule)*
- ε_s Energy per Symbol *(Joule)*

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