WCET Glossary, Constants, Equations
November 30, 2010 (Version 12)

Constants and Conversions

Boltzmann’s constant: \( k = 1.38 \times 10^{-23} \) Joules/Kelvin

Speed of light: \( c = 3 \times 10^8 \) meters/second

Radius of the earth: \( R \approx 6,367 \) km

Natural log base: \( e \approx 2.718 \)

Log base conversion: \( \log_2 (x) = \frac{(\ln x)}{(\ln 2)} \approx 1.443 \ln x \)

Equations

Radiowave propagation in free space:

\[
\frac{P_r}{P_t} = G_t G_r \left( \frac{\lambda}{4\pi d} \right)^2
\]

Total path loss:

\[
L_{tot}(d) = \left( \frac{\lambda}{4\pi d_0} \right)^2 \times \left( \frac{d_0}{d} \right)^n
\]

Approximate LOS distance to the radio horizon:

\[ d \approx \sqrt{17h}, \]

with \( d \) given in km and \( h \) in meters

LOS clearance above an obstacle (metric):

\[
R = 17.3 \sqrt{\frac{d_1 d_2}{F (d_1 + d_2)}}
\]

with \( d_1 \) and \( d_2 \) given in km, \( F \) in GHz, and \( R \) in meters
Wavelength: $\lambda = c / f$

Maximum Doppler frequency shift: $f_m = v / \lambda$

Level-crossing rate (Rayleigh fading): $N_R = \sqrt{2\pi} f_m \rho e^{-\rho^2}$

Average fade duration (Rayleigh fading): $\bar{\tau} = \frac{e^{\rho^2} - 1}{\rho f_m \sqrt{2\pi}}$

Erlang B distribution:

$$P = \frac{A^C / C!}{\sum_{k=0}^{C} A^k / k!}$$

Channel capacity:

$$C = W \log_2 \left(1 + \frac{S}{N}\right)$$

Antenna design equations

Antenna Gain: $G = DE_{ant} = D \frac{R_{rad}}{R_{rad} + R_{loss}}$
Parabolic antenna directivity: \( D = \varepsilon_{ap} \left( \frac{2\pi r}{\lambda} \right)^2 \)

Near/far-field boundary: \( R = \frac{2L^2}{\lambda} \)

Noise figure calculations

\[ F_{sys} = F_1 + \frac{F_2 - 1}{G_1} + \frac{F_3 - 1}{G_1G_2} + \ldots \]

**Abbreviations and Acronyms**

3GPP = third generation partnership project

3GPP = 3rd Generation Partnership Project

3GPP2 = 3rd Generation Partnership Project 2

A = availability

AAA = authentication authorization accounting

AAH = asterisk at home (server)

ACK = acknowledgement

ADC = analog to digital converter

AFD = average fade distortion

AM = amplitude modulation

AES = advanced encryption standard

AMPS = advanced mobile phone service (system)

AODR = *ad hoc* on demand routing
AP = access point
APCO = Association of Public Safety Communication Officials
ARQ = automatic repeat-request
ASK = amplitude shift keying
ASN.1 = abstract syntax notation one
ATPC = automatic transmit power control
AS = autonomous system
AUC = authentication center
AWGN = additive white Gaussian noise

BER = bit error rate
BGP = border gateway protocol
BPSK = binary phase shift
BS = base station
BSC = base station controller
BSS = basic service set
BTS = base transceiver station

CB = certification body
CDMA = code division multiple access
CNR = carrier-to-noise ratio
COFDM = coded orthogonal frequency division multiplexing
CP = cyclic prefix
CPC = cyclic prefix code
CRC = cyclic redundancy check (cyclic redundancy code)
CS = circuit switched
CSA = Canadian Standard Association
CSMA/CA = carrier-sense multiple access with collision avoidance
CSMA/CD = carrier sense multiple access with collision detection
CTS = clear to send

DCF = distributed coordination function
DES = data encryption standard
DDoS = distributed denial-of-service
DIFS = Distributed Inter-Frame Space
DoS = denial-of-service
DPCCH = dedicated physical control channel
DPSK = differential phase shift keying
DQPSK = differential quadrature (or quaternary) phase shift keying
DS-CDMA = direct sequence code division multiple access
DSR = dynamic source routing
DSSS = direct sequence spread spectrum
DWDM = dense wavelength division multiplexing

EAP = extensible authentication protocol
\( E_b / N_0 \) = energy per bit to white noise power spectral density ratio
EDGE = enhanced data rates for GSM evolution
EGC = equal gain combining
EIR = equipment identity register
EIRP = effective isotropic radiated power
ESS = extended service set
ET = error tracking
ETSI - European Telecommunication Standards Institute

FA = foreign agent
FCAPS = Fault Configuration Accounting Performance and Security
FCC = Federal Communications Commission
FDD = frequency division duplexing
FDMA = frequency division multiple access
FHSS = frequency hop spread spectrum
FSK = frequency shift keying
GEO = geostationary earth orbit
GMSC = gateway mobile switching center
GGSN = GPRS gateway support node
GMSK = Gaussian minimum shift keying
GPRS = general packet radio service
GPS = global positioning system
GSM = Global System for Mobile-communications

HA = home agent
HARQ = hybrid automatic repeat request
HDLC = high-level data link control
HLR = home location register

ICMP = internet control message protocol
ID= Identification
IDU = indoor unit
IECEE = International Electrotechnical Committee for Conformity testing to standards for Electrical Equipment
IF = intermediate frequency
IKE = internet key exchange
IMS = IP multimedia subsystem
IMSI = international mobile subscriber identity
IP = internet protocol
IPv6 = internet protocol version 6
IPSec = internet protocol security
ISAKMP = Internet Security Association and Key Management Protocol
ISI = inter-symbol interference
IS-95 = Interim Standard 95
IS-IS = intermediate system to intermediate system
ISM = industrial, scientific, and medical (band)
I-TCP = indirect transmission control protocol
ITU = International Telecommunication Union
ITU-R = ITU-Radiocommunication (radio communication sector)
ITU-T = ITU-Telecommunication (standards sector)

LAN = local area network
LEO = low earth orbit
LO = local oscillator
LOS = line of sight
LR-WPAN = low rate wireless personal area network
LTE = long term evolution

MAC = media access protocol
MAN = metropolitan area network
MRC = maximum ratio combining
MD5 = message digest (algorithm) 5
MEO = medium earth orbit
MIB = management information base
MIC = message integrity check
MIMO = multiple-input multiple-output
MR = mesh router
MSC = mobile switching center
MSISDN = mobile station integrated services digital network
MSK = minimum-shift keying
MSRN= mobile station roaming number
MSS = maximum segment size
MTBF = mean time between failures
MTTR = mean time to repair
NACK = negative acknowledgement
NBAP= node B application part
NCRP = National Council on Radiation Protection
NGN = next generation network(s)
NF = noise figure
NIC= network interface card
NLOS = non-line-of-sight
NMS = network management system
Node B = base station designation in UMTS
NPA = nonlinear power amplifier
NRZ = non-return to zero
ODU = outdoor unit
OFDM = orthogonal frequency division multiplexing
OFDMA = orthogonal frequency division multiple access
OLSR = optimized link state routing
OSPF = open shortest path first
OSI = open systems interconnection

PA = power amplifier
PAN = personal area network
PBCCH = Packet Broadcast Control Channel
PHY = physical (layer)
PCM = pulse code modulation
PLMN = Public Land-Mobile Network
PN = pseudo-noise
PS = packet switched
PSK = phase shift keying
PSTN = public switched telephone network

QAM = quadrature amplitude modulation
QoS = quality of service
QPSK = quadrature (quaternary) phase shift keying

RAB = radio access bearer
RF = radio frequency
RIP = routing information protocol
RMON = Remote network MONitoring
RNC = radio network control
RSSI = received signal strength indicator
RTP = real time protocol
RTS = request to send
RZ = return to zero

SAR = specific absorption rate
SCTP = stream control transmission protocol
SCCP = signaling connection control protocol
SDH = synchronous digital hierarchy
SDP = session description protocol
SDMA = space division multiple access
SET = secure electronic transaction
SGSN = serving GPRS support node
SHA = secure hash algorithm
SIFS = Short Inter-Frame Space
SIGTRAN = signal transport
SIM = subscriber identity module
SINR = signal-to-interference-plus-noise ratio
SIP = session initiation protocol
SIR = signal to interference ratio
SNMP = simple network management protocol
SNR = signal-to-noise ratio
SS7 = signaling system number 7
SSPA = solid state power amplifier
STM = synchronous transfer mode
SYN = synchronization

TCP = transmission control protocol
TDD = time division duplex
TDMA = time division multiple access
TDOA = time difference of arrival
TIMSI = temporary international mobile subscriber identity
TKIP = temporal key integrity protocol
TRAP = TDMA-based randomly addressed polling

UDP = user datagram protocol
UE = user equipment
UL = Underwriters Laboratories
UMTS = universal mobile telecommunications system
UPS = uninterruptible power supply
USIM = universal subscriber identity module
UWB = ultra-wideband
VoIP = Voice over Internet Protocol
VSAT = very small aperture terminal
VSWR = voltage standing-wave ratio

WCDMA = wideband code division multiple access
WEP = wired equivalent privacy
Wi-Fi = Wireless Fidelity
WiMAX = worldwide interoperability for microwave access
WLAN = wireless local area network
WMAN = wireless metropolitan area network
WMN = wireless mesh network
WPA = Wi-Fi Protected Access
WPAN = wireless personal area network
WRC = World Radiocommunication Conference

XKMS = XML Key Management Services

ZRP = zone routing protocol