



Digital and Analog Fiber Optic
COMMUNICATIONS
for CATV and FTTx Applications

Avigdor Brilliant

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*To my wife Merav
and our children Guy, Rotem, and Eden*

*In the memory of my parents,
Rosita Brillant (Segal) and Edmond Wilhelm Brillant*

Nomenclature

ABB	analog base-band
ABR	available bit rate
AC	alternating current or audio compression
ACI	adjacent channel interference
ADC	analog-to-digital converter
ADS	advanced design system (RF design software)
ADSL	asymmetric digital subscriber line
ADM	add-drop multiplexing
AGC	automatic gain control
AFC	automatic frequency control
ALC	automatic level control
AM	amplitude modulation
ANSI	american national standards institute
AOC	automatic offset compensation or automatic offset control
AON	active optical network
APC	automatic power control or angled physical contact
APD	avalanche photo detector
APE	annealed proton exchange
APPC	angled polished physical contact
AR	aspect ratio
ARPANET	advanced research projects agency network
ASC	automatic slope control
ASIC	application specific integrated circuit
ATC	automatic temperature control or automatic threshold control
ATIS	alliance for telecommunications industry solutions
ATM	asynchronous transfer mode
ATP	acceptance test procedure
ATR	acceptance test results
ATRC	advanced television research consortium
ATSC	advanced television systems committee
ATV	advanced television
AV	voltage gain
AWG	arrayed waveguide gratings
AWGN	additive white gaussian noise

BALUN	balanced to unbalanced
BBI	balanced bridge interferometer
BCD	binary coded decimal
BE	base emitter
BELCORE	Bell Labs communications research
BER	bit error rate
BERT	bit error rate tester
B-GT	birefringent analog
BGA	bragg grating arrays
BH	buried heterostructure
BJT	bipolar junction transistor
BiDi	bi directional
BLD	bottom level detector
BMR	burst mode receiver
BNC	Bayonet Neill-Concelman (inventors of the BNC connector)
BOM	bill of materials
BPF	band-pass filter
BPON	broadband passive optical network
BT	British Telecom
BTS	balanced twill structure
BW	bandwidth
BWER	bandwidth enhancement ratio
CAD	computer aided design
CATV	community access television
CB	common base
CBD	cumulative bit difference
CBR	constant bit rate
CC	common collector
CCD	coupled charged device
CCDP	cross-coupled differential pair
CCF	continuous carbon fiber
CCIR	committee consultatif international radiocommunications
CCITT	comite consultatif internationale de telegraphie et telephonie
CCN	carrier-to-composite noise
CDF	cumulative distribution function
CDR	clock data recovery
CE	common emitter
CFBG	chirp fiber bragg gratings
CID	consecutive identical data bits
CIN	carrier-to-intermodulation noise
CLDI	chrominance-to-luminance delay inequality
CLEC	competitive local exchange carrier
CLK	clock
CLR	cable loss ratio

CMA	constant modulus algorithm
CMOS	complementary metal oxide semiconductor
CMOT	common management interface protocol
CMRR	common mode rejection ratio
CMTS	cable modem termination system
CNR	carrier-to-noise ratio
CO	central office
CPLR	coupler
CPU	central processing unit
CRT	cathode ray tube
CS	component side
CSO	composite second order
CTB	composite triple beat
CTC	coefficient of thermal conductivity
CTN	carrier-to-thermal noise
CTU	coaxial termination unit
CW	continuous wave
CWDM	coarse WDM
DA	data aided
DAC	digital-to-analog converter
DAVIC	digital audio visual council
dB	decibels
dBc	decibels relative to carrier power
dBFS	decibels full scale
dBm	decibels relative to 1 mW
dBmv	decibels relative to 1 mV
DBR	distributed Bragg reflector
DBS	direct broadcast satellite
dBW	decibels relative to 1W
DCA	digital controlled attenuator
DCT	discrete cosine transform
DD	decision directed
DEMUX	demultiplexing
DFB	distributed feedback
DFF	delay flip flop
DFT	discrete Fourier transform
DG	differential gain
DH	double heterostructure
DIG	digital section
DIR	directional coupler
DLC	digital loop carrier
DLVA	detector log video amplifier
DML	direct modulated laser
DNS	domain name system
DOCSIS	data over cable service interface specifications

DOD	Department of Defense
DOE	diffractive optical element
DP	differential phase/dispersion penalty
DPCM	discrete pulse code modulation
DQPSK	differential QPSK
DSB	double side band
DSF	dispersion shift fiber
DSL	digital subscriber line
DSLAM	digital subscriber line access multiplexer
DSO	discrete second order
DSP	digital signal processing
DSSS	direct sequence spread spectrum
DTB	discrete triple beat
DTO	discrete third order
DTS	decode time stamp
DUR	desired to undesired ratio, or demodulated to unmodulated radio
DUT	device under test
DVB	digital video broadcasting
DVB-H	digital video broadcasting—handheld
DVB-T	digital video broadcasting—terrestrial
DWDM	dense WDM
ECL	external cavity laser or emitter coupled logic
EDFA	erbium doped fiber amplifier
EDTV	enhanced definition television (which is reduced resolution compared to HDTV)
EFMA	ethernet in the first mile alliance
EGSM	extended global system for mobile communication
EIA	electronic industries alliance
EiCN	equivalent input current noise
ELR	excess loss ratio
EMI	electromagnetic emission
EML	external modulated laser
ENR	excess noise ratio
EOL	end of life
EPON	ethernet passive optical network
EPM	external phase modulation
ER	extinction ratio
EVM	error vector magnitude
ETSI	European telecommunications standardization institute
FBG	fiber Bragg grating
FC	face contact
FC/APC	face contact/angled polished physical contact
FCC	federal communication commission
FDM	frequency division multiplexing

FDF	fiber distribution frame
FDH	fiber distribution hub
FEC	forward error correction
FET	field effect transistor
FF	feed forward or flip flop
FFT	fast Fourier transform
FHSS	frequency hopping spread spectrum
FIFO	first in first out
FIR	finite impulse response filter
FITL	fiber in the loop
FITs	functional integrity testing
FM	frequency modulation
FOC	fiber optical connector
FP	Fabry–Perot
FPD	frequency phase detector
FR	frame rate
FS	frame store
FSAN	full service access network
FSE	fractionally spaced equalizer
FSR	free spectra range/feedback shift register
FT	fourier transform
FTTB	fiber to the building
FTTC	fiber to the curb
FTTH	fiber to the home
FTTP	fiber to the premises
FTTx	fiber to the home, curb, building, business, premises
FWHM	full width at half maximum
Gb	gigabit
Gbps	gigabit per second
GBIC	gigabit interface converter
GBW	gain bandwidth
GBWP	gain bandwidth product
GCA	gain controlled amplifier
GCC	gain control circuit
GCSR	grating-assisted codirectional coupler with sampled reflector
GDR	group delay ripple
GF	Galois field
GHz	gigahertz (1,000,000,000 Hz)
GND	ground
GOP	group of pictures
GPON	gigabit passive optical network
GPRS	general packet radio service
GRIN	grated index or gradually variable reflection index
GS	gain state
GSM	global system for mobile communication

GT	Gires Tournois
GWS	grating waveguide structure
HBT	heterojunction bipolar transistor
HDTV	high definition television
HEMT	high electron mobility transistor
HFC	hybrid fiber coax
HFX	hybrid fiber X, where X can be either copper or coax
HP	home passed
HPF	high pass filter
HPNA	home phone networking alliance
HPPLA	home plug power line alliance
HRC	harmonically related carrier
IC	integrated circuit
I ² C-BUS	inter IC bus (philips invention)
ID	integration derivative
IE	ion exchange
IF	intermediate frequency
IFFT	inverse fast fourier transform
IIP2	second order input intercept point
IIP3	third order input intercept point
IIR	infinite impulse response filter
ILEC	incumbent local exchange carriers
IMD	inter-modulation
IO	image-orthicon
IP	intercept point or internet protocol
IP2	second-order intercept point
IP3	third-order intercept point
IRC	incrementally related carrier
IRE	Institute of Radio Engineers (former name of today's IEEE)
ISDB-T	terrestrial integrated services digital broadcasting
ISDN	integrated services digital networks
ISI	inter symbol interference
ISO	international standard organization
ITC	integrated triplexer to the curb
ITR	integrated triplexer
ITU	International Telecommunications Union
IEEE	Institute of Electrical and Electronic Engineers
IXC	interexchange carriers
JBIG	Joint Bilevel Image Experts Group
JPEG	Joint Photographic Experts Group
KCL	Kirchoff's current law
KHz	kilohertz (1000 Hz)
KVL	Kirchoff's voltage law
L1P	first layer protocol
LAN	local area network

LATA	local transport area
LC	inductance–capacitance
LCF	long carbon fiber
LCM	last common multiple
LCN	logical channels
LCP	liquid crystal polymer
LDS	laser driver stage
LEAF	large effective area fiber
LEC	local exchange carrier
LED	light emitting diode
LF	lattice filter
LFE	linear feedforward equalizer
LFSR	linear feedback shift register
LLC	logical link control
LMDS	local multipoint distribution system
LMS	least mean square
LNA	low-noise amplifier
LO	local oscillator
LPF	low-pass filter
LSB	low side band or least significant beat
LT	loop transmission (open loop gain)
LTE	linear transversal equalizer
LVC MOS	low-voltage CMOS
LVPECL	low-voltage pseudo-emitter coupled logic
MAC	media access control
Mb	megabit
MBE	molecular beam epitaxy
MCEF	modulation current efficiency
MCNS	multimedia cable network system
MDS	minimum detectable signal
MES	modified error signal
MEMS	micro electro mechanical system
MER	modulation error ratio
MESFET	metal-semiconductor field effect transistor
MFD	mode field diameter
M-FLO	media forward link only
MHN	mode hopping noise
MHz	megahertz
MIS	metal insulator semiconductor
ML	maximum likelihood
MMDS	multichannel multipoint distribution system
MMIC	monolithic microwave integrated circuit
MMSE	minimum mean square error
MOCVD	metal organic chemical vapor deposition
MODEM	modulator/demodulator

MOS	metal oxide semiconductor
MOSFET	metal-oxide-semiconductor field-effect transistor
M-PD	monitor photodiode or monitor photodetector
MPE	mode partition error
MPN	mode partition noise
MPEG	moving picture experts group
MQW	multiple quantum well
MSA	multisource agreement
MSR	mode suppression ratio
MTBF	mean time between failure
MUSE	multiple sub-Nyquist sampling encoding (japanese HDTV standard)
MUX	multiplexer, multiplexing
MZ	Mach-Zehnder
MZI	Mach-Zehnder interferometer
NA	network analyzer
NB	noise burst
NCO	numerically controlled oscillator
NCTA	national cable television association
NDA	none data aided
NEB	noise equivalent bandwidth
NF	noise figure $10 \log(F)$ /noise factor
NG-DLC	new/next generation digital loop carriers
NH	network header
NICAM	near instantaneous companding audio multiplex
NL	nonlinear
NLD	nonlinear distortions
NLG	nonlinear gain
NOG	noise over gain
NOL	number of levels
NOS	number of steps
NPDU	network protocol data units
NPR	noise power ratio
NRC	nyquist raised cosine
NRZ	nonreturn to zero
NTC	negative temperature coefficient
NTF	noise transfer function
NTT	Nippon telegraph and telephone
NTSC	National Television Systems Committee
OADM	optical add drop multiplexer
OC-1	optical carrier level 1 (51.48 MB/Sec)
OC12	optical carrier level 12 (12×51.48 MB/Sec)
OC-24	optical carrier level 24 (24×51.48 MB/Sec)
OC-48	optical carrier level 48 (48×51.48 MB/Sec)
OC-192	optical carrier level 192 (192×51.48 MB/Sec)

OCDMA	optical code division multiple access
ODN	optical distribution network
ODP	optical double port
OFDM	orthogonal frequency division multiplexing
OFE	optical front end
OHI	optical hybrid integrated module
OIF	optical internetworking forum
OLT	optical line terminal
OMI	optical modulation index
ONT	optical network terminal
ONU	optical network unit
OOK	on–off keying
ORCAD	Oregon computer aided design
OSA	optical subassembly
OSI	open systems interconnection
OSR	over sampling ratio
OSNR	optical signal-to-noise ratio
OSP	outside plant
OTP	optical triple port
PAL	phase altered line
PANDA	polarization maintaining and absorption reducing
PAR	peak to average
PBS	polarized beamsplitter
PC	physical contact, power combiner, personal computer, peak comparator, polarization control
P/C	PECL to CMOS converter
PCB	printed circuit board
PCM	pulse coded modulation
PCR	program clock reference
PD	photodetector
PDD	polarization-dependent distortions
PDF	probability density function
PDL	polarization-dependent loss
PDU	protocol data unit
PD- λ	polarization-dependent wavelength
PECL	pseudo emitter coupled logic
PEL	picture element
PEP	peak envelope power
PES	packetized elementary stream
PHEMT	pseudo high electron mobility transistor
PHY	physical layer
PI	proportional integrator
PID	proportional integrative derivative
PLC	planar lightwave circuits
PLL	phase locked loop

PLOAM	operation and maintenance
PM	phase modulation
PMD	polarization mode dependent
PMMA	poly-methyl-meth-acrylate
PON	passive optical network
POTS	plain old telephone service
PPD	polarization dependent distortions
PPG	pulse pattern generator
PRBS	pseudo-random beat sequence
PRF	pulse repetition frequency
PRI	pulse repetition interval
PS	print side or power splitter or portal service
PSD	power spectral density
PSPICE	personal computer simulation program with integrated circuits emphasis (circuit simulation software)
PSRR	power supply rejection ratio
PSTN	public switched telephone network
PTFE	polytetrafluoroethylene
PTS	presentation time stamp
PW	pulse width
PWD	pulse width distortion
PWM	pulse width modulation
QAM	quadrature amplitude modulation
QE	quantum efficiency
QPSK	quadrature phase shift keying
QTP	qualification test procedure
QTR	qualification test results
QW	quantum well
R	resistor
RAP	radio access point
RAU	remote antenna unit
RC	resistance–capacitance or raised cosine or resistor capacitor network
RCF	receiver control field
RF	radio frequency
RFFE	RF front end
RFI	radio frequency interference
RFIC	radio frequency integrate circuit
RFC	radio frequency choke
RFL	reflection linearizer
RGB	red green blue
RHS	right hand side
RIN	relative intensity noise
R/L	return loss
RLC	resistor inductor capacitor network

RLL	retardation locked loop
rms	root mean square
ROF	radio over fiber
ROSA	receiver optical subassembly
RS	Reed–Solomon
RSSI	received signal strength indication
RZ	return to zero
$\Sigma\Delta$	sigma delta
SA	spectrum analyzer
SAI	serving area interface
SAR	sample to average ratio
S&H	sample and hold
SAW	surface acoustic wave
SBS	stimulated Brillouin scattering
SC	square/subcarrier connector
SC/APC	angled physical contact
SCTE	Society of Cable Telecommunications Engineers
SCH	separate confinement heterostructure
SCM	subcarrier multiplexed
SDH	synchronous digital hierarchy
SDR	signal-to-distortion ratio
SDV	switched digital video
SE	shielding effectiveness
SECAM	sequential color with memory in french sequentiel couleur avec memoire
SER	symbol error
SFF	small form factor
SFP	small form pluggable
SGD	stochastic gradient descent
SG-DBR	sampled grating distributed Bragg reflector
SHB	spectral hole burning
SHIP	silicon hetero interface photodetector
SINAD	signal-to-noise and distortion
SL	strained layer
SLM	single longitudinal mode
SMA	sub miniature version A connector
SMB	sub miniature version B connector
SMF	single mode fiber
SMPTE	society of motion picture and television engineers
SMSR	side mode suppression ratio
SMT	surface mount technology
SMTP	simple mail transfer protocol
SNA	scalar network analyzer
SNMP	simple network management protocol
SNR	signal-to-noise ratio

SOA	semiconductor optical amplifier
SOI	second-order intermodulations
SONET	synchronous optical network
SOP	system on package
SoS	silica on silicon
SP	serial to parallel
SPC	super physical contact
SPICE	simulation program with integrated circuits emphasis (circuit simulation software)
SPM	self phase modulation
SQW	single quantum well
SRRC	square root raised cosine
SRS	stimulated raman scattering
SSB	single side band
SSC-LD	spot size converted laser
ST	straight tip connector
STF	signal transfer function
STB	set top box
STD	standard
SZ	step size
TCM	trellis coded modulation
TCP	transmission control protocol
TCP/IP	transmission control protocol/internet protocol
TDM	time division multiplexing
T-DMB	terrestrial digital multimedia broadcasting
TDMA	time division multiplexing access
TEC	thermo-electric cooler or thermally expanded core
TELNET	TELEtype NETwork
TEM	thermo electric module/transverse electro-magnetic
THz	tera hertz (1,000,000,000,000 Hz)
TIA	trans impedance amplifier
TIG	trans impedance gain
TIR	total internal reflection
TLCG	tapered linearly chirped gratings
TO (TO-can)	transistor outline metal can package
TODC	turn-on delay comparator
TOG	take over gain
TOI	third-order intermodulations
TOSA	transmitter optical subassembly
T-PDU	transport protocol data units
TRL	transmission line linearizer
TR008	telephone ring (008, 75 etc)
TS	transport stream
TSS	three-step search or tangential sensitivity
TV	television
TW	traveling wave

UDP	user data protocol
UHF	ultra high frequency
UMTS	universal mobile telecommunications system
UPC	ultra polish physical contact
USB	upper side band or universal serial bus
US-TX	up-stream transmit
UUT	unit under test
UV	ultraviolet
VB	video buffer
VBR	variable bit rate
VCO	voltage controlled oscillator
VCSEL	vertical cavity surface emitting laser
VDSL	very high speed digital subscriber line
VGA	variable gain amplifier
VHF	very high frequency
VITS	vertical interval test signal
VLC	variable length code
VLD	variable length coded words
VLSI	very large scale integration
VNA	vector network analyzer
VOD	video on demand
VSΒ + C	vestigial side band plus carrier
VSWR	voltage standing wave ratio
VT-WSPD	voltage tunable–wavelength selective photodetector
VVA	voltage variable attenuator
WAN	wide area network
WCDMA	wideband code division multiple access
WG	waveguide
WG-PD	waveguide photodiode
WDM	wavelength division multiplexing
WLAN	wireless LAN
WSP/WSPD	wavelength selective photodetector
XFMR	transformer
XFP	10 gigabit small form pluggable
XOR	exclusive OR
XPM	cross phase modulation
XTAL	crystal
X-MOD	cross-modulation
X-Talk	cross talk
YAG	yttrium aluminum garnet
ZFE	zero forcing equalizer

Substances and Composites

Alumina	Al ₂ O ₃
Aluminum	Al