References
30

US Customary to Metric Conversion Factors

International System of Units (SI)—Metric Units

Prefix	*Symbol*	————*Multiplication Factor*————		
exe	E	10^{18}	=	1,000,000 000,000,000,000
peta	P	10^{15}	=	1,000 000,000,000,000
tera	T	10^{12}	=	1,000,000,000,000
giga	G	10^{9}	=	1,000,000,000
mega	M	10^{6}	=	1,000,000
kilo	k	10^{3}	=	1,000
hecto	h	10^{2}	=	100
deca	da	10^{1}	=	10
(unit)		10^{0}	=	1
deci	d	10^{-1}	=	0.1
centi	c	10^{-2}	=	0.01
milli	m	10^{-3}	=	0.001
micro	μ	10^{-6}	=	0.000001
nano	n	10^{-9}	=	0.000000001
pico	p	10^{-12}	=	0.000000000001
femto	f	10^{-15}	=	0.000000000000001
atto	a	10^{-18}	=	0.000000000000000001

Linear

1 meter (m) = 100 centimeters (cm) = 1000 millimeters (mm)

Area

1 m^2 = 1 × 10^4 cm^2 = 1 × 10^6 mm^2

Volume

1 m^3 = 1 × 10^6 cm^3 = 1 × 10^9 mm^3
1 liter (l) = 1000 cm^3 = 1 × 10^6 mm^3

Mass

1 kilogram (kg) = 1000 grams (g)
(Approximately the mass of 1 liter of water)
1 metric ton (or tonne) = 1000 kg

Continued on next page.

US Customary to Metric Conversion Factors

Continued from previous page.

US Customary Units

Linear Units

12 inches (in) = 1 foot (ft)
36 inches = 3 feet = 1 yard (yd)
1 rod = $5^1/_2$ yards = $16^1/_2$ feet
1 statute mile = 1760 yards = 5280 feet
1 nautical mile = 6076.11549 feet

Area

1 ft^2 = 144 in^2
1 yd^2 = 9 ft^2 = 1296 in^2
1 rod^2 = $30^1/_4$ yd^2
1 acre = 4840 yd^2 = 43,560 ft^2
1 acre = 160 rod^2
1 $mile^2$ = 640 acres

Volume

1 ft^3 = 1728 in^3
1 yd^3 = 27 ft^3

Liquid Volume Measure

1 fluid ounce (fl oz) = 8 fluid drams = 1.804 in
1 pint (pt) = 16 fl oz
1 quart (qt) = 2 pt = 32 fl oz = $57^3/_4$ in^3
1 gallon (gal) = 4 qt = 231 in^3
1 barrel = $31^1/_2$ gal

Dry Volume Measure

1 quart (qt) = 2 pints (pt) = 67.2 in^3
1 peck = 8 qt
1 bushel = 4 pecks = 2150.42 in^3

Avoirdupois Weight

1 dram (dr) = 27.343 grains (gr) or (gr a)
1 ounce (oz) = 437.5 gr
1 pound (lb) = 16 oz = 7000 gr
1 short ton = 2000 lb, 1 long ton = 2240 lb

Troy Weight

1 grain troy (gr t) = 1 grain avoirdupois
1 pennyweight (dwt) or (pwt) = 24 gr t
1 ounce troy (oz t) = 480 grains
1 lb t = 12 oz t = 5760 grains

Apothecaries' Weight

1 grain apothecaries' (gr ap) = 1 gr t = 1 gr
1 dram ap (dr ap) = 60 gr
1 oz ap = 1 oz t = 8 dr ap = 480 gr
1 lb ap = 1 lb t = 12 oz ap = 5760 gr

Multiply →

Metric Unit = Conversion Factor × US Customary Unit

← Divide

Metric Unit ÷ Conversion Factor = US Customary Unit

Metric Unit	=	Conversion Factor	×	US Unit
(Length)				
mm		25.4		inch
cm		2.54		inch
cm		30.48		foot
m		0.3048		foot
m		0.9144		yard
km		1.609		mile
km		1.852		nautical mile
(Area)				
mm^2		645.16		$inch^2$
cm^2		6.4516		in^2
cm^2		929.03		ft^2
m^2		0.0929		ft^2
cm^2		8361.3		yd^2
m^2		0.83613		yd^2
m^2		4047		acre
km^2		2.59		mi^2
(Mass)		***(Avoirdupois Weight)***		
grams		0.0648		grains
g		28.349		oz
g		453.59		lb
kg		0.45359		lb
tonne		0.907		short ton
tonne		1.016		long ton

Metric Unit	=	Conversion Factor	×	US Unit
(Volume)				
mm^3		16387.064		in^3
cm^3		16.387		in^3
m^3		0.028316		ft^3
m^3		0.764555		yd^3
ml		16.387		in^3
ml		29.57		fl oz
ml		473		pint
ml		946.333		quart
l		28.32		ft^3
l		0.9463		quart
l		3.785		gallon
l		1.101		dry quart
l		8.809		peck
l		35.238		bushel
(Mass)		***(Troy Weight)***		
g		31.103		oz t
g		373.248		lb t
(Mass)		***(Apothecaries' Weight)***		
g		3.387		dr ap
g		31.103		oz ap
g		373.248		lb ap

Abbreviations List

A

a—atto (prefix for 10^{-18})
A—ampere (unit of electrical current)
ac—alternating current
ACC—Affiliated Club Coordinator
ACSSB—amplitude-compandored single sideband
A/D—analog-to-digital
ADC—analog-to-digital converter
AF—audio frequency
AFC—automatic frequency control
AFSK—audio frequency-shift keying
AGC—automatic gain control
A/h—ampere hour
ALC—automatic level control
AM—amplitude modulation
AMRAD—Amateur Radio Research and Development Corp
AMSAT—Radio Amateur Satellite Corp
AMTOR—Amateur Teleprinting Over Radio
ANT—antenna
ARA—Amateur Radio Association
ARC—Amateur Radio Club
ARES—Amateur Radio Emergency Service
ARQ—Automatic repeat request
ARRL—American Radio Relay League
ARS—Amateur Radio Society (station)
ASCII—American National Standard Code for Information Interchange
ATV—amateur television
AVC—automatic volume control
AWG—American wire gauge
az-el—azimuth-elevation

B

B—bel; blower; susceptance; flux density, (inductors)
balun—balanced to unbalanced (transformer)
BC—broadcast
BCD—binary coded decimal
BCI—broadcast interference
Bd—baud (bids in single-channel binary data transmission)
BER—bit error rate
BFO—beat-frequency oscillator
bit—binary digit
bit/s—bits per second
BM—Bulletin Manager
BPF—band-pass filter
BPL—Brass Pounders League
BT—battery
BW—bandwidth

C

c—centi (prefix for 10^{-2})
C—coulomb (quantity of electric charge); capacitor
CAC—Contest Advisory Committee
CATVI—cable television interference
CB—Citizens Band (radio)
CBBS—computer bulletin-board service
CBMS—computer-based message system
CCITT—International Telegraph and Telephone Consultative Committee
CCTV—closed-circuit television
CCW—coherent CW
ccw—counterclockwise

Continued on next page.

Abbreviations List

Continued from previous page.

CD—civil defense
cm—centimeter
CMOS—complimentary-symmetry metal-oxide semiconductor
coax—coaxial cable
COR—carrier-operated relay
CP—code proficiency (award)
CPU—central processing unit
CRT—cathode ray tube
CT—center tap
CTCSS—continuous tone-coded squelch system
cw—clockwise
CW—continuous wave

D

d—deci (prefix for 10^{-1})
D—diode
da—deca (prefix for 10)
D/A—digital-to-analog
DAC—digital-to-analog converter
dB—decibel (0.1 bel)
dBi—decibels above (or below) isotropic antenna
dBm—decibels above (or below) 1 milliwatt
DBM—doubly balanced mixer
dBV—decibels above/below 1 V (in video, relative to 1 V P-P)
dBW—decibels above/below 1 W
dc—direct current
D-C—direct conversion
DDS—direct digital synthesis
DEC—District Emergency Coordinator
deg—degree
DET—detector
DF—direction finding; direction finder
DIP—dual in-line package
DMM—digital multimeter
DPDT—double-pole double-throw (switch)
DPSK—differential phase-shift keying
DPST—double-pole single-throw (switch)
DS—direct sequence (spread spectrum); display
DSB—double sideband
DSP—digital signal processing
DTMF—dual-tone multifrequency
DVM—digital voltmeter
DX—long distance; duplex
DXAC—DX Advisory Committee
DXCC—DX Century Club

E

e—base of natural logarithms (2.71828)
E—voltage
EA—ARRL Educational Advisor
EC—Emergency Coordinator
ECL—emitter-coupled logic
EHF—extremely high frequency (30-300 GHz)
EIA—Electronic Industries Assn
EIRP—effective isotropic radiated power
ELF—extremely low frequency
ELT—emergency locator transmitter
EMC—electromagnetic compatibility
EME—earth-moon-earth (moonbounce)

Continued on next page.

Abbreviations List

Continued from previous page.

EMF—electromotive force
EMI—electromagnetic interference
EMP—electromagnetic pulse
EOC—emergency operations center
EPROM—erasable programmable read only memory

F

f—femto (prefix for 10^{-5}); frequency
F—farad (capacitance unit); fuse
fax—facsimile
FCC—Federal Communications Commission
FD—Field Day
FEMA—Federal Emergency Management Agency
FET—field-effect transistor
FFT—fast Fourier transform
FL—filter
FM—frequency modulation
FMTV—frequency-modulated television
FSK—frequency-shift keying
FSTV—fast-scan (real-time) television
ft—foot (unit of length)

G

g—gram (unit of mass)
G—giga (prefix for 10^9); conductance
GaAs—gallium arsenide
GDO—grid- or gate-dip oscillator
GHz—gigahertz (10^9 Hz)
GND—ground

H

h—hecto (prefix for 10^2)
H—henry (unit of inductance)
HF—high frequency (3-30 MHz)
HFO—high-frequency oscillator; heterodyne frequency oscillator
HPF—highest probable frequency; high-pass filter
Hz—hertz (unit of frequency, 1 cycle/s)

I

I—current, indicating lamp
IARU—International Amateur Radio Union
IC—integrated circuit
ID—identification; inside diameter
IEEE—Institute of Electrical and Electronics Engineers
IF—intermediate frequency
IMD—intermodulation distortion
in.—inch (unit of length)
in./s—inch per second (unit of velocity)
I/O—input/output
IRC—international reply coupon
ISB—independent sideband
ITF—Interference Task Force
ITU—International Telecommunication Union

J

j—operator for complex notation, as for reactive component of an impedance (+*j* inductive; –*j* capacitive)
J—joule (kg m^2/s^2) (energy or work unit); jack
JFET—junction field-effect transistor

Continued on next page.

Abbreviations List

Continued from previous page.

K

k—kilo (prefix for 10^3); Boltzmann's constant (1.38×10^{-23} J/K)
K—kelvin (used without degree symbol) absolute temperature scale; relay
kBd—1000 bauds
kbit—1024 bits
kbit/s—1024 bits per second
kbyte—1024 bytes
kg—kilogram
kHz—kilohertz
km—kilometer
kV—kilovolt
kW—kilowatt
kΩ—kilohm

L

l—liter (liquid volume)
L—lambert; inductor
lb—pound (force unit)
LC—inductance-capacitance
LCD—liquid crystal display
LED—light-emitting diode
LF—low frequency (30-300 kHz)
LHC—left-hand circular (polarization)
LO—local oscillator; Leadership Official
LP—log periodic
LS—loudspeaker
lsb—least significant bit
LSB—lower sideband
LSI—large-scale integration
LUF—lowest usable frequency

M

m—meter (length); milli (prefix for 10^{-3})
M—mega (prefix for 10^6); meter (instrument)
mA—milliampere
mAh—milliampere hour
MCP—multimode communications processor
MDS—Multipoint Distribution Service; minimum discernible (or detectable) signal
MF—medium frequency (300-3000 kHz)
mH—millihenry
MHz—megahertz
mi—mile, statute (unit of length)
mi/h—mile per hour
mi/s—mile per second
mic—microphone
min—minute (time)
MIX—mixer
mm—millimeter
MOD—modulator
modem—modulator/demodulator
MOS—metal-oxide semiconductor
MOSFET—metal-oxide semiconductor field-effect transistor
MS—meteor scatter
ms—millisecond
m/s—meters per second
msb—most-significant bit
MSI—medium-scale integration
MSK—minimum-shift keying

Continued on next page.

Abbreviations List

Continued from previous page.

MSO—message storage operation
MUF—maximum usable frequency
mV—millivolt
mW—milliwatt
MΩ—megohm

N

n—nano (prefix for 10^{-9}); number of turns (inductors)
NBFM—narrow-band frequency modulation
NC—no connection; normally closed
NCS—net-control station; National Communications System
nF—nanofarad
NF—noise figure
nH—nanohenry
NiCd—nickel cadmium
NM—Net Manager
NMOS—N-channel metal-oxide silicon
NO—normally open
NPN—negative-positive-negative (transistor)
NPRM—Notice of Proposed Rule Making (FCC)
ns—nanosecond
NTIA—National Telecommunications and Information Administration
NTS—National Traffic System

O

OBS—Official Bulletin Station
OD—outside diameter
OES—Official Emergency Station
OO—Official Observer
op amp—operational amplifier
ORS—Official Relay Station
OSC—oscillator
OSCAR—Orbiting Satellite Carrying Amateur Radio
OTC—Old Timer's Club
oz—ounce (force unit, $^{1}/_{16}$ pound)

P

p—pico (prefix for 10^{-12})
P—power; plug
PA—power amplifier
PACTOR—digital mode combining aspects of packet and AMTOR
PAM—pulse-amplitude modulation
PBS—packet bulletin-board system
PC—printed circuit
P_D—power dissipation
PEP—peak envelope power
PEV—peak envelope voltage
pF—picofarad
pH—picohenry
PIC—Public Information Coordinator
PIN—positive-intrinsic-negative (semiconductor)
PIO—Public Information Officer
PIV—peak inverse voltage
PLL—phase-locked loop
PM—phase modulation
PMOS—P-channel (metal-oxide semiconductor)
PNP—positive negative positive (transistor)
pot—potentiometer

Continued on next page.

Abbreviations List

Continued from previous page.

P-P—peak to peak
ppd—postpaid
PROM—programmable read-only memory
PSAC—Public Service Advisory Committee
PSHR—Public Service Honor Roll
PTO—permeability-tuned oscillator
PTT—push to talk

Q-R

Q—figure of merit (tuned circuit); transistor
QRP—low power (less than 5-W output)
R—resistor
RACES—Radio Amateur Civil Emergency Service
RAM—random-access memory
RC—resistance-capacitance
R/C—radio control
RCC—Rag Chewer's Club
RDF—radio direction finding
RF—radio frequency
RFC—radio-frequency choke
RFI—radio-frequency interference
RHC—right-hand circular (polarization)
RIT—receiver incremental tuning
RLC—resistance-inductance-capacitance
RM—rule making (number assigned to petition)
r/min—revolutions per minute
RMS—root mean square
ROM—read-only memory
r/s—revolutions per second
RS—Radio Sputnik, Russian ham satellite
RST—readability-strength-tone (CW signal report)
RTTY—radioteletype
RX—receiver, receiving

S

s—second (time)
S—siemens (unit of conductance); switch
SASE—self-addressed stamped envelope
SCF—switched capacitor filter
SCR—silicon controlled rectifier
SEC—Section Emergency Coordinator
SET—Simulated Emergency Test
SGL—State Government Liaison
SHF—super-high frequency (3-30 GHz)
SM—Section Manager; silver mica (capacitor)
S/N—signal-to-noise ratio
SPDT—single pole double-throw (switch)
SPST—single-pole single-throw (switch)
SS—Sweepstakes; spread spectrum
SSB—single sideband
SSC—Special Service Club
SSI—small-scale integration
SSTV—slow-scan television
STM—Section Traffic Manager
SX—simplex
sync—synchronous, synchronizing
SWL—shortwave listener
SWR—standing-wave ratio

Continued on next page.

Abbreviations List

Continued from previous page.

T

T—tera (prefix for 10^{12}); transformer
TA—ARRL Technical Advisor
TC—Technical Coordinator
TCC—Transcontinental Corps (NTS)
TCP/IP—Transmission Control Protocol/ Internet Protocol
tfc—traffic
TNC—terminal node controller (packet radio)
TR—transmit/receive
TS—Technical Specialist
TTL—transistor-transistor logic
TTY—teletypewriter
TU—terminal unit
TV—television
TVI—television interference
TX—transmitter, transmitting

U

U—integrated circuit
UHF—ultra-high frequency (300 MHz to 3 GHz)
USB—upper sideband
UTC—Coordinated Universal Time (also abbreviated Z)
UV—ultraviolet

V

V—volt; vacuum tube
VCO—voltage-controlled oscillator
VCR—video cassette recorder
VDT—video-display terminal
VE—Volunteer Examiner
VEC—Volunteer Examiner Coordinator
VFO—variable-frequency oscillator
VHF—very-high frequency (30-300 MHz)
VLF—very-low frequency (3-30 kHz)
VLSI—very-large-scale integration
VMOS—V-topology metal-oxide semiconductor
VOM—volt-ohmmeter
VOX—voice-operated switch
VR—voltage regulator
VSWR—voltage standing-wave ratio
VTVM—vacuum-tube voltmeter
VUCC—VHF/UHF Century Club
VXO—variable-frequency crystal oscillator

W

W—watt (kg m^2s^{-3}), unit of power
WAC—Worked All Continents
WAS—Worked All States
WBFM—wide-band frequency modulation
WEFAX—weather facsimile
Wh—watthour
WPM—words per minute
WRC—World Radio Conference
WVDC—working voltage, direct current

X

X—reactance

Continued on next page.

Abbreviations List

Continued from previous page.

XCVR—transceiver
XFMR—transformer
XIT—transmitter incremental tuning
XO—crystal oscillator
XTAL—crystal
XVTR—transverter

Y-Z

Y—crystal; admittance
YIG—yttrium iron garnet
Z—impedance; also see UTC

Numbers/Symbols

5BDXCC—Five-Band DXCC
5BWAC—Five-Band WAC
5BWAS—Five-Band WAS
6BWAC—Six-Band WAC
°—degree (plane angle)
°C—degree Celsius (temperature)
°F—degree Fahrenheit (temperature)
α—(alpha) angles; coefficients, attenuation constant, absorption factor, area, common-base forward current-transfer ratio of a bipolar transistor
β—(beta) angles; coefficients, phase constant current gain of common-emitter transistor amplifiers
γ—(gamma) specific gravity, angles, electrical conductivity, propagation constant
Γ—(gamma) complex propagation constant
δ—(delta) increment or decrement; density; angles
Δ—(delta) increment or decrement determinant, permittivity
ε—(epsilon) dielectric constant; permittivity; electric intensity
ζ—(zeta) coordinates; coefficients
η—(eta) intrinsic impedance; efficiency; surface charge density; hysteresis; coordinate
θ—(theta) angular phase displacement; time constant; reluctance; angles
ι—(iota) unit vector
K—(kappa) susceptibility; coupling coefficient
λ—(lambda) wavelength; attenuation constant
Λ—(lambda) permeance
μ—(mu) permeability; amplification factor; micro (prefix for 10^{-6})
μC—microcomputer
μF—microfarad
μH—microhenry
μP—microprocessor
ξ—(xi) coordinates
π—(pi) 3.14159
ρ—(rho) resistivity; volume charge density; coordinates; reflection coefficient
σ—(sigma) surface charge density; complex propagation constant; electrical conductivity; leakage coefficient; deviation
Σ—(sigma) summation
τ—(tau) time constant; volume resistivity; time-phase displacement; transmission factor; density
ϕ—(phi) magnetic flux angles
Φ—(phi) summation
χ—(chi) electric susceptibility; angles
Ψ—(psi) dielectric flux; phase difference; coordinates; angles
ω—(omega) angular velocity $2\pi f$
Ω—(omega) resistance in ohms; solid angle

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British Amateur Television Club
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Bucks HP12 4DD
United Kingdom
01494-528899
e-mail memsec@batc.org.uk

Buckmaster Publishing
6196 Jefferson Highway
Mineral, VA 23117
800-282-5628
540-894-5777
fax 540-894-9141
e-mail info@buck.com
web www.buck.com/

Caddock Electronics
1717 Chicago Ave
Riverside, CA 92507-2364
909-788-1700
fax 909-369-1151
web www.caddock.com/

Calogic
237 Whitney Pl
Fremont, CA 94539
510-656-2900

Jim Cates, WA6GER
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Sacramento, CA 95821
916-487-3580

Cetron Communications
715 Hamilton St
Geneva, IL 60134
800-238-7661
708-208-3700
fax 708-208-3750

Circuit Specialists
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Mesa, AZ 85210
602-966-0764
800-528-1417
480-464-2485
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Coilcraft
1102 Silver Lake Rd
Cary, IL 60013
847-639-6400
fax 847-639-1469
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web www.coilcraft.com/

Communication Concepts, Inc (CCI)
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San Carlos, CA 94070-2682
800-414-TUBE (414-8823)
650-594-4175
web www.eimac.com/

Communications Specialists Inc
426 West Taft Ave
Orange, CA 92865-4296
714-998-3021
800-854-0547
fax 714-974-3420 or 800-850-0547
web www.com-spec.com/

Condenser Products Corp
2131 Broad St
Brooksville, FL 34609
904-796-3561
fax 904-799-0221

Contact East, Inc
335 Willow St
North Andover, MA 01845
508-682-2000
fax 508-688-7829

Ken Cornell
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Point Pleasant, NJ 08742

Courage HANDI-HAM System
3915 Golden Valley Rd
Golden Valley, MN 55422
763-520-0511
763-520-0245 (TTY)
fax 763-520-0577
e-mail handiham@mtn.org
web www.mtn.org/handiham/

CQ Communications
25 Newbridge Rd
Hicksville, NY 11801
516-681-2922 (business office)
fax 516-681-2926
e-mail cqmagazine@aol.com
web www.cq-amateur-radio.com/

Curry Communications
PO Box 1884
Burbank, CA 91507
818-846-0617

Cushcraft Corp
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Manchester, NH 03103
603-627-7877
fax 603-627-1764
e-mail hamsales@cushcraft.com
web www.cushcraft.com/

Custom Computer Services, Inc
PO Box 2452
Brookfield, WI 53008
414-781-2794
web www.ccsinfo.com/picc.html

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Kingston, ON K7M 4Z3
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613-634-1519
e-mail monitor@limestone.kosone.com

Dallas Remote Imaging Group
4209 Meadowdale Dr, Ste 3
Carrollton, TX 75010
214-394-7438 (BBS)
214-394-7325 (Voice)
fax 214-492-7747
e-mail jwallach@drig.com
web www.drig.com/

Davis RF Co, Div of Davis Associates Wire & Cable, LLC
PO Box 730
Carlisle, MA 01741
800-328-4773 (orders and general info)
978-369-1738 (technical info)
fax 978-369-3484
e-mail davisRFinc@aol.com
web www.davisRF.com/

DC Electronics
PO Box 3203
2200 N Scottsdale Rd
Scottsdale, AZ 85271-3203
800-467-7736
web www.dckits.com/index.htm

DCI Inc
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White City, SK S0G 5B0
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306-781-4451
e-mail dci@dci.ca
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Digi-Key Corp
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800-344-4539 (800-DIGI-KEY)
fax 218-681-3380
web www.digikey.com/

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270 Bridge St
Dedham, MA 02026
617-329-5400
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Dover Research
321 W 4th St
Jordan, MN 55352-1313
612-492-3913

Down East Microwave
954 Rte 519
Frenchtown, NJ 08825
908-996-3584
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web www.downeastmicrowave.com/

East Coast Amateur Radio, Inc
415 Division St
N Tonawanda, NY 14120
716-695-3929

EDI, Inc
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Wauconda, IL 60084
708-487-3347
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2700 Hempstead Tpk
Levittown, NY 11756-1443
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Electric Radio Magazine
14643 County Rd G
Cortez, CO 81321-9575
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602-437-8633
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Electronic Equipment Bank (EEB)
323 Mill St, NE
Vienna, VA 22180
orders 800-368-3270
technical 703-938-3350
fax 703-938-6911
e-mail eeb@access.digex.net
web www.access.digex.net/eeb/eeb/html

Electronic Industries Alliance (EIA)
2500 Wilson Blvd
Arlington, VA 22201-3834
703-907-7500
web www.eia.org/

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11651 87th St
Largo, FL 34643-4917
800-367-4649
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Electronic Rainbow, Inc
6227 Coffman Rd
Indianapolis, IN 46268
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fax 317-291-7269

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Farmingdale, NY 11735
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914-679-2497

Embedded Research
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Rochester, NY 14692
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EMI Filter Company
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Plano, TX 75074

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Fair-Rite Products Corp
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Fala Electronics
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Milwaukee, WI 53201-1376

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Dundee, IL 60118-9269
847-836-9148 (voice and **fax**)
web www.cl.ais.net/faircir/

Federal Emergency Management Agency (FEMA)
web www.fema.gov

G-O-Metric
909 Norwich Ave
Delran, NJ 08075

Gary Meyers, K9RX
1753 Elmwood Dr
Rockhill, SC 29730

Gateway Electronics
8123 Page Blvd
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Glen Martin Engineering
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Grove Enterprises Inc
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HAL Communications Corp
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Piscataway, NJ 08855-1331
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Indianapolis, IN 46218-0495
317-545-5412
800-423-2666
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Industrial Safety Co
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Lima, OH 45801
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International Components Corp
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International Crystal Mfg Co
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Oklahoma City, OK 73126-0330
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405-236-3741
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web www.icmfg.com/

International Radio
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541-459-5623
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web www.qth.com/inrad/

International Telecommunication Union (ITU)
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CH 1211
Geneva 20, Switzerland
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Nashville, TN 37214
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Jameco Electronics
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2341 Crystal Dr
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Fort Myers, FL 33906-6017
800-526-9825 (JAN-XTAL)
941-936-2397
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JDR Microdevices
1850 South 10th St
San Jose, CA 95122-4108
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fax 800-538-5005
e-mail sales@jdr.com
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Findlay, OH 45840
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419-423-5643
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Kangaroo Tabor Software
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Farwell, TX 79325-9430
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2201 East Dominguez St
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Long Beach, CA 90801-5745
310-639-5300 (customer support)
800-536-9663 - (repairs/parts)
310-761-8284 (BBS)
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web www.kenwood.net

Kepro Circuit Systems, Inc
630 Axminister Dr
Fenton, MO 63026-2992
800-325-3878
314-343-1630
fax 314-343-0668

Kilo-Tec
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Oak View, CA 93022
805-646-9645 (voice and fax)

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298 West Carmel Dr
Carmel, IN 46032
317-843-2212

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Ventura, CA 93003
805-642-8521

KVG
2240 Woolbright Rd, Ste 320-A
Boynton Beach, FL 33426-6325
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Westbury, NY 11590
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L. L. Grace Communications
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M/A-COM, Inc (an AMP Company)
1011 Pawtucket Blvd
PO Box 3295
Lowell, MA 01853-3295
508-442-4500
fax 508-442-4436
e-mail sales@macom.com
web www.amp.com/

M^2 Antenna Systems
7560 North Del Mar Ave
Fresno, CA 93711
559-432-8873
fax 559-432-3059
e-mail mzinc@mzinc.com
web www.mzinc.com/

MAI/Prime Parts
5736 N Michigan Rd
Indianapolis, IN 46208
317-257-6811
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The Manual Man
27 Walling St
Sayreville, NJ 08872-1818
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800-521-MARK (CA orders)
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Lake Park, FL 33403-0685
800-652-6733
561-848-8236 (Tech)
fax 800-432-9937
e-mail mpja@gate.net

Air Force MARS
HQ AFC4A/SYXR (MARS)
203 Losey St, Room 205
Scott AFB IL 62225-5234
web public.afca.scott.af.mil/public/mars1.htm

Navy-Marine Corps MARS
Chief US Navy-Marine Corps
Military Affiliate Radio System
(MARS)—Bldg 13
NAVCOMMU WASHINGTON
Washington, DC 20397-5161
web www.navymars.org/

Army MARS
HQ US ARMY SIGNAL COMMAND
ATTN: AFSC-OPE-MA (ARMY MARS)
Ft Huachuca, AZ 85613-5000
web www.asc.army.mil/mars/

Maxim Integrated Products
120 San Gabriel Dr
Sunnyvale, CA 94086
408-737-7600
fax 408-737-7194
web www.maxim-ic.com/

Richard Measures, AG6K
6455 LaCumbre Rd
Somis, CA 93066
805-384-3734
e-mail 2@vc.net
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Mendelsohn Electronics Co, Inc
340 E First St
Dayton, OH 45402
800-344-4465
937-461-3525
fax 937-461-3391

Metal and Cable Corp, Inc
9241 Ravenna Rd, Unit C-10
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Twinsburg, OH 44087
216-425-8455
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MFJ Enterprises
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Colorado Springs, CO 80933-7532
719-520-5323
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Microchip Technology
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Chandler, AZ 85224-6199
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fax 602-899-9210
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Microcraft Corp
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Thiensville, WI 53092
414-241-8144

Microwave Components of Michigan
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Taylor, MI 48180
313-753-4581 (evenings)

Microwave Filter Co, Inc
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fax 315-463-1467
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web www.mwfilter.com/

Mini Circuits Labs
PO Box 350166
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718-934-4500
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Mirage Communications
116 Willow Rd
Starkville, MS 39759
601-323-8287
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Bob Mobile, WA1OUB
RFD 2, Hillsboro Cir
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Muncie, IN 47302
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Modern Radio Laboratories
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Phoenix, AZ 85008
512-891-2030
512-891-3773
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Mouser Electronics
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800-346-6873
fax 817-483-0931
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National Fire Protection Association
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Quincy, MA 02269-9101
800-344-3555
web www.nfpa.org/

National Semiconductor Corp
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Santa Clara, CA 95052-8090
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408-721-5000
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5285 Port Royal Rd
Springfield, VA 22161
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PC Electronics
2522 Paxson Ln
Arcadia, CA 91007
626-447-4565
fax 626-447-0489
e-mail tom@hamtv.com
web www.hamtv.com/

Peter W. Dahl Co, Inc
5869 Waycross Ave
El Paso, TX 79924
915-751-2300
fax 915-751-0768
e-mail pwdco@pwdahl.com
web www.pwdahl.com/

Continued on next page.

ARRL Handbook Address List

Continued from previous page.

Phillips Components
PO Box 8533
Scottsdale, AZ 85252
602-269-5974
800-880-6637 (MMDS)
602-947-7700
fax 602-947-7799

Philips-Tech Electronics
PO Box 737
Trinidad, CA 95570
707-677-0159
fax 707-677-0934
web www.phillips-tech.com

Bob Platts, G8OZP
43 Ironwalls Ln
Tutbury, Strafordshire DE13 9NH
United Kingdom
01 283 531443
e-mail
bobplatts@compuserve.com

Popular Communications
— See CQ Communications

Power Supply Components
677 Palomar Ave
Sunnyvale, CA 94086
408-737-1333
fax 408-737-0502

Practical Wireless
Arrowsmith Court
Station Approach
Broadstone, Dorset BH18 8PW
United Kingdom
44-1202-659950
e-mail rob@pwpub.demon.co.uk

PRO Distributors
2811-B 74th St
Lubbock, TX 79423
800-658-2027

PSK31
web aintel.bi.ehu.es/psk31.html

The PX Shack
52 Stonewyck Dr
Belle Mead, NJ 08502

QRP Quarterly (Subscriptions)
2046 Ash Hill Rd
Carrolton, TX 75007

Quantics
PO Box 2163
Nevada City, CA 95959-1263

R & B Enterprises
20 Clipper Rd
W Conshohocken, PA 19428
610-825-1960
fax 610-825-1684
e-mail rbemc@ix.netcom.net

R & D Electronics
5363 Broadway Ave
Cleveland, OH 44127-1551
800-642-1123 (orders)
216-621-1121
fax 216-621-8628

R & L Electronics
1315 Maple Ave
Hamilton, OH 45011
800-221-7735
513-868-6399
fax 513-868-6574
e-mail sales@randl.com
web www.randl.com/

Radio Adventures Corp.
RD #4, Box 240
Summit Dr
Franklin, PA 16346
814-437-5355
fax 814-437-5432
e-mail info@radioadv.com
web www.radioadv.com/

Radio Amateur Telecommunications Society
203 Bishop Blvd
N Brunswick, NJ 08902
e-mail askrat@rats.org
web www.rats.org/

Radio Book Store
PO Box 209
Rindge, NH 03461
800-457-7373
fax 603-899-6826
web www.radiobooks.com/

Radio Society of Great Britain
Lambda House
Cranborne Rd
Potters Bar
Herts EN6 3JE
United Kingdom
44—01-707-659015
web www.rsgb.org/

Radio Switch Corp.
PO Box 159
Marlboro, NJ 07746-0159
732-462-6100

Radiokit
PO Box 973
Pelham, NH 03076
603-635-2235
Telex: 887697
fax 603-635-2943

Radioware
PO Box 209
Rindge, NH 03461
800-457-7373
fax 603-899-6826
e-mail radware@radio-ware.com
web www.radio-ware.com/

Rainy Day Books
PO Box 775
Fitzwilliam, NH 03447
603-585-3448
fax 603-215-0046

Ramsey Electronics, Inc
793 Canning Pkwy
Victor, NY 14564
716-924-4560
fax 716-924-4555

The Raymond Sarrio Co
6147 Via Serena St
Alta Loma CA 91701
800-413-1129 (orders)
909-413-1129
fax 909-484-5125
e-mail wb6siv@cyberg8t.com
web www.sario.com/

Marius Rensen
web www.hffax.de/

RF Parts Co
435 South Pacific St
San Marcos, CA 92069
760-744-0700
800-737-2787 (orders)
fax 760-744-1943
e-mail rfp@rfparts.com
web www.rfparts.com/

RMD Technology, Inc
250 Airport Industrial Dr
Ypsilanti, MI 48198-6061
313-482-2670
fax 313-482-2671
e-mail robertrau@aol.com

Robert H. Bauman Sales
PO Box 122
Itasca, IL 60143

Continued on next page.

ARRL Handbook Address List

Continued from previous page.

ROHN
PO Box 2000
Peoria, IL 61656
309-697-4400
fax 309-697-5612
e-mail rohn@rohnnet.com

Ron Boucher
PO Box 541
Goffstown, NH 03045
603-497-2988
fax 603-497-3244
e-mail 72440.1356@compuserve.com

S & S Engineering
14102 Brown Rd
Smithsburg, MD 21783
301-416-0661
fax 301-416-0963
e-mail n3ga@aol.com
web www.xmetric.com/sseng/

Sentry Mfg Co
PO Box 250
Chickasha, OK 73023
405-224-6780
800-252-6780
fax 405-224-8808

SESCOM, Inc
2100 Ward Dr
Henderson, NV 89015-4249
702-565-3400
fax 702-565-4828

SHF Microwave Parts Company
7102 West 500 South
219-785-4552
La Porte, IN 46350-9575
219-785-4552
e-mail prutz@shfmicro.com
web www.shfmicro.com/

Simple Design Implementations
PO Box 9303
Forestville, CT 06011-9303
860-582-8526

Sky Publishing Company
PO Box 9111
Belmont, MA 02178-9111
800-253-0245
617-864-7360
fax 617-864-6117
e-mail skytel@skypub.com
web www.skypub.com/

SkymooN
9012 Kings Dr
Manvel, TX 7578

SkyWave Technologies
17 Pine Knoll Rd
Lexington, MA 02173
617-862-6742

Small Parts, Inc
13980 NW 58th Ct
PO Box 4650
Miami Lakes, FL 33014-0650
800-220-4242 (Orders)
305-557-7955 (Customer service)
fax 800-423-9009
e-mail smlparts@smallparts.com
web www.smallparts.com/

Society of Wireless Pioneers, Inc
PO Box 86
Geyserville, CA 95441
e-mail k6dzy@netdex.com
web web.mountain.net/~carto/

Software Systems Consulting
615 South El Camino Real
San Clemente, CA 92672
714-498-5784
fax 714-498-0568

The Solar Depot
99 rear Washington St
Melrose, MA 02176
617-665-7609
e-mail rmeuse@world.std.com

Solar Energy of South Florida
1024 NE 21st St
Belle Glade, FL 33430
407-996-6290

Solder-It Co
Box 20100
Cleveland, OH 44120
216-791-4600
800-897-8989
fax 216-721-3700
e-mail fdoo6@apk.net
web www.solder-it.com/

Southern Electronics Supply
1909 Tulane Ave
New Orleans, LA 70112
504-524-2343
e-mail e-mail@southernele.com
web www.southernele.com/

Southwestern Bell
7486 Shadeland Station Way
Indianapolis, IN 46256
317-576-6847

Sparrevohn Engineering
143 Nieto Ave SW #1
Long Beach, CA 90815
562-799-1577
web www.members.aol.com/zsmrtfred/

SPEC-COM Journal
PO Box 1002
Dubuque, IA 52004-1002
319-557-8791
fax 319-583-6462

Spectrum International, Inc
PO Box 1084
Concord, MA 01742
508-263-2145
fax 508-263-7008

Star Circuits
PO Box 94917
Las Vegas, NV 89193
800-433-6319

Star-Tronics
PO Box 98102
Las Vegas, NV 89193-8102
702-795-7151 (voice and **fax**)

Steinmetz Electronics
7519 Maplewood Ave
Hammond, IN 46324
219-931-9316

Sunlight Energy Systems
955 Manchester Ave SW
N Lawrence, OH 44666
330-832-4161

Surplus Sales of Nebraska
1502 Jones St
Omaha, NE 68102-3112
800-244-4567 (orders)
402-346-4750
fax 402-346-2939
e-mail grinnell@surplussales.com
web www.surplussales.com/

Continued on next page.

ARRL Handbook Address List

Continued from previous page.

Surplus Traders
PO Box 276, Winters Ln
Alburg, VT 05440
514-739-9328
fax 514-345-8303
e-mail marv@73.com
web www.73.com/a/

Svetlana Electron Devices
8200 S. Memorial Parkway
Huntsville, AL 35802
256-882-1344
800-239-6900
fax 256-880-8077
e-mail sales@svetlana.com
web www.svetlana.com/

TAB/McGraw-Hill, Inc
860 Taylor Station Rd
Blacklick, OH 43004
800-262-4729
fax 614-759-3641
e-mail customer.service@mcgraw-hill.com

Tandy National Parts
900 E Northside Dr
Ft Worth, TX 76102
800-322-3690
fax 817-870-5626

TCE Labs
2365 Waterfront Park Dr
Canyon Lake, TX 78133
830-899-4575

TE Systems
PO Box 25845
Los Angeles, CA 90025
310-478-0591
fax 310-473-4038

Tech America
PO Box 1981
Fort Worth, TX 76101-1981
web www.techam.com
800-877-0072

Tejas RF Technology
PO Box 720331
Houston, TX 77272-0331
713-879-9300
fax 713-879-9494

Telecom Industries
1385 Akron St
Copaigue, NY 11726
516-789-5020

Teletec Corp
10101 Capital Blvd
Wake Forest, NC 27587
909-556-7800

Telex Communications, Inc
8601 East Cornhusker Highway
Lincoln, NE 68505
402-467-5321
402-465-7021 (parts and service)
fax 402-467-3279

Tempo Research Corp
—see AEA

Ten-Tec, Inc
1185 Dolly Parton Pkwy
Sevierville, TN 37862
423-453-7172
fax 423-428-4483
web www.tentec.com/

Texas Towers
1108 Summit Ave, Suite 4
Plano, TX 75074
800-272-3467
972-422-7306 (Tech)
fax 972-881-0776
e-mail sales@texastowers.com
web www.texastowers.com/

Timewave Technology, Inc
2401 Pilot Knob Rd
Suite 134
St Paul MN 55120
612-452-5939
fax 612-452-4571

Toroid Corp of Maryland
202 Northwood Dr
Salisbury, MD 21801
410-860-0300
fax 410-860-0302

Tri-Ex Tower Corp
7182 Rasmussen Ave
Visalia, CA 93291
800-328-2393 (orders)
209-651-7850 ext. 352 or 353 (Tech Support)
fax 209-651-5157

Trinity Software
7801 Rice Dr
Rowlett, TX 75088
972-475-7132

Tucson Amateur Packet Radio
8987-309 E Tanque Verde Rd, #337
Tucson, AZ 85749-9399
817-383-0000 (voice mail)
fax 817-566-2544
e-mail tapr@tapr.org
web www.tapr.org

TX RX Systems, Inc
8625 Industrial Pky
Angola, NY 14006
716-549-4700
fax 716-549-4772

Typetronics
PO Box 8873
Fort Lauderdale, FL 33310-8873
954-583-1340
fax 954-583-0777

Unified Microsystems
PO Box 133
Slinger, WI 53086
414-644-9036
fax 414-644-9036
e-mail uns@nconnect.net

United Nations Bookstore
UN General Assembly Building, Room 32B
New York, NY 10017

Universal Manufacturing Co
43900 Groesbeck Hwy
Clinton Township, MI 48036
810-463-2560
fax 810-463-2964

US Electronics
585 North Bicycle Path
Port Jefferson Station, NY 11776
516-331-2552
e-mail info@uselec.com
web www.uselectronics.com/

US Government Printing Office
Washington, DC 20402-9371
202-783-3238
202-512-1800 (credit card orders)
web www.gpo.gov/

US Plastic Corp
1390 Neubrecht Rd
Lima, OH 45801
800-537-9724
fax 419-228-5034

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US Tower Corp
1220 Marcin St
Visalia, CA 93291
209-733-2438
fax 209-733-7194

VK3UM EME Planner
Doug McArthur
30 Rolloway Rise
Chirnside Park 3116
Australia

The W5YI Group
PO Box 565101
Dallas, TX 75356
800-669-9594 (orders)
817-274-0400
e-mail w5yi@w5yi.org
web www.w5yi.org/

W6EL Software
11058 Queensland St
Los Angeles, CA 90034-3029
310-473-7322
e-mail ad363@lafn.org

W7FG Vintage Manuals
3300 Wayside Dr
Bartlesville, OK 74006
800-807-6146 (orders)
918-333-3754
e-mail w7fg@eigen.net
web www.w7fg.com/

Watkins-Johnson Company,
Telecommunications Group
700 Quince Orchard Rd
Gaithersburg, MD 20878-1794
301-948-7550
800-954-3577
(800-WJ-HELPS)
fax 301-921-7479
e-mail wjhelps@wj.com or
mike.cox@wj.com
web www.wj.com/

Ed Wetherhold, W3NQN
1426 Catlyn Pl
Annapolis, MD 21401-4208
410-268-0916
fax 410-268-4779

Wilderness Radio
PO Box 734
Los Altos, CA 94023-0734
650-494-3806
e-mail qrpbob@datamers.com
web www.fix.net/jparker/wild.html

Winegard
3000 Kirkwood St
Burlington, IA 52601-1007

The Wireman Inc
261 Pittman Rd
Landrum, SC 29356-9544
800-727-WIRE (800-727-9473)
Orders only
864-895-4195 Technical
fax 864-895-5811
e-mail info@thewireman.com
web www.thewireman.com/

Worldradio
2120 28th St
Sacramento, CA 95818
916-457-3655
800-366-9192 (subscriptions)
e-mail kb6hp@ms.net
web www.wr6w.com/

Wyman Research, Inc
8339 South, 850 West
Waldron, IN 46182-9644
765-525-6452

Yaesu U.S.A.
17210 Edwards Rd
Cerritos, CA 90703
562-404-2700
fax 562-404-1210
e-mail yaesu@worldnet.att.net
web www.yaesu.com/

Zero Surge
944 State Rte 12
Frenchtown NJ 08825
908-996-7700
fax 908-996-7773

Z-TRAK
RFD 1 Box 33
Milo, ME 04463

73 Amateur Radio Today
70 Route 202N
Peterborough, NH 03458
603-924-0058
800-274-7373 (subscriptions)

The ARRL Technical Information Service (TIS)

The ARRL answers questions of a technical nature for ARRL members and nonmembers alike through the Technical Information Service. Questions may be submitted via e-mail (tis@arrl.org); phone (860-594-0214); Fax (860-594-0259); or mail (TIS, ARRL, 225 Main St, Newington, CT 06111). The TIS also maintains a home page on *ARRLWeb*: **http://www.arrl.org/tis**. This site contains links to several technical areas:

TISfind – This search engine contains over 2000 providers of products, services and information of interest to radio amateurs. Before contacting TIS for the address of someone who can repair your radio, or sells antennas, or has old manuals or schematics, look in *TISfind*. Instructions and categories are on the *TISfind* page. This file may be downloaded for use off-line.

ARRL Periodicals Index Search – This **Members Only** search engine contains the *QST* index from 1915 to the present and the *QEX* index from 1981 to the present. For *QST* issues from 1970 to the present, and some selected articles back to 1950, identifying keywords have been added to the database. By entering keywords (such as ANTENNA) or combinations of keywords (such as CONSTRUCTION ANTENNA VERTICAL HF) into the **Title words:** field, you may create dynamic bibliographies. A KEYWORD list is provided on the ARRL Periodicals Index Search page. This replaces the old bibliographies TXT files.

QST Product Reviews — There is a link to a list of Product Reviews from 1970 to the present and for **Members Only** these Product Reviews may be viewed online or downloaded to your computer for printing. There are also links to ARRL book companion software, project templates, product notes, and source code and programs mentioned in *QST* articles.

TIS Pages — The flagship of the TIS Web Page is the Technical Information Pages menu. These articles replace the old TIS Packages that were available only by mail in the past. There are now over 100 topics containing over 500 articles for viewing or download. A list of topics follows:

Access for the Blind

Antennas
- Antenna Projects
- Antenna Gain
- Antenna Ground
- Antenna Theory
- Balloon Antenna
- Grounding
- Indoor
- Receiving Wire Antennas
- Smith Charts
- Transmission Lines/SWR
- Transmatch/Antenna Tuner

Antique/Vintage Radio

Amateur Television
- ATV — Fast Scan TV
- SSTV — Slow Scan TV

Batteries

Buying a Rig

Beginner Ham
- First Steps in Radio
- Your First Antenna

Construction Projects/Techniques
- Antenna Projects
- Building Equipment
- Construction Techniques
- Projects for the Ham Shack
- QRP Projects
- Servicing Equipment
- Surface Mount Technology
- Tube Amplifiers
- VHF Projects
- Tube Transmitters/Receivers

Digital Modes
- AMTOR, APRS, Packet, RTTY, TCP/IP
- Digital Voice
- PSK31
- WEFAX

DSP — Digital Signal Processing

EME — Moonbounce

Emergency/Alternative Power

Grid Squares

Ham Radio History

Internet Ham Radio

Lab Notes, Complete

Laser Communications

Lightning Protection

Link/Remote Control

Mobile
- Marine
- VHF Antennas

Morse/CW
- Coherent CW

Propagation

QRP

Repeaters

RF Exposure

RFI/EMI

Safety
- EDS (Electrostatic Discharge Safety)
- Electrical Safety
- RF Exposure (New!)

Satellites
- General
- Phase 3D

Science Fair/Merit Badge Projects

UHF/Microwave
- UHF/Microwave Projects and Information

Check back often for new and updated TIS pages.

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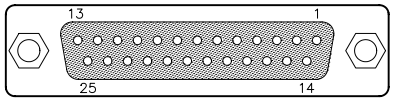
Computer Connector Pinouts

(A)

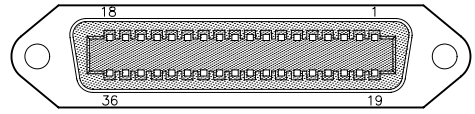
Parallel Port (DB 25 pin)
Female



Pin	Signal	Pin	Signal
1	Strobe	10	Acknowledge
2	Data 0	11	Busy
3	Data 1	12	Paper Empty
4	Data 2	13	Select
5	Data 3	14	Auto Feed
6	Data 4	15	Error
7	Data 5	16	Initialize
8	Data 6	17	Select In
9	Data 7	18–25	GND

(B)

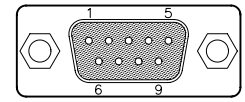
Parallel Port (Centronics 36 pin)
Female



Pin	Signal	Pin	Signal
1	Strobe	13	Select
2	Data 0	14	Auto Feed
3	Data 1	15	N/C (not connected)
4	Data 2	16	Signal GND
5	Data 3	17	Frame GND
6	Data 4	18	+5 V Out
7	Data 5	19–30	GND
8	Data 6	31	Reset
9	Data 7	32	Error
10	Acknowledge	33	External GND
11	Busy	34	N/C
12	Paper Empty	35	N/C
		36	Select In

(C)

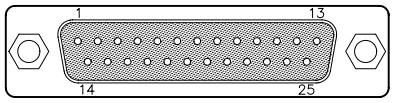
Serial Port (DB 9 pin)
Male



Pin	Signal
1	DCD (Data Carrier Detect)
2	RxD (Receive Data)
3	TxD (Transmit Data)
4	DTR (Data Terminal Ready)
5	GND (Signal Ground)
6	DSR (Data Set Ready)
7	RTS (Request To Send)
8	CTS (Clear To Send)
9	RI (Ring Indicator)

(D)

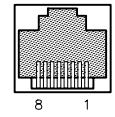
Serial Port (DB 25 pin)
Male



Pin	Signal	Pin	Signal
1	N/C (not connected)	20	DTR (Data Terminal Ready)
2	TxD (Transmit Data)	21	N/C
3	RxD (Receive Data)	22	RI (Ring Indicator)
4	RTS (Request To Send)	23	N/C
5	CTS (Clear To Send)	24	N/C
6	DSR (Data Set Ready)	25	N/C
7	GND (Signal Ground)		
8	DCD (Data Carrier Detect)		
9–19	N/C		

(E)

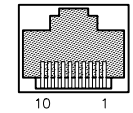
Ethernet Connector (RJ45–8 pin)
Female



Pin	Signal
1	Output Transmit Data (+)
2	Output Transmit Data (–)
3	Input Receive Data (+)
4	N/C (not connected)
5	N/C
6	Input Receive Data (–)
7	N/C
8	N/C

(F)

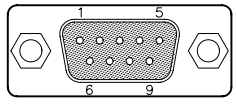
Ethernet Connector (RJ45–10 pin)
Female



Pin	Signal
1	DCD (Data Carrier Detect)
2	DTR (Data Terminal Ready)
3	CTS (Clear To Send)
4	GND (Signal Ground)
5	RxD (Receive Data)
6	TxD (Transmit Data)
7	GND (Frame Ground)
8	RTS (Request To Send)
9	DSR (Data Set Ready)
10	RI (Ring Indicator)

(G)

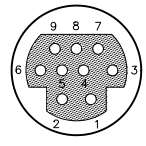
Mouse Port (DB 9 pin)
Male



Pin	Signal
1	N/C (not connected)
2	Data
3	Clock
4	N/C
5	GND (Signal Ground)
6	N/C
7	RTS (12–9 V)
8	N/C
9	N/C

(H)

Mouse Port (mini DIN 9 pin)
Female

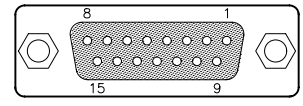


Pin	Signal
1	+5 V
2	X–A
3	X–B
4	Y–A
5	Y–B
6	Button 1
7	Button 2
8	Button 3
9	GND

Note: All figures not drawn to same scale.

(I)

Game/Joystick Port (DB 15 pin)
Female



Pin	Signal	Pin	Signal
1	+5 V	10	Button (B–1)
2	Button (A–1)	11	Position (B–X)
3	Position (A–X)	12	GND
4	GND	13	Position (B–Y)
5	GND	14	Button (B–2)
6	Position (A–Y)	15	+5 V
7	Button (A–2)		
8	+5 V		
9	+5 V		

Voltage-Power Conversion Table

Based on a 50-ohm system

Voltage			Power	
RMS	**Peak-to-Peak**	**dBmV**	**Watts**	**dBm**
0.01 µV	0.0283 µV	–100	2×10^{-18}	–147.0
0.02 µV	0.0566 µV	–93.98	8×10^{-18}	–141.0
0.04 µV	0.113 µV	–87.96	32×10^{-18}	–134.9
0.08 µV	0.226 µV	–81.94	128×10^{-18}	–128.9
0.1 µV	0.283 µV	–80.0	200×10^{-18}	–127.0
0.2 µV	0.566 µV	–73.98	800×10^{-18}	–121.0
0.4 µV	1.131 µV	–67.96	3.2×10^{-15}	–114.9
0.8 µV	2.236 µV	–61.94	12.8×10^{-15}	–108.9
1.0 µV	2.828 µV	–60.0	20.0×10^{15}	–107.0
2.0 µV	5.657 µV	–53.98	80.0×10^{-15}	–101.0
4.0 µV	11.31 µV	–47.96	320.0×10^{-15}	–94.95
8.0 µV	22.63 µV	–41.94	1.28×10^{-12}	–88.93
10.0 µV	28.28 µV	–40.00	2.0×10^{-12}	– 86.99
20.0 µV	56.57 µV	–33.98	8.0×10^{-12}	–80.97
40.0 µV	113.1 µV	–27.96	32.0×10^{-12}	–74.95
80.0 µV	226.3 µV	–21.94	128.0×10^{-12}	–68.93
100.0 µV	282.8 µV	–20.0	200.0×10^{-12}	–66.99
200.0 µV	565.7 µV	–13.98	800.0×10^{-12}	–60.97
400.0 µV	1.131 mV	–7.959	3.2×10^{-9}	–54.95
800.0 µV	2.263 mV	–1.938	12.8×10^{-9}	–48.93
1.0 mV	2.828 mV	0.0	20.0×10^{-9}	–46.99
2.0 mV	5.657 mV	6.02	80.0×10^{-9}	–40.97
4.0 mV	11.31 mV	12.04	320×10^{-9}	–34.95
8.0 mV	22.63 mV	18.06	1.28 µW	–28.93
10.0 mV	28.28 mV	20.00	2.0 µW	–26.99
20.0 mV	56.57 mV	26.02	8.0 µW	–20.97
40.0 mV	113.1 mV	32.04	32.0 µW	–14.95
80.0 mV	226.3 mV	38.06	128.0 µW	–8.93
100.0 mV	282.8 mV	40.0	200.0 µW	–6.99
200.0 mV	565.7 mV	46.02	800.0 µW	–0.97
223.6 mV	632.4 mV	46.99	1.0 mW	0
400.0 mV	1.131 V	52.04	3.2 mW	5.05
800.0 mV	2.263 V	58.06	12.80 mW	11.07
1.0 V	2.828 V	60.0	20.0 mW	13.01
2.0 V	5.657 V	66.02	80.0 mW	19.03
4.0 V	11.31 V	72.04	320.0 mW	25.05
8.0 V	22.63 V	78.06	1.28 W	31.07
10.0 V	28.28 V	80.0	2.0 W	33.01
20.0 V	56.57 V	86.02	8.0 W	39.03
40.0 V	113.1 V	92.04	32.0 W	45.05
80.0 V	226.3 V	98.06	128.0 W	51.07
100.0 V	282.8 V	100.0	200.0 W	53.01
200.0 V	565.7 V	106.0	800.0 W	59.03
223.6 V	632.4 V	107.0	1000.0 W	60.0
400.0 V	1,131.0 V	112.0	3,200.0 W	65.05
800.0 V	2,263.0 V	118.1	12,800.0 W	71.07
1000.0 V	2,828.0 V	120.0	20,000 W	73.01
2000.0 V	5,657.0 V	126.0	80,000 W	79.03
4000.0 V	11,310.0 V	132.0	320,000 W	85.05
8000.0 V	22,630.0 V	138.1	1.28 MW	91.07
10,000.0 V	28,280.0 V	140.0	2.0 MW	93.01

Continued on next page.

Voltage-Power Conversion Table

Continued from previous page.

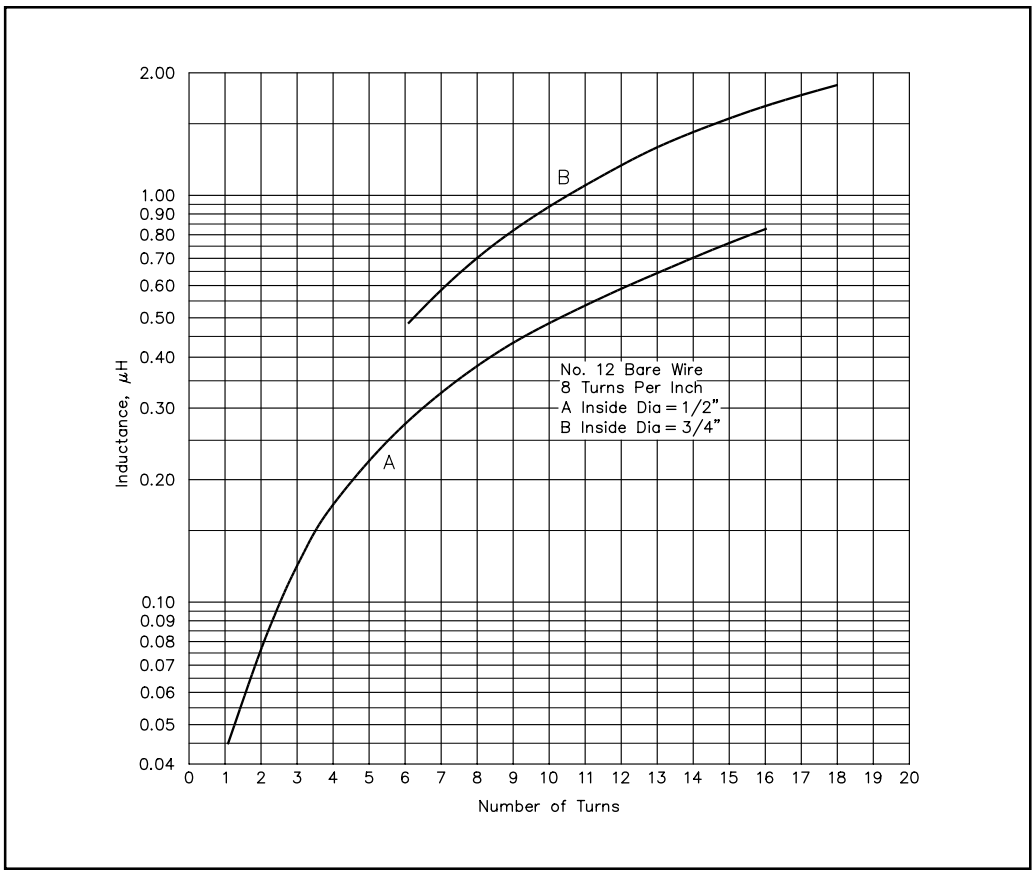
$$\text{Voltage}, V_{p-p} = V_{RMS} \times \sqrt{2}$$

$$\text{Voltage}, \text{dBmV} = 20 \times \text{Log}_{10}\left[\frac{V_{RMS}}{0.001\text{V}}\right]$$

$$\text{Power}, \text{Watts} = \left[\frac{V_{RMS}^{\ 2}}{50\,\Omega}\right]$$

$$\text{Power}, \text{dBm} = 10 \times \text{Log}_{10}\left[\frac{\text{Power}\,(\text{watts})}{0.001\text{W}}\right]$$

Measured inductance for #12 Wire Windings

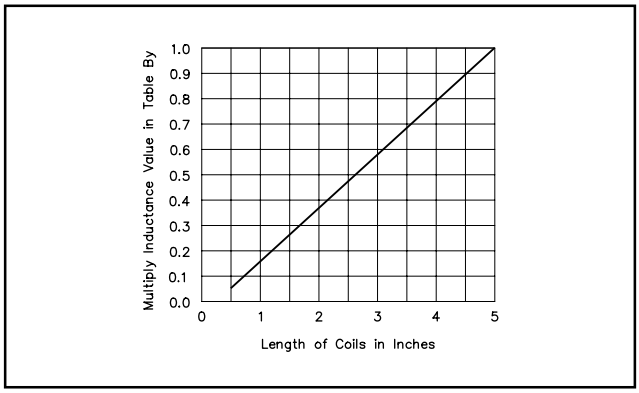


Values are for inductors with half-inch leads and wound with eight turns per inch.

Large Machine-Wound Coil Specifications

Coil Dia, Inches	*Turns Per Inch*	*Inductance in µH*
$1^1/_4$	4	2.75
	6	6.3
	8	11.2
	10	17.5
	16	42.5
$1^1/_2$	4	3.9
	6	8.8
	8	15.6
	10	24.5
	16	63
$1^3/_4$	4	5.2
	6	11.8
	8	21
	10	33
	16	85
2	4	6.6
	6	15
	8	26.5
	10	42
	16	108
$2^1/_2$	4	10.2
	6	23
	8	41
	10	64
3	4	14
	6	31.5
	8	56
	10	89

Inductance Factor for Large Machine-Wound Coils

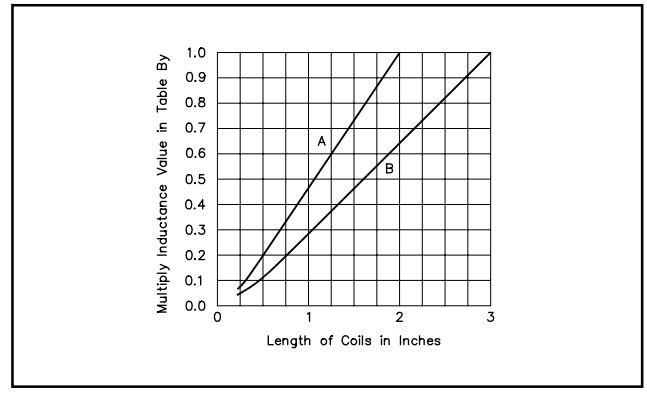


Factor to be applied to the inductance of large coils for coil lengths up to 5 inches.

Small Machine-Wound Coil Specifications

Coil Dia, Inches	*Turns Per Inch*	*Inductance in µH*
$^1/_2$ (A)	4	0.18
	6	0.40
	8	0.72
	10	1.12
	16	2.8
	32	12
$^5/_8$ (A)	4	0.28
	6	0.62
	8	1.1
	10	1.7
	16	4.4
	32	18
$^3/_4$ (B)	4	0.6
	6	1.35
	8	2.4
	10	3.8
	16	9.9
	32	40
1 (B)	4	1.0
	6	2.3
	8	4.2
	10	6.6
	16	16.9
	32	68

Inductance Factor for Small Machine-Wound Coils



Factor to be applied to the inductance of small coils as a function of coil length. Use curve A for coils marked A, and curve B for coils marked B.

How to Use the Standard Value Capacitor (SVC) Filter Tables

Detailed instructions for using these tables appear in the Filters chapter. If you are unfamiliar with filter design from tables, look there to learn the basics. This simple example is intended as a memory aid, not a tutorial.

Let's design a low-pass filter for a 20-m CW transmitter. Based on measurements of the second harmonic, insertion loss (attenuation) should be at least 20 dB at the minimum second-harmonic frequency (28 MHz). Insertion loss should be minimal at the maximum operating frequency (14.1 MHz).

When choosing a filter, look for appropriate cutoff and attenuation frequencies, but *ignore the decimal points* because the component values are easily scaled by powers of ten. A 5-element Chebyshev design looks like a good choice because designs 20 through 22 show 20-dB frequencies of 2.73 and 2.77 MHz and cutoff frequencies of 1.44 to 1.66 MHz. In fact, those numbers are *too* close to our targets (27.7 MHz is only 1.1% under 28 MHz). Using 5% components, we would be lucky to get within 5% of the design targets. It's better to move each target value 10% or so to the safe side, which yields 20 dB at 25.2 MHz and f_{co} = 15.5 MHz. No 5-element design in the table can meet these criteria.

In the 7-element Chebyshev list, however, design 25 meets the needs. It has a maximum SWR of 1.099:1, which is acceptable.

FREQUENCY (MHz)

NO.	*F_{co}*	*3 dB*	*20 dB*	*40 dB*	*MAX SWR*	*C1,7 (pF)*	*L2,6 (µH)*	*C3,5 (pF)*	*L4 (µH)*
25	1.68	1.93	2.35	3.03	1.099	1500	6.58	3300	7.72

Scaling the filter is easy. We need only divide one of the frequencies listed into the desired frequency, round to the nearest power of ten and multiply all frequencies and divide all component values by the result: 28/2.35 = 11.91, say 10; which gives:

FREQUENCY (MHz)

NO.	*F_{co}*	*3 dB*	*20 dB*	*40 dB*	*MAX SWR*	*C1,7 (pF)*	*L2,6 (µH)*	*C3,5 (pF)*	*L4 (µH)*
25	16.8	19.3	23.5	30.3	1.099	150	0.658	330	0.772

In some cases, the filter terminating impedances may not be 50 Ω. Then we need to adjust the filter values to match the required impedance. All tabulated designs are easily scaled to impedance levels other than 50 Ω, while keeping the convenience of standard-value capacitors and the "scan mode" of design selection. If the desired new impedance level differs from 50 Ω by a factor that is some power of ten, the 50-Ω design is scaled by shifting the decimal points of the component values, that is multiplying or dividing by some power of ten. The other data remain unchanged. For example, if the impedance level is increased by ten or one hundred times (to 500 or 5000 Ω), the decimal point of the capacitor is shifted to the left (dividing) one or two places and the decimal point of the inductor is shifted to the right (multiplying) one or two places. With increasing impedance, capacitor values decrease and inductor values increase. The opposite is true when impedance decreases.

When the desired impedance level differs from the standard 50-Ω value by a factor that is not a power of ten, such as 1.2, 1.5 or 1.86, the search criteria to select the design number must be adjusted by that factor:

1. Calculate the impedance scaling ratio:

$$R = \frac{Z_x}{50} \qquad (1)$$

where Z_x is the desired new impedance level, in ohms.

2. Calculate the cutoff frequency (f_{50co}) of a "trial" 50-Ω filter,

$$f_{50co} = R \times f_{xco} \qquad (2)$$

where R is the impedance scaling ratio and f_{xco} is the desired cutoff frequency of the filter at the new impedance level.

3. Select a design from the SVC tables based on the calculated f_{50co}. The capacitor values of this design are taken directly, but the frequency and inductor values must be scaled to the new impedance level.

Continued on next page.

How to Use the Standard Value Capacitor (SVC) Filter Tables

Continued from previous page.

4. Calculate the exact f_{xco} values, where

$$f_{xco} = \frac{f'50co}{R} \qquad (3)$$

and f'_{50co} is the tabulated cutoff frequency of the selected design. Calculate the other frequencies of the design in the same way.

5. Calculate the inductor values for the new filter by multiplying the tabulated inductor values of the selected design by the square of the scaling ratio, R.

For example, assume that our 20-m low-pass filter were to be used in a 1000-Ω IF stage. This requires that we apply both methods, because a change from 50 to 1000 involves factors of 10 and 2 (50 × 2 × 10 = 1000). Therefore, we must first scale the desired frequencies by from 50 Ω to 100 Ω (50 × 2 = 100):

R = 100/50 = 2

f_{50co} = 2 × 15.5 = 31 MHz

f_{20dB} = 2 × 25.2 = 50.4 MHz

Select a filter based on these two values. Design 59 from the 7-element low-pass Chebyshev list looks good. Scale all frequencies of the final design by dividing the tabulated frequencies impedance scaling ratio, 2:

f_{co} = 3.3/2 = 1.65

f_{20dB} = 4.81/2 = 2.405

The inductor values are scaled to 100 Ω by multiplying them by the square of the impedance ratio, where R = 2 and R^2 = 4.0:

L2,6 = 4.0 × 3.24 µH = 12.96 µH

L4 = 4.0 × 3.88 µH = 15.52 µH

The 100-Ω design is now impedance scaled to 1000 Ω by shifting the decimal points of the capacitor values to the left and the decimal points of the inductor values to the right. The final scaled component values for the 1000-Ω filter are:

C1,7 = 68 pF

C3,5 = 160 pF

L2,6 = 129.6 µH

L4 = 155.2 µH.

5-Element Chebyshev Low-Pass Filter Designs—
50-Ohm Impedance, C-In/Out for Standard E24 Capacitor Values

Filter No.	—— Frequency (MHz) —— F_{co}	3 dB	20 dB	40 dB	Max SWR	C1,5 (pF)	L2,4 (µH)	C3 (pF)
1	1.01	1.15	1.53	2.25	1.355	3600	10.8	6200
2	1.02	1.21	1.65	2.45	1.212	3000	10.7	5600
3	1.15	1.29	1.71	2.51	1.391	3300	9.49	5600
4	1.10	1.32	1.81	2.69	1.196	2700	9.88	5100
5	1.25	1.41	1.88	2.75	1.386	3000	8.67	5100
6	1.04	1.37	1.94	2.94	1.085	2200	9.82	4700
7	1.15	1.41	1.95	2.92	1.155	2400	9.37	4700
8	1.32	1.50	2.01	2.96	1.332	2700	8.29	4700
9	1.13	1.50	2.12	3.22	1.081	2000	9.00	4300
10	1.26	1.54	2.13	3.19	1.157	2200	8.56	4300
11	1.39	1.61	2.18	3.21	1.276	2400	7.88	4300
12	1.05	1.62	2.38	3.66	1.028	1600	8.35	3900
13	1.23	1.65	2.34	3.55	1.076	1800	8.19	3900
14	1.39	1.70	2.35	3.51	1.159	2000	7.75	3900
15	1.55	1.79	2.41	3.55	1.295	2200	7.05	3900
16	1.17	1.76	2.57	3.94	1.033	1500	7.70	3600
17	1.27	1.77	2.55	3.88	1.057	1600	7.64	3600
18	1.46	1.82	2.54	3.81	1.135	1800	7.28	3600
19	1.65	1.92	2.59	3.83	1.268	2000	6.64	3600
20	1.88	2.08	2.73	3.97	1.497	2200	5.70	3600
21	1.43	1.94	2.77	4.21	1.068	1500	6.96	3300
22	1.54	1.97	2.77	4.17	1.109	1600	6.79	3300
23	1.76	2.07	2.81	4.17	1.238	1800	6.21	3300
24	2.02	2.25	2.96	4.31	1.470	2000	5.31	3300
25	1.31	2.10	3.11	4.79	1.022	1200	6.43	3000
26	1.48	2.12	3.06	4.68	1.046	1300	6.39	3000
27	1.75	2.19	3.05	4.57	1.135	1500	6.07	3000
28	1.89	2.25	3.08	4.57	1.206	1600	5.77	3000
29	2.19	2.45	3.23	4.71	1.440	1800	4.92	3000
30	1.51	2.34	3.44	5.29	1.026	1100	5.78	2700
31	1.70	2.36	3.40	5.17	1.057	1200	5.73	2700
32	1.87	2.40	3.38	5.10	1.104	1300	5.57	2700
33	2.20	2.56	3.46	5.11	1.268	1500	4.98	2700
34	2.39	2.69	3.56	5.21	1.406	1600	4.53	2700
35	1.75	2.63	3.85	5.91	1.033	1000	5.14	2400
36	1.99	2.67	3.81	5.78	1.072	1100	5.05	2400
37	2.19	2.74	3.81	5.71	1.135	1200	4.85	2400
38	2.40	2.84	3.86	5.73	1.227	1300	4.55	2400
39	1.89	2.87	4.21	6.47	1.030	910	4.71	2200
40	2.14	2.91	4.16	6.31	1.068	1000	4.64	2200
41	2.39	2.99	4.16	6.23	1.135	1100	4.45	2200
42	2.64	3.11	4.22	6.25	1.238	1200	4.14	2200
43	2.93	3.29	4.36	6.39	1.398	1300	3.71	2200
44	2.05	3.16	4.64	7.13	1.028	820	4.28	2000
45	2.36	3.20	4.57	6.94	1.068	910	4.22	2000
46	2.63	3.28	4.57	6.86	1.135	1000	4.05	2000
47	2.93	3.43	4.65	6.89	1.251	1100	3.73	2000
48	3.29	3.67	4.85	7.07	1.440	1200	3.28	2000
49	2.34	3.51	5.14	7.88	1.033	750	3.85	1800
50	2.63	3.56	5.08	7.71	1.069	820	3.79	1800
51	2.96	3.66	5.09	7.62	1.145	910	3.61	1800
52	3.30	3.84	5.19	7.67	1.268	1000	3.32	1800
53	3.76	4.15	5.45	7.93	1.497	1100	2.85	1800
54	2.70	3.96	5.76	8.82	1.039	680	3.42	1600

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5-Element Chebyshev Low-Pass Filter Designs—
50-Ohm Impedance, C-In/Out for Standard E24 Capacitor Values

Continued from previous page.

Filter	—— Frequency (MHz) ——				Max	C1,5	L2,4	C3
No.	F_{co}	3 dB	20 dB	40 dB	SWR	(pF)	(µH)	(pF)
55	3.06	4.03	5.71	8.63	1.086	750	3.34	1600
56	3.38	4.14	5.73	8.57	1.159	820	3.18	1600
57	3.82	4.39	5.89	8.67	1.311	910	2.86	1600
58	2.77	4.21	6.18	9.48	1.030	620	3.21	1500
59	3.14	4.26	6.10	9.26	1.067	680	3.17	1500
60	3.51	4.38	6.10	9.14	1.135	750	3.03	1500
61	3.88	4.56	6.20	9.17	1.241	820	2.82	1500
62	4.46	4.95	6.51	9.48	1.473	910	2.41	1500
63	3.39	4.88	7.08	10.8	1.044	560	2.77	1300
64	3.84	4.98	7.02	10.6	1.097	620	2.70	1300
65	4.26	5.14	7.08	10.5	1.181	680	2.55	1300
66	4.79	5.46	7.29	10.7	1.341	750	2.28	1300
67	3.61	5.28	7.68	11.8	1.039	510	2.56	1200
68	4.06	5.36	7.61	11.5	1.083	560	2.51	1200
69	4.55	5.54	7.65	11.4	1.167	620	2.37	1200
70	5.07	5.84	7.84	11.5	1.304	680	2.16	1200
71	3.96	5.76	8.38	12.8	1.041	470	2.35	1100
72	4.39	5.84	8.31	12.6	1.079	510	2.31	1100
73	4.88	6.01	8.33	12.5	1.152	560	2.20	1100
74	5.50	6.34	8.54	12.6	1.293	620	1.99	1100
75	4.40	6.34	9.20	14.1	1.043	430	2.13	1000
76	4.91	6.45	9.13	13.8	1.087	470	2.09	1000
77	5.38	6.62	9.17	13.7	1.154	510	2.00	1000
78	6.00	6.95	9.37	13.8	1.282	560	1.83	1000
79	4.81	6.97	10.1	15.5	1.042	390	1.94	910
80	5.43	7.09	10.0	15.2	1 091	430	1.89	910
81	6.00	7.31	10.1	15.1	1.167	470	1.80	910
82	6.60	7.64	10.3	15.2	1.283	510	1.66	910
83	4.86	7.69	11.4	17.5	1.023	330	1.76	820
84	5.51	7.76	11.2	17.1	1.052	360	1.74	820
85	6.07	7.89	11.1	16.8	1.095	390	1.70	820
86	6.77	8.17	11.2	16.7	1.184	430	1.60	820
87	7.54	8.61	11.5	17.0	1.327	470	1.45	820
88	5.26	8.40	12.4	19.2	1.022	300	1.61	750
89	6.04	8.49	12.2	18.7	1.052	330	1.59	750
90	6.70	8.64	12.2	18.4	1.101	360	1.55	750
91	7.33	8.89	12.3	18.3	1.175	390	1.48	750
92	8.24	9.42	12.6	18.5	1.327	430	1.33	750
93	6.69	9.36	13.5	20.6	1.054	300	1.44	680
94	7.48	9.56	13.4	20.2	1.110	330	1.40	680
95	8.25	9.89	13.6	20.2	1.196	360	1.32	680
96	9.10	10.4	13.9	20.4	1.328	390	1.20	680
97	7.21	10.2	14.8	22.6	1.048	270	1.32	620
98	8.18	10.5	14.7	22.2	1.107	300	1.28	620
99	9.11	10.9	14.9	22.1	1.203	330	1.19	620
100	10.1	11.5	15.3	22.5	1.355	360	1.08	620
101	7.82	11.3	16.4	25.1	1.042	240	1.19	560
102	9.02	11.6	16.3	24.6	1.105	270	1.16	560
103	8.66	12.4	18.0	27.6	1.044	220	1.09	510
104	9.64	12.6	17.9	27.1	1.088	240	1.06	510
105	9.22	13.5	19.6	30.0	1.039	200	1.00	470
106	9.85	14.7	21.5	33.0	1.034	180	0.919	430

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5-Element Chebyshev Low-Pass Filter Designs— 50-Ohm Impedance, C-In/Out for Standard E24 Capacitor Values

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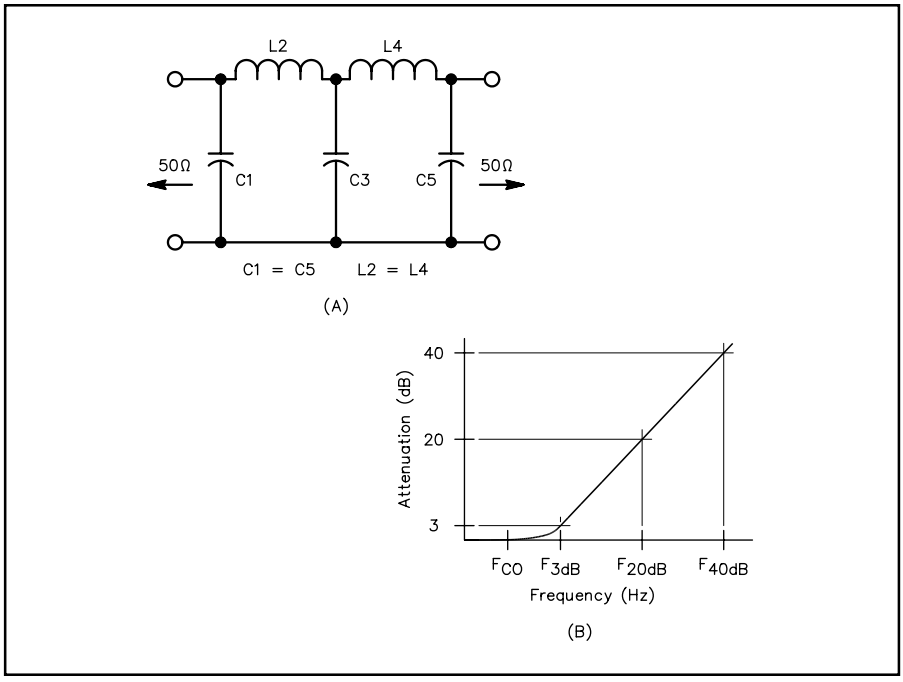

The schematic for a 5-element capacitor input/output Chebyshev low-pass filter is shown at A. At B is the typical attenuation response curve.

7-Element Chebyshev Low-Pass Filter Designs—50-Ohm Impedance, C-In/Out for Standard E24 Capacitor Values

Filter No.	—— Frequency (MHz) —— F_{co}	3 dB	20 dB	40 dB	Max SWR	C1,7 (pF)	L2,6 (µH)	C3,5 (pF)	L4 (µH)
1	1.02	1.10	1.31	1.65	1.254	3300	11.2	6200	12.6
2	1.04	1.16	1.40	1.79	1.142	2700	10.9	5600	12.6
3	1.13	1.23	1.45	1.84	1.264	3000	10.1	5600	11.3
4	1.05	1.23	1.51	1.96	1.071	2200	10.3	5100	12.3
5	1.12	1.26	1.53	1.96	1.123	2400	10.0	5100	11.7
6	1.23	1.34	1.59	2.01	1.247	2700	9.29	5100	10.4
7	1.03	1.30	1.63	2.15	1.030	1800	9.52	4700	11.9
8	1.12	1.33	1.64	2.13	1.064	2000	9.50	4700	11.4
9	1.21	1.37	1.66	2.13	1.119	2200	9.27	4700	10.8
10	1.29	1.42	1.70	2.16	1.200	2400	8.82	4700	10.0
11	1.10	1.41	1.79	2.36	1.023	1600	8.68	4300	11.0
12	1.21	1.45	1.79	2.33	1.058	1800	8.71	4300	10.5
13	1.31	1.49	1.81	2.33	1.114	2000	8.50	4300	9.91
14	1.42	1.56	1.86	2.36	1.202	2200	8.06	4300	9.14
15	1.54	1.65	1.93	2.43	1.336	2400	7.39	4300	8.18
16	1.25	1.57	1.97	2.59	1.031	1500	7.90	3900	9.85
17	1.32	1.59	1.97	2.57	1.050	1600	7.91	3900	9.62
18	1.44	1.64	1.99	2.56	1.109	1800	7.73	3900	9.04
19	1.57	1.72	2.05	2.60	1.205	2000	7.30	3900	8.27
20	1.44	1.73	2.14	2.78	1.056	1500	7.29	3600	8.82
21	1.52	1.76	2.15	2.78	1.086	1600	7.22	3600	8.54
22	1.66	1.84	2.20	2.81	1.176	1800	6.86	3600	7.83
23	1.83	1.96	2.30	2.90	1.327	2000	6.22	3600	6.90
24	1.51	1.86	2.32	3.05	1.037	1300	6.70	3300	8.27
25	1.68	1.93	2.35	3.03	1.099	1500	6.58	3300	7.72
26	1.77	1.98	2.38	3.05	1.147	1600	6.40	3300	7.37
27	1.96	2.11	2.49	3.14	1.294	1800	5.83	3300	6.50
28	1.56	2.02	2.56	3.38	1.021	1100	6.04	3000	7.68
29	1.68	2.05	2.56	3.35	1.042	1200	6.09	3000	7.47
30	1.79	2.09	2.57	3.33	1.073	1300	6.05	3000	7.21
31	1.99	2.20	2.64	3.37	1.176	1500	5.72	3000	6.52
32	2.11	2.28	2.70	3.42	1.257	1600	5.42	3000	6.08
33	1.75	2.25	2.84	3.75	1.023	1000	5.45	2700	6.89
34	1.89	2.29	2.84	3.71	1.048	1100	5.48	2700	6.68
35	2.02	2.34	2.86	3.70	1.086	1200	5.41	2700	6.40
36	2.15	2.41	2.90	3.72	1.141	1300	5.26	2700	6.06
37	2.44	2.61	3.07	3.86	1.327	1500	4.66	2700	5.18
38	2.01	2.54	3.20	4.21	1.027	910	4.86	2400	6.09
39	2.17	2.59	3.20	4.17	1.056	1000	4.86	2400	5.88
40	2.33	2.66	3.24	4.17	1.104	1100	4.77	2400	5.59
41	2.49	2.76	3.30	4.21	1.176	1200	4.57	2400	5.22
42	2.67	2.88	3.41	4.30	1.282	1300	4.27	2400	4.77
43	2.15	2.76	3.49	4.60	1.024	820	4.44	2200	5.61
44	2.35	2.82	3.49	4.55	1.053	910	4.46	2200	5.41
45	2.52	2.89	3.52	4.54	1.099	1000	4.38	2200	5.15
46	2.72	3.01	3.60	4.59	1.176	1100	4.19	2200	4.78
47	2.94	3.16	3.73	4.70	1.294	1200	3.88	2200	4.33
48	2.38	3.04	3.84	5.06	1.025	750	4.04	2000	5.09
49	2.57	3.09	3.84	5.01	1.050	820	4.06	2000	4.93
50	2.78	3.18	3.88	5.00	1.100	910	3.98	2000	4.68
51	2.99	3.31	3.96	5.05	1.176	1000	3.81	2000	4.35
52	3.26	3.50	4.12	5.19	1.308	1100	3.50	2000	3.89
53	2.67	3.38	4.26	5.61	1.027	680	3.64	1800	4.57
54	2.89	3.45	4.27	5.56	1.056	750	3.65	1800	4.41
55	3.09	3.54	4.31	5.55	1.100	820	3.59	1800	4.21

Continued on next page.

7-Element Chebyshev Low-Pass Filter Designs—50-Ohm Impedance, C-In/Out for Standard E24 Capacitor Values

Continued from previous page.

Filter No.	—— Frequency (MHz) —— F_{co}	3 dB	20 dB	40 dB	Max SWR	C1,7 (pF)	L2,6 (µH)	C3,5 (pF)	L4 (µH)
56	3.35	3.69	4.42	5.62	1.188	910	3.40	1800	3.87
57	3.65	3.92	4.60	5.80	1.327	1000	3.11	1800	3.45
58	3.07	3.82	4.80	6.30	1.033	620	3.24	1600	4.03
59	3.30	3.90	4.81	6.25	1.064	680	3.24	1600	3.88
60	3.55	4.02	4.87	6.26	1.120	750	3.15	1600	3.67
61	3.81	4.18	4.99	6.34	1.204	820	3.00	1600	3.39
62	3.16	4.05	5.12	6.75	1.024	560	3.03	1500	3.82
63	3.45	4.13	5.12	6.68	1.053	620	3.04	1500	3.69
64	3.69	4.24	5.17	6.66	1.097	680	2.99	1500	3.51
65	3.99	4.41	5.28	6.73	1.176	750	2.86	1500	3.26
66	4.31	4.64	5.48	6.91	1.297	820	2.64	1500	2.94
67	3.81	4.72	5.90	7.74	1.036	510	2.64	1300	3.26
68	4.10	4.82	5.93	7.69	1.070	560	2.62	1300	3.14
69	4.43	4.98	6.02	7.72	1.133	620	2.54	1300	2.94
70	4.78	5.21	6.19	7.85	1.230	680	2.39	1300	2.70
71	4.13	5.11	6.39	8.38	1.035	470	2.43	1200	3.01
72	4.40	5.20	6.41	8.33	1.064	510	2.43	1200	2.91
73	4.72	5.35	6.49	8.34	1.116	560	2.37	1200	2.76
74	5.12	5.60	6.67	8.48	1.214	620	2.23	1200	2.52
75	4.49	5.57	6.97	9.15	1.035	430	2.23	1100	2.76
76	4.82	5.68	7.00	9.09	1.066	470	2.22	1100	2.66
77	5.12	5.83	7.07	9.10	1.112	510	2.18	1100	2.54
78	5.52	6.07	7.24	9.21	1.196	560	2.07	1100	2.35
79	4.93	6.12	7.67	10.1	1.034	390	2.03	1000	2.51
80	5.33	6.26	7.70	10.0	1.069	430	2.02	1000	2.41
81	5.69	6.44	7.80	10.0	1.122	470	1.97	1000	2.29
82	6.08	6.68	7.97	10.1	1.198	510	1.88	1000	2.13
83	6.63	7.09	8.32	10.5	1.343	560	1.71	1000	1.89
84	5.48	6.75	8.43	11.0	1.038	360	1.85	910	2.28
85	5.84	6.87	8.46	11.0	1.068	390	1.84	910	2.20
86	6.28	7.09	8.58	11.0	1.126	430	1.79	910	2.07
87	6.75	7.39	8.80	11.2	1.213	470	1.69	910	1.91
88	5.68	7.39	9.37	12.4	1.020	300	1.65	820	2.10
89	6.17	7.52	9.36	12.2	1.043	330	1.66	820	2.04
90	6.60	7.68	9.41	12.2	1.079	360	1.65	820	1.96
91	7.01	7.89	9.53	12.2	1.131	390	1.61	820	1.86
92	7.59	8.27	9.82	12.5	1.233	430	1.51	820	1.70
93	6.72	8.21	10.2	13.4	1.042	300	1.52	750	1.87
94	7.23	8.40	10.3	13.3	1.080	330	1.51	750	1.79
95	7.72	8.66	10.4	13.4	1.138	360	1.46	750	1.69
96	8.24	9.00	10.7	13.6	1.222	390	1.39	750	1.57
97	7.36	9.04	11.3	14.8	1.039	270	1.38	680	1.70
98	7.98	9.27	11.4	14.7	1.082	300	1.37	680	1.62
99	8.58	9.59	11.6	14.8	1.148	330	1.32	680	1.52
100	9.23	10.0	11.9	15.1	1.247	360	1.24	680	1.39
101	7.91	9.86	12.4	16.2	1.032	240	1.26	620	1.56
102	8.67	10.1	12.4	16.1	1.075	270	1.25	620	1.49
103	9.39	10.5	12.7	16.2	1.145	300	1.20	620	1.39
104	8.86	11.0	13.7	18.0	1.036	220	1.14	560	1.40
105	9.49	11.2	13.8	17.8	1.068	240	1.13	560	1.35
106	9.72	12.0	15.0	19.7	1.036	200	1.03	510	1.28

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7-Element Chebyshev Low-Pass Filter Designs—50-Ohm Impedance, C-In/Out for Standard E24 Capacitor Values

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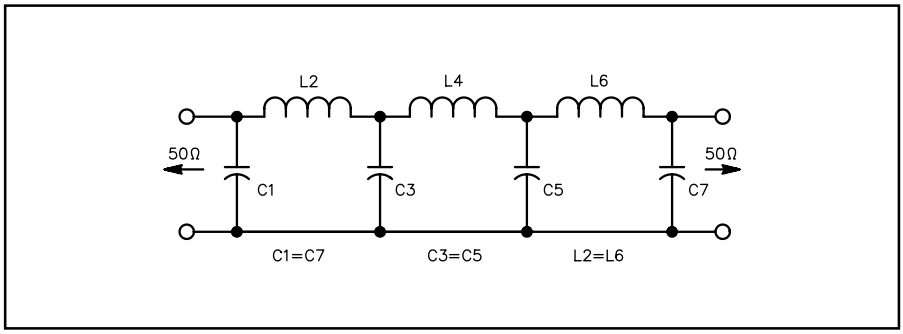

The schematic for a 7-element Chebyshev low-pass filter. See page 30.33 for the attenuation response curve.

5-Element Chebyshev Low-Pass Filter Designs—50-Ohm Impedance, L-In/Out for Standard-Value L and C

Filter No.	—— Frequency (MHz) —— F_{co}	3 dB	20 dB	40 dB	Max SWR	L1,5 (µH)	C2,4 (pF)	L3 (µH)
1	0.744	1.15	1.69	2.60	1.027	5.60	4700	13.7
2	0.901	1.26	1.81	2.76	1.055	5.60	4300	12.7
3	1.06	1.38	1.94	2.93	1.096	5.60	3900	11.8
4	1.19	1.47	2.05	3.07	1.138	5.60	3600	11.2
5	1.32	1.58	2.17	3.23	1.192	5.60	3300	10.6
6	0.911	1.39	2.03	3.12	1.030	4.70	3900	11.4
7	1.08	1.50	2.16	3.29	1.056	4.70	3600	10.6
8	1.25	1.63	2.30	3.48	1.092	4.70	3300	9.92
9	1.42	1.77	2.46	3.68	1.142	4.70	3000	9.32
10	1.61	1.92	2.63	3.90	1.209	4.70	2700	8.79
11	1.05	1.64	2.41	3.72	1.025	3.90	3300	9.63
12	1.29	1.80	2.60	3.96	1.054	3.90	3000	8.83
13	1.54	1.99	2.80	4.22	1.099	3.90	2700	8.15
14	1.80	2.19	3.03	4.53	1.164	3.90	2400	7.57
15	1.99	2.35	3.20	4.75	1.222	3.90	2200	7.23
16	1.34	2.00	2.93	4.49	1.034	3.30	2700	7.89
17	1.68	2.25	3.20	4.84	1.077	3.30	2400	7.15
18	1.92	2.43	3.40	5.11	1.118	3.30	2200	6.73
19	2.16	2.63	3.62	5.40	1.174	3.30	2000	6.35
20	1.65	2.46	3.59	5.51	1.035	2.70	2200	6.43
21	1.99	2.70	3.86	5.85	1.069	2.70	2000	5.93
22	2.34	2.97	4.15	6.24	1.118	2.70	1800	5.50
23	2.71	3.27	4.49	6.68	1.188	2.70	1600	5.13
24	2.92	3.43	4.67	6.92	1.233	2.70	1500	4.97
25	2.01	3.01	4.39	6.74	1.034	2.20	1800	5.26
26	2.52	3.37	4.80	7.27	1.077	2.20	1600	4.76
27	2.78	3.57	5.02	7.56	1.107	2.20	1500	4.55
28	3.34	4.02	5.52	8.21	1.190	2.20	1300	4.18
29	2.36	3.61	5.29	8.14	1.029	1.80	1500	4.38
30	3.12	4.14	5.89	8.92	1.080	1.80	1300	3.88
31	3.51	4.45	6.23	9.36	1.118	1.80	1200	3.67
32	3.93	4.78	6.60	9.85	1.169	1.80	1100	3.48
33	4.37	5.15	7.01	10.4	1.233	1.80	1000	3.31
34	3.10	4.51	6.56	10.0	1.041	1.50	1200	3.51
35	3.65	4.90	6.99	10.6	1.073	1.50	1100	3.27
36	4.21	5.34	7.47	11.2	1.118	1.50	1000	3.06
37	4.75	5.77	7.95	11.9	1.173	1.50	910	2.89
38	3.53	5.41	7.94	12.2	1.029	1.20	1000	2.92
39	4.30	5.94	8.53	13.0	1.060	1.20	910	2.69
40	5.09	6.53	9.18	13.8	1.106	1.20	820	2.49
41	5.73	7.04	9.75	14.6	1.155	1.20	750	2.35
42	6.42	7.61	10.4	15.4	1.219	1.20	680	2.23
43	4.40	6.60	9.65	14.8	1.033	1.00	820	2.40
44	5.27	7.20	10.3	15.7	1.064	1.00	750	2.22
45	6.15	7.87	11.1	16.7	1.108	1.00	680	2.07
46	6.95	8.51	11.8	17.6	1.160	1.00	620	1.95
47	7.80	9.22	12.6	18.6	1.227	1.00	560	1.85
48	5.23	7.96	11.7	17.9	1.030	0.82	680	1.99
49	6.33	8.72	12.5	19.0	1.061	0.82	620	1.83
50	7.45	9.56	13.4	20.3	1.106	0.82	560	1.70
51	8.44	10.3	14.3	21.4	1.158	0.82	510	1.60
52	9.28	11.0	15.1	22.4	1.211	0.82	470	1.53
53	6.41	9.66	14.1	21.7	1.032	0.68	560	1.64
54	7.75	10.6	15.2	23.1	1.064	0.68	510	1.51
55	8.83	11.4	16.1	24.3	1.100	0.68	470	1.42
56	9.97	12.3	17.1	25.6	1.148	0.68	430	1.34

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5-Element Chebyshev Low-Pass Filter Designs—50-Ohm Impedance, L-In/Out for Standard-Value L and C

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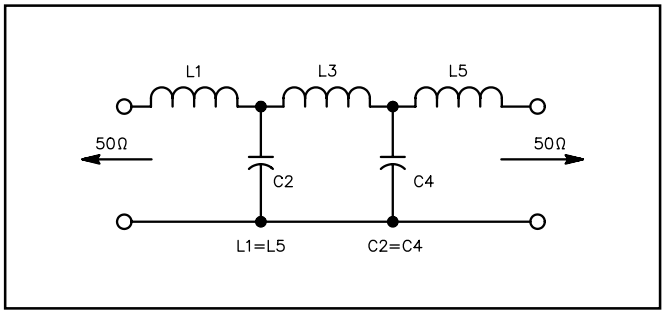
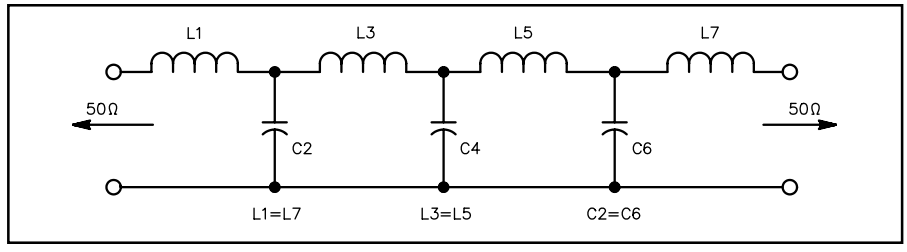


The schematic for a 5-element inductor input/output Chebyshev low-pass filter. See page 30.33 for the attenuation response curve.

7-Element Chebyshev Low-Pass Filter Designs—50-Ohm Impedance, L-In/Out for Standard-Value L and C

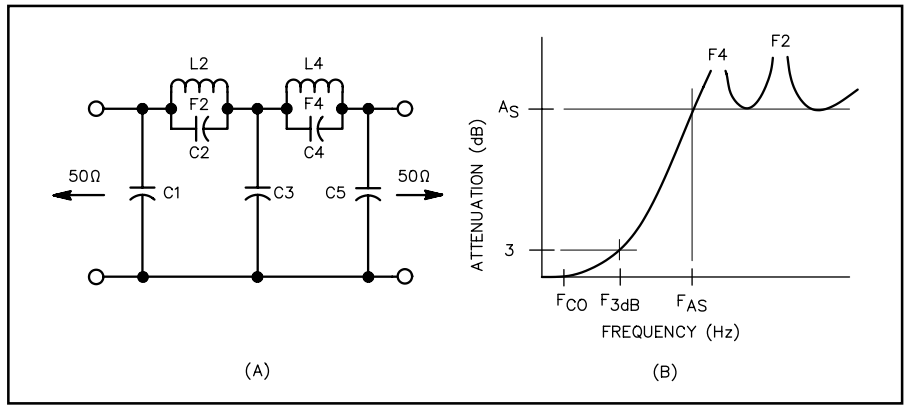
Filter No.	—— Frequency (MHz) —— F_{co}	3 dB	20 dB	40 dB	Max SWR	L1,7 (µH)	C2,6 (pF)	L3,5 (µH)	C4 (pF)
1	1.01	1.18	1.44	1.87	1.081	5.89	4300	13.4	5100
2	1.09	1.29	1.60	2.08	1.059	5.06	3900	12.0	4700
3	1.03	1.09	1.26	1.58	1.480	10.1	4300	17.1	4700
4	1.20	1.40	1.73	2.24	1.071	4.81	3600	11.2	4300
5	1.16	1.23	1.44	1.81	1.383	8.34	3900	14.6	4300
6	1.33	1.54	1.88	2.43	1.087	4.58	3300	10.3	3900
7	1.42	1.68	2.07	2.70	1.064	3.95	3000	9.27	3600
8	1.34	1.41	1.63	2.04	1.506	7.98	3300	13.4	3600
9	1.53	1.85	2.31	3.02	1.045	3.36	2700	8.32	3300
10	1.50	1.59	1.86	2.33	1.406	6.57	3000	11.4	3300
11	1.63	2.06	2.59	3.41	1.029	2.83	2400	7.41	3000
12	1.69	1.81	2.13	2.68	1.317	5.36	2700	9.70	3000
13	1.86	2.27	2.83	3.70	1.042	2.71	2200	6.78	2700
14	1.91	2.07	2.46	3.12	1.238	4.31	2400	8.19	2700
15	2.14	2.52	3.11	4.04	1.064	2.63	2000	6.18	2400
16	2.01	2.11	2.45	3.06	1.506	5.32	2200	8.91	2400
17	2.29	2.78	3.46	4.52	1.045	2.24	1800	5.54	2200
18	2.25	2.39	2.79	3.49	1.406	4.38	2000	7.61	2200
19	2.45	3.09	3.88	5.11	1.029	1.89	1600	4.94	2000
20	2.53	2.71	3.19	4.02	1.317	3.57	1800	6.47	2000
21	2.85	3.37	4.15	5.39	1.064	1.97	1500	4.64	1800
22	2.86	3.11	3.69	4.68	1.238	2.88	1600	5.46	1800
23	3.13	3.84	4.79	6.27	1.039	1.59	1300	4.00	1600
24	3.27	4.12	5.18	6.81	1.029	1.41	1200	3.70	1500
25	3.47	3.90	4.70	6.02	1.140	2.01	1300	4.17	1500
26	3.99	4.61	5.64	7.28	1.087	1.53	1100	3.43	1300
27	4.27	5.05	6.22	8.09	1.064	1.32	1000	3.09	1200
28	4.01	4.22	4.90	6.11	1.506	2.66	1100	4.45	1200
29	4.63	5.53	6.85	8.91	1.056	1.17	910	2.81	1100
30	4.49	4.77	5.57	6.98	1.406	2.19	1000	3.81	1100
31	5.05	6.11	7.60	9.92	1.047	1.03	820	2.53	1000
32	4.93	5.23	6.10	7.64	1.416	2.02	910	3.49	1000
33	5.58	6.70	8.31	10.8	1.052	0.954	750	2.31	910
34	5.54	5.94	6.99	8.80	1.326	1.65	820	2.97	910
35	6.23	7.41	9.16	11.9	1.059	0.881	680	2.10	820
36	5.92	6.24	7.26	9.06	1.476	1.76	750	2.98	820
37	6.79	8.12	10.0	13.1	1.055	0.796	620	1.91	750
38	6.64	7.07	8.27	10.4	1.379	1.45	680	2.54	750
39	7.46	8.97	11.1	14.5	1.051	0.711	560	1.73	680
40	7.21	7.63	8.89	11.1	1.438	1.40	620	2.41	680
41	8.18	9.85	12.2	15.9	1.050	0.645	510	1.57	620
42	8.10	8.66	10.2	12.8	1.345	1.15	560	2.05	620
43	9.21	10.8	13.2	17.1	1.074	0.633	470	1.46	560
44	8.78	9.31	10.9	13.6	1.425	1.14	510	1.96	560
45	10.1	11.8	14.4	18.7	1.081	0.589	430	1.34	510



The schematic for a 7-element inductor input/output Chebyshev low-pass filter. See page 30.33 for the attenuation response curve.

5-Branch Elliptic Low-Pass Filter Designs—
50-Ohm Impedance, Standard E12 Capacitor Values for C1, C3 and C5

Filter No.	F_{co}	F_{3dB} (MHz)	F_{As}	A_s (dB)	Max. SWR	C1	C3	C5 (pF)	C2	C4	L2	L4 (µH)	F2	F4 (MHz)
1	0.795	0.989	1.57	47.4	1.092	2700	5600	2200	324	937	12.1	10.1	2.54	1.64
2	1.06	1.20	1.77	46.2	1.234	2700	4700	2200	341	982	9.36	7.56	2.82	1.85
3	1.47	1.57	2.15	45.4	1.586	2700	3900	2200	364	1045	6.32	4.88	3.32	2.23
4	0.929	1.18	1.91	48.0	1.077	2200	4700	1800	257	743	10.2	8.59	3.11	1.99
5	1.27	1.45	2.17	46.7	1.215	2200	3900	1800	271	779	7.85	6.39	3.45	2.26
6	1.69	1.82	2.54	45.9	1.489	2200	3300	1800	287	821	5.64	4.42	3.96	2.64
7	1.12	1.44	2.41	49.8	1.071	1800	3900	1500	192	549	8.45	7.25	3.95	2.52
8	1.49	1.73	2.70	48.8	1.183	1800	3300	1500	200	570	6.75	5.62	4.33	2.81
9	2.11	2.27	3.27	47.8	1.506	1800	2700	1500	213	604	4.55	3.64	5.12	3.40
10	1.28	1.66	2.63	46.3	1.064	1500	3300	1200	192	561	7.20	6.00	4.28	2.74
11	1.79	2.06	2.99	44.8	1.195	1500	2700	1200	204	592	5.52	4.42	4.75	3.11
12	2.52	2.70	3.63	43.8	1.525	1500	2200	1200	220	636	3.71	2.82	5.58	3.76
13	1.56	2.08	3.55	50.1	1.055	1200	2700	1000	127	363	5.88	5.07	5.83	3.71
14	2.23	2.59	4.04	48.8	1.183	1200	2200	1000	133	380	4.50	3.75	6.50	4.22
15	3.17	3.41	4.90	47.8	1.506	1200	1800	1000	142	402	3.03	2.42	7.68	5.10
16	1.94	2.52	4.15	48.4	1.064	1000	2200	820	115	331	4.79	4.06	6.78	4.34
17	2.73	3.14	4.73	47.0	1.199	1000	1800	820	121	348	3.66	2.99	7.56	4.93
18	3.73	4.02	5.63	46.2	1.491	1000	1500	820	129	368	2.56	2.01	8.76	5.85
19	2.39	3.11	5.20	49.4	1.065	820	1800	680	89.3	256	3.91	3.35	8.51	5.44
20	3.26	3.79	5.85	48.2	1.185	820	1500	680	93.6	267	3.07	2.54	9.39	6.10
21	4.83	5.17	7.30	47.2	1.569	820	1200	680	100	286	1.95	1.54	11.4	7.58
22	2.85	3.71	6.15	48.8	1.063	680	1500	560	76.6	220	3.26	2.78	10.1	6.43
23	4.16	4.74	7.14	47.3	1.221	680	1200	560	81.3	233	2.40	1.97	11.4	7.44
24	5.72	6.13	8.58	46.5	1.547	680	1000	560	86.3	246	1.65	1.30	13.3	8.91
25	3.67	4.69	7.95	50.5	1.076	560	1200	470	57.6	164	2.59	2.23	13.0	8.31
26	5.02	5.77	9.01	49.4	1.212	560	1000	470	60.3	171	2.01	1.68	14.5	9.40
27	7.18	7.68	11.1	48.6	1.582	560	820	470	64.1	181	1.32	1.06	17.3	11.5
28	4.40	5.60	9.24	49.3	1.079	470	1000	390	51.4	147	2.16	1.84	15.1	9.66
29	6.17	7.01	10.6	48.0	1.236	470	820	390	54.2	155	1.63	1.34	17.0	11.1
30	8.63	9.20	12.9	47.3	1.604	470	680	390	57.6	164	1.09	0.857	20.1	13.4
31	5.47	6.91	11.8	51.3	1.086	390	820	330	38.5	109	1.76	1.52	19.3	12.3
32	7.55	8.59	13.5	50.2	1.242	390	680	330	40.4	114	1.34	1.12	21.7	14.1
33	10.9	11.5	16.8	49.5	1.659	390	560	330	42.8	120	0.862	0.695	26.2	17.4
34	6.59	8.17	13.0	47.7	1.096	330	680	270	39.0	112	1.46	1.22	21.1	13.6
35	9.10	10.2	15.0	46.5	1.267	330	560	270	41.2	118	1.09	0.881	23.7	15.6
36	12.4	13.2	18.1	45.8	1.635	330	470	270	43.9	125	0.741	0.573	27.9	18.8



The schematic for a 5-branch elliptic low-pass filter is shown at A. At B is the typical attenuation response curve.

5-Element Chebyshev High-Pass Filter Designs— 50-Ohm Impedance, C-In/Out for Standard E24 Capacitor Values

Filter	—— Frequency (MHz) ——				Max	C1,5	L2,4	C3
No.	F_{co}	3 dB	20 dB	40 dB	SWR	(pF)	(µH)	(pF)
1	1.04	0.726	0.501	0.328	1.044	5100	6.45	2200
2	1.04	0.788	0.554	0.366	1.081	4300	5.97	2000
3	1.17	0.800	0.550	0.359	1.039	4700	5.85	2000
4	1.07	0.857	0.615	0.410	1.135	3600	5.56	1800
5	1.17	0.877	0.616	0.406	1.076	3900	5.36	1800
6	1.33	0.890	0.609	0.397	1.034	4300	5.26	1800
7	1.12	0.938	0.686	0.461	1.206	3000	5.20	1600
8	1.25	0.974	0.693	0.461	1.109	3300	4.86	1600
9	1.38	0.994	0.691	0.454	1.057	3600	4.71	1600
10	1.54	1.00	0.683	0.444	1.028	3900	4.67	1600
11	1.14	0.978	0.723	0.490	1.268	2700	5.09	1500
12	1.28	1.03	0.738	0.492	1.135	3000	4.64	1500
13	1.43	1.06	0.738	0.486	1.068	3300	4.44	1500
14	1.61	1.07	0.730	0.476	1.033	3600	4.38	1500
15	1.21	1.08	0.812	0.555	1.398	2200	4.82	1300
16	1.35	1.14	0.841	0.567	1.227	2400	4.29	1300
17	1.55	1.20	0.853	0.566	1.104	2700	3.94	1300
18	1.75	1.23	0.848	0.555	1.046	3000	3.81	1300
19	1.28	1.15	0.871	0.597	1.440	2000	4.57	1200
20	1.45	1.24	0.909	0.614	1.238	2200	3.99	1200
21	1.60	1.29	0.923	0.616	1.135	2400	3.71	1200
22	1.84	1.32	0.921	0.605	1.057	2700	3.54	1200
23	2.14	1.34	0.906	0.588	1.022	3000	3.50	1200
24	1.57	1.34	0.989	0.669	1.251	2000	3.69	1100
25	1.75	1.40	1.01	0.672	1.135	2200	3.40	1100
26	1.93	1.44	1.01	0.664	1.072	2400	3.27	1100
27	2.27	1.46	0.992	0.645	1.026	2700	3.21	1100
28	1.71	1.47	1.08	0.734	1.268	1800	3.39	1000
29	1.93	1.54	1.11	0.739	1.135	2000	3.09	1000
30	2.15	1.58	1.11	0.730	1.068	2200	2.96	1000
31	2.41	1.60	1.10	0.714	1.033	2400	2.92	1000
32	1.66	1.50	1.14	0.783	1.473	1500	3.54	910
33	1.82	1.59	1.18	0.803	1.311	1600	3.18	910
34	2.09	1.69	1.22	0.812	1.145	1800	2.83	910
35	2.36	1.74	1.22	0.802	1.068	2000	2.70	910
36	2.68	1.76	1.20	0.783	1.030	2200	2.66	910
37	2.12	1.81	1.33	0.898	1.241	1500	2.73	820
38	2.28	1.86	1.35	0.902	1.159	1600	2.58	820
39	2.61	1.93	1.35	0.890	1.069	1800	2.43	820
40	3.01	1.96	1.33	0.866	1.028	2000	2.39	820
41	2.17	1.90	1.42	0.970	1.341	1300	2.67	750
42	2.57	2.06	1.48	0.985	1.135	1500	2.32	750
43	2.76	2.10	1.48	0.978	1.086	1600	2.25	750
44	3.21	2.14	1.46	0.952	1.033	1800	2.19	750
45	2.45	2.13	1.58	1.08	1.304	1200	2.36	680
46	2.69	2.23	1.62	1.09	1.181	1300	2.17	680
47	3.17	2.33	1.63	1.07	1.067	1500	2.01	680
48	3.44	2.35	1.62	1.06	1.039	1600	1.99	680
49	2.70	2.34	1.74	1.18	1.293	1100	2.14	620
50	2.99	2.46	1.78	1.19	1.167	1200	1.96	620
51	3.28	2.53	1.79	1.19	1.097	1300	1.87	620
52	3.93	2.59	1.76	1.15	1.030	1500	1.81	620
53	3.02	2.60	1.93	1.31	1.282	1000	1.92	560
54	3.37	2.74	1.97	1.32	1.152	1100	1.75	560

Continued on next page.

5-Element Chebyshev High-Pass Filter Designs— 50-Ohm Impedance, C-In/Out for Standard E24 Capacitor Values

Continued from previous page.

Filter No.	—— Frequency (MHz) —— F_{co}	3 dB	20 dB	40 dB	Max SWR	C1,5 (pF)	L2,4 (µH)	C3 (pF)
55	3.72	2.81	1.98	1.31	1.083	1200	1.67	560
56	4.10	2.85	1.97	1.29	1.044	1300	1.64	560
57	3.31	2.86	2.12	1.44	1.283	910	1.75	510
58	3.69	3.00	2.17	1.45	1.154	1000	1.60	510
59	4.11	3.09	2.17	1.44	1.079	1100	1.52	510
60	4.59	3.14	2.15	1.41	1.039	1200	1.49	510
61	3.49	3.05	2.28	1.55	1.327	820	1.66	470
62	3.95	3.24	2.35	1.57	1.167	910	1.49	470
63	4.39	3.34	2.36	1.56	1.087	1000	1.41	470
64	4.94	3.40	2.34	1.53	1.041	1100	1.38	470
65	3.81	3.34	2.49	1.70	1.327	750	1.52	430
66	4.24	3.52	2.56	1.72	1.184	820	1.38	430
67	4.77	3.65	2.58	1.71	1.091	910	1.29	430
68	5.36	3.72	2.56	1.68	1.043	1000	1.26	430
69	4.20	3.68	2.75	1.87	1.328	680	1.38	390
70	4.72	3.89	2.83	1.90	1.175	750	1.24	390
71	5.22	4.02	2.84	1.88	1.095	820	1.17	390
72	5.93	4.10	2.82	1.85	1.042	910	1.14	390
73	4.48	3.95	2.96	2.02	1.355	620	1.30	360
74	5.01	4.18	3.05	2.05	1.196	680	1.16	360
75	5.60	4.34	3.08	2.04	1.101	750	1.09	360
76	6.23	4.42	3.07	2.01	1.052	820	1.06	360
77	4.79	4.25	3.20	2.19	1.391	560	1.22	330
78	5.44	4.55	3.33	2.24	1.203	620	1.07	330
79	6.03	4.72	3.36	2.23	1.110	680	1.00	330
80	6.77	4.82	3.35	2.20	1.052	750	0.970	330
81	7.70	4.87	3.30	2.14	1.023	820	0.962	330
82	5.28	4.68	3.53	2.41	1.386	510	1.10	300
83	5.94	4.99	3.65	2.46	1.212	560	0.978	300
84	6.66	5.20	3.70	2.46	1.107	620	0.910	300
85	7.43	5.31	3.68	2.42	1.054	680	0.882	300
86	8.56	5.36	3.62	2.35	1.022	750	0.875	300
87	6.05	5.31	3.97	2.70	1.332	470	0.956	270
88	6.69	5.58	4.07	2.74	1.196	510	0.870	270
89	7.43	5.78	4.11	2.73	1.105	560	0.817	270
90	8.39	5.91	4.08	2.68	1.048	620	0.792	270
91	7.07	6.09	4.51	3.06	1.276	430	0.818	240
92	7.84	6.38	4.61	3.08	1.155	470	0.752	240
93	8.59	6.55	4.62	3.06	1.088	510	0.719	240
94	9.64	6.66	4.58	3.00	1.042	560	0.702	240
95	7.61	6.60	4.90	3.33	1.295	390	0.760	220
96	8.53	6.95	5.02	3.36	1.157	430	0.690	220
97	9.43	7.15	5.04	3.33	1.085	470	0.658	220
98	10.4	7.26	5.01	3.28	1.044	510	0.644	220
99	7.58	6.83	5.19	3.56	1.470	330	0.776	200
100	8.53	7.33	5.42	3.67	1.268	360	0.678	200
101	9.36	7.64	5.52	3.70	1.159	390	0.628	200
102	10.4	7.88	5.54	3.66	1.081	430	0.596	200
103	8.55	7.67	5.81	3.98	1.440	300	0.685	180
104	9.69	8.24	6.06	4.09	1.238	330	0.597	180
105	10.7	8.57	6.15	4.10	1.135	360	0.556	180
106	9.80	8.73	6.58	4.50	1.406	270	0.595	160

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5-Element Chebyshev High-Pass Filter Designs— 50-Ohm Impedance, C-In/Out for Standard E24 Capacitor Values

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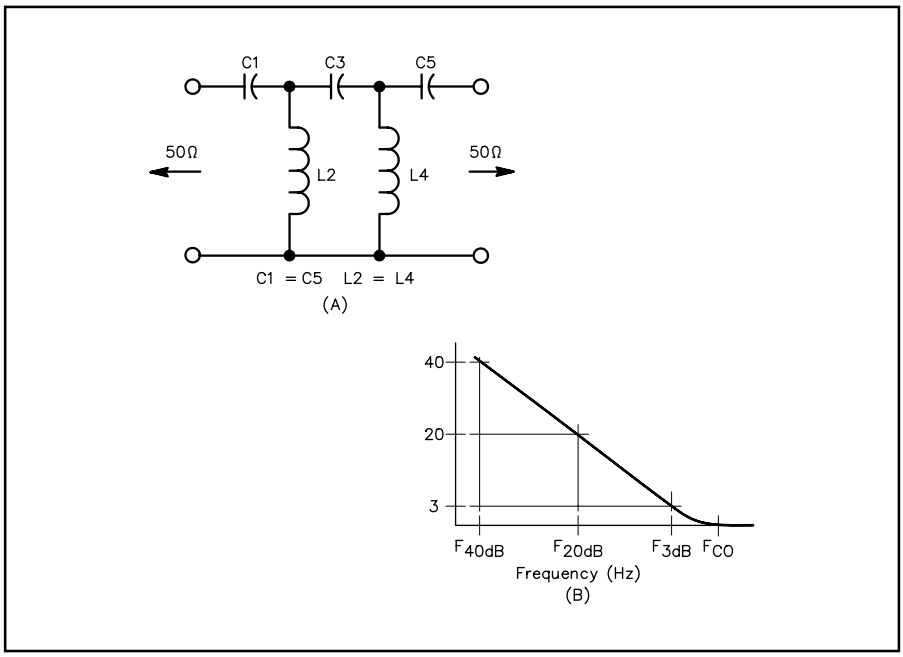

The schematic for a 5-element capacitor input/output Chebyshev high-pass filter is shown at A. At B is the typical attenuation response curve.

7-Element Chebyshev High-Pass Filter Designs— 50-Ohm Impedance, C-In/Out for Standard E24 Capacitor Values

Filter	—— Frequency (MHz) ——				Max	C1,7	L2,6	C3,5	L4
No.	F_{co}	3 dB	20 dB	40 dB	SWR	(pF)	(µH)	(pF)	(µH)
1	1.02	0.826	0.660	0.504	1.036	5100	6.16	2000	4.98
2	1.00	0.880	0.724	0.563	1.109	3900	5.67	1800	4.86
3	1.08	0.905	0.732	0.563	1.058	4300	5.55	1800	4.60
4	1.16	0.922	0.734	0.558	1.030	4700	5.55	1800	4.45
5	1.00	0.924	0.780	0.617	1.257	3000	5.53	1600	4.93
6	1.09	0.971	0.806	0.630	1.147	3300	5.15	1600	4.48
7	1.16	1.00	0.819	0.634	1.086	3600	4.99	1600	4.22
8	1.23	1.02	0.824	0.632	1.050	3900	4.93	1600	4.05
9	1.34	1.04	0.825	0.625	1.023	4300	4.95	1600	3.92
10	1.03	0.958	0.815	0.648	1.327	2700	5.43	1500	4.89
11	1.13	1.02	0.853	0.669	1.176	3000	4.92	1500	4.31
12	1.22	1.06	0.871	0.676	1.099	3300	4.70	1500	4.01
13	1.30	1.09	0.879	0.675	1.056	3600	4.63	1500	3.83
14	1.39	1.11	0.880	0.670	1.031	3900	4.63	1500	3.71
15	1.22	1.13	0.954	0.755	1.282	2400	4.57	1300	4.09
16	1.34	1.20	0.994	0.776	1.141	2700	4.17	1300	3.62
17	1.45	1.24	1.01	0.780	1.073	3000	4.03	1300	3.38
18	1.57	1.27	1.02	0.775	1.037	3300	4.00	1300	3.24
19	1.31	1.21	1.03	0.816	1.294	2200	4.25	1200	3.81
20	1.41	1.28	1.07	0.836	1.176	2400	3.94	1200	3.45
21	1.55	1.34	1.09	0.845	1.086	2700	3.74	1200	3.16
22	1.68	1.37	1.10	0.841	1.042	3000	3.70	1200	3.01
23	1.41	1.32	1.12	0.887	1.308	2000	3.93	1100	3.53
24	1.54	1.39	1.16	0.912	1.176	2200	3.61	1100	3.16
25	1.65	1.44	1.19	0.921	1.104	2400	3.46	1100	2.95
26	1.80	1.49	1.20	0.919	1.048	2700	3.39	1100	2.78
27	1.97	1.52	1.20	0.907	1.021	3000	3.41	1100	2.68
28	1.54	1.44	1.22	0.971	1.327	1800	3.62	1000	3.26
29	1.70	1.53	1.28	1.00	1.176	2000	3.28	1000	2.87
30	1.82	1.59	1.31	1.01	1.099	2200	3.14	1000	2.67
31	1.95	1.63	1.32	1.01	1.056	2400	3.08	1000	2.55
32	2.15	1.67	1.32	1.00	1.023	2700	3.10	1000	2.45
33	1.85	1.67	1.40	1.10	1.188	1800	3.01	910	2.64
34	2.00	1.75	1.44	1.11	1.100	2000	2.85	910	2.43
35	2.15	1.80	1.45	1.11	1.053	2200	2.81	910	2.31
36	2.31	1.83	1.45	1.10	1.027	2400	2.81	910	2.24
37	1.91	1.77	1.50	1.19	1.297	1500	2.91	820	2.61
38	2.03	1.85	1.55	1.22	1.204	1600	2.74	820	2.42
39	2.22	1.94	1.59	1.24	1.100	1800	2.57	820	2.19
40	2.41	2.00	1.61	1.23	1.050	2000	2.53	820	2.08
41	2.61	2.03	1.61	1.22	1.024	2200	2.54	820	2.01
42	2.26	2.04	1.71	1.34	1.176	1500	2.46	750	2.16
43	2.38	2.10	1.73	1.35	1.120	1600	2.38	750	2.04
44	2.60	2.17	1.76	1.35	1.056	1800	2.31	750	1.91
45	2.83	2.22	1.76	1.34	1.025	2000	2.32	750	1.84
46	2.40	2.20	1.85	1.46	1.230	1300	2.31	680	2.05
47	2.69	2.34	1.92	1.49	1.097	1500	2.13	680	1.81
48	2.82	2.39	1.94	1.49	1.064	1600	2.10	680	1.75
49	3.11	2.45	1.94	1.47	1.027	1800	2.10	680	1.67
50	2.66	2.43	2.04	1.61	1.214	1200	2.08	620	1.84
51	2.84	2.52	2.09	1.63	1.133	1300	1.98	620	1.71
52	3.16	2.64	2.13	1.63	1.053	1500	1.91	620	1.58
53	3.33	2.67	2.13	1.62	1.033	1600	1.91	620	1.54
54	2.73	2.55	2.17	1.73	1.343	1000	2.05	560	1.85

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7-Element Chebyshev High-Pass Filter Designs— 50-Ohm Impedance, C-In/Out for Standard E24 Capacitor Values

Continued from previous page.

Filter No.	—— Frequency (MHz) —— F_{co}	3 dB	20 dB	40 dB	Max SWR	C1,7 (pF)	L2,6 (µH)	C3,5 (pF)	L4 (µH)
55	2.98	2.71	2.27	1.79	1.196	1100	1.86	560	1.64
56	3.19	2.82	2.32	1.81	1.116	1200	1.77	560	1.52
57	3.39	2.89	2.35	1.81	1.070	1300	1.73	560	1.45
58	3.81	2.98	2.36	1.79	1.024	1500	1.73	560	1.37
59	3.27	2.97	2.49	1.96	1.198	1000	1.70	510	1.49
60	3.53	3.10	2.55	1.99	1.112	1100	1.61	510	1.38
61	3.76	3.18	2.58	1.99	1.064	1200	1.58	510	1.31
62	4.01	3.24	2.59	1.98	1.036	1300	1.57	510	1.27
63	3.51	3.21	2.69	2.12	1.213	910	1.58	470	1.40
64	3.79	3.35	2.76	2.15	1.122	1000	1.49	470	1.28
65	4.07	3.45	2.80	2.16	1.066	1100	1.45	470	1.21
66	4.35	3.52	2.81	2.14	1.035	1200	1.45	470	1.17
67	3.79	3.47	2.93	2.31	1.233	820	1.46	430	1.30
68	4.12	3.65	3.02	2.35	1.126	910	1.37	430	1.18
69	4.42	3.76	3.06	2.36	1.069	1000	1.33	430	1.11
70	4.77	3.85	3.07	2.34	1.035	1100	1.33	430	1.07
71	4.20	3.85	3.24	2.55	1.222	750	1.32	390	1.17
72	4.52	4.02	3.32	2.59	1.131	820	1.24	390	1.07
73	4.89	4.15	3.37	2.60	1.068	910	1.21	390	1.01
74	5.27	4.24	3.39	2.58	1.034	1000	1.20	390	0.969
75	4.48	4.13	3.48	2.75	1.247	680	1.24	360	1.10
76	4.86	4.33	3.59	2.80	1.138	750	1.15	360	1.00
77	5.20	4.47	3.65	2.82	1.079	820	1.12	360	0.942
78	5.64	4.58	3.67	2.80	1.038	910	1.11	360	0.899
79	4.87	4.49	3.79	2.99	1.254	620	1.14	330	1.01
80	5.26	4.71	3.91	3.05	1.148	680	1.06	330	0.924
81	5.67	4.87	3.98	3.07	1.080	750	1.03	330	0.864
82	6.07	4.98	4.00	3.06	1.043	820	1.02	330	0.829
83	5.32	4.91	4.15	3.28	1.264	560	1.04	300	0.930
84	5.80	5.18	4.30	3.36	1.145	620	0.965	300	0.838
85	6.22	5.36	4.37	3.38	1.082	680	0.933	300	0.787
86	6.71	5.49	4.40	3.36	1.042	750	0.923	300	0.752
87	7.25	5.58	4.40	3.33	1.020	820	0.931	300	0.731
88	5.98	5.50	4.64	3.66	1.247	510	0.926	270	0.824
89	6.46	5.77	4.78	3.74	1.142	560	0.867	270	0.752
90	6.98	5.97	4.87	3.76	1.075	620	0.837	270	0.703
91	7.50	6.11	4.89	3.74	1.039	680	0.831	270	0.675
92	6.39	5.97	5.08	4.04	1.336	430	0.873	240	0.787
93	6.94	6.32	5.29	4.16	1.200	470	0.798	240	0.704
94	7.41	6.55	5.41	4.21	1.123	510	0.762	240	0.656
95	7.95	6.75	5.48	4.22	1.068	560	0.742	240	0.620
96	8.61	6.90	5.50	4.19	1.032	620	0.740	240	0.595
97	7.56	6.88	5.77	4.54	1.202	430	0.733	220	0.646
98	8.11	7.16	5.91	4.60	1.119	470	0.697	220	0.599
99	8.63	7.35	5.98	4.61	1.071	510	0.681	220	0.570
100	9.28	7.51	6.00	4.58	1.036	560	0.677	220	0.548
101	7.70	7.19	6.11	4.86	1.327	360	0.723	200	0.652
102	8.30	7.56	6.34	4.99	1.205	390	0.667	200	0.589
103	8.97	7.90	6.51	5.06	1.114	430	0.632	200	0.542
104	9.59	8.11	6.58	5.07	1.064	470	0.618	200	0.515
105	8.72	8.09	6.86	5.44	1.294	330	0.637	180	0.571
106	9.42	8.51	7.11	5.57	1.176	360	0.590	180	0.517

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7-Element Chebyshev High-Pass Filter Designs— 50-Ohm Impedance, C-In/Out for Standard E24 Capacitor Values

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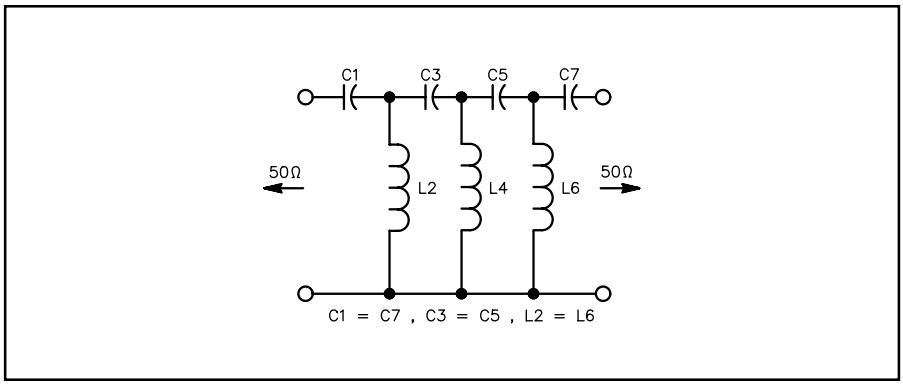
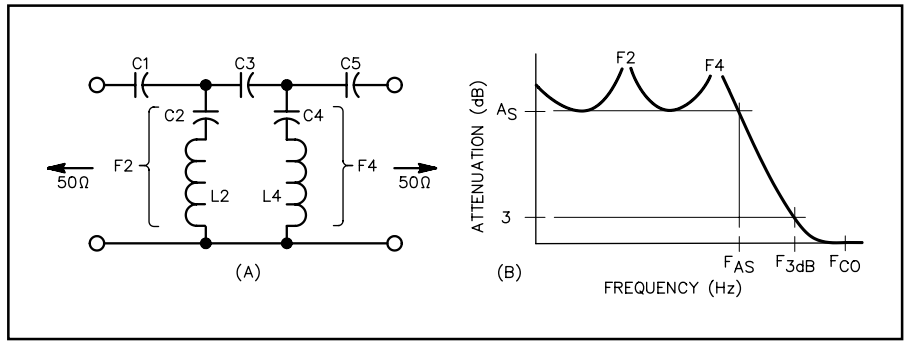


The schematic for a 7-element capacitor input/output Chebyshev high-pass filter. See page 30.43 for the attenuation response curve.

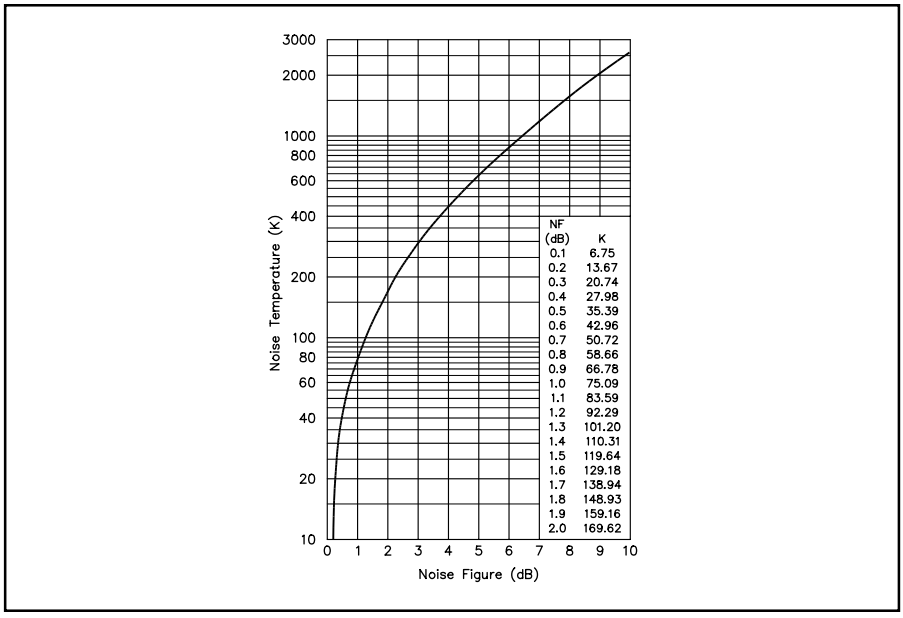
5-Branch Elliptic High-Pass Filter Designs— 50-Ohm Impedance, Standard E12 Capacitor Values for C1, C3 and C5

Filter No.	F_{co}	F_{3dB} (MHz)	F_{As}	A_s (dB)	Max. SWR	C1	C3	C5 (nF)	C2	C4	L2 (µH)	L4	F2 (MHz)	F4
1	1.01	0.936	0.670	45.9	1.489	2.7	1.8	3.3	20.7	7.24	6.58	8.40	0.431	0.646
2	1.14	0.976	0.608	50.4	1.186	3.3	1.8	3.9	32.3	11.4	5.53	6.54	0.377	0.582
3	1.30	1.01	0.604	49.4	1.071	3.9	1.8	4.7	35.8	12.5	5.19	6.07	0.369	0.578
4	1.19	1.11	0.810	45.4	1.543	2.2	1.5	2.7	16.4	5.71	5.65	7.28	0.523	0.780
5	1.38	1.20	0.797	46.8	1.199	2.7	1.5	3.3	22.0	7.66	4.61	5.65	0.499	0.765
6	1.56	1.19	0.685	51.6	1.064	3.3	1.5	3.9	33.7	11.9	4.32	4.97	0.417	0.655
7	1.51	1.40	1.01	45.9	1.489	1.8	1.2	2.2	13.8	4.82	4.39	5.60	0.646	0.968
8	1.75	1.51	1.00	46.6	1.180	2.2	1.2	2.7	17.7	6.14	3.65	4.47	0.627	0.961
9	2.02	1.52	0.920	48.3	1.055	2.7	1.2	3.3	23.4	8.09	3.44	4.04	0.562	0.880
10	1.78	1.65	1.15	47.8	1.506	1.5	1.0	1.8	12.7	4.47	3.71	4.64	0.733	1.10
11	2.07	1.80	1.20	46.8	1.199	1.8	1.0	2.2	14.7	5.11	3.07	3.77	0.749	1.15
12	2.38	1.83	1.13	47.8	1.064	2.2	1.0	2.7	18.6	6.43	2.87	3.40	0.689	1.08
13	2.22	2.08	1.55	43.7	1.531	1.2	0.82	1.5	8.19	2.83	3.05	4.02	1.01	1.49
14	2.52	2.17	1.39	48.7	1.186	1.5	0.82	1.8	13.5	4.73	2.51	3.01	0.865	1.33
15	2.89	2.23	1.36	48.2	1.065	1.8	0.82	2.2	15.5	5.37	2.36	2.78	0.833	1.30
16	2.57	2.40	1.68	47.8	1.560	1.0	0.68	1.2	8.40	2.96	2.60	3.27	1.08	1.62
17	3.05	2.68	1.85	44.7	1.215	1.2	0.68	1.5	8.77	3.02	2.10	2.64	1.17	1.78
18	3.48	2.66	1.57	49.9	1.063	1.5	0.68	1.8	14.1	4.94	1.96	2.28	0.957	1.50
19	3.17	2.96	2.13	46.1	1.554	0.82	0.56	1.0	6.31	2.21	2.13	2.72	1.37	2.05
20	3.62	3.16	2.05	48.6	1.210	1.0	0.56	1.2	8.93	3.14	1.74	2.10	1.28	1.96
21	4.19	3.30	2.11	46.1	1.076	1.2	0.56	1.5	9.30	3.19	1.61	1.94	1.30	2.02
22	4.30	3.79	2.55	46.9	1.233	0.82	0.47	1.0	6.69	2.33	1.48	1.82	1.60	2.45
23	4.89	3.84	2.31	49.7	1.079	1.0	0.47	1.2	9.34	3.27	1.36	1.59	1.41	2.21
24	5.87	3.89	2.31	47.4	1.021	1.2	0.47	1.5	9.71	3.32	1.35	1.58	1.39	2.20
25	4.44	4.17	3.01	46.5	1.618	0.56	0.39	0.68	4.37	1.53	1.54	1.97	1.94	2.90
26	5.14	4.52	2.99	48.0	1.236	0.68	0.39	0.82	5.88	2.06	1.23	1.50	1.87	2.87
27	5.88	4.67	2.90	48.0	1.085	0.82	0.39	1.0	7.05	2.45	1.13	1.34	1.78	2.78
28	5.99	5.34	3.60	47.1	1.269	0.56	0.33	0.68	4.63	1.62	1.06	1.31	2.27	3.46
29	6.81	5.48	3.37	49.0	1.096	0.68	0.33	0.82	6.15	2.15	0.961	1.13	2.07	3.22
30	8.07	5.50	3.17	49.3	1.026	0.82	0.33	1.0	7.33	2.54	0.945	1.09	1.91	3.02
31	6.38	5.99	4.26	47.3	1.609	0.39	0.27	0.47	3.18	1.12	1.06	1.34	2.74	4.10
32	7.34	6.47	4.18	49.2	1.241	0.47	0.27	0.56	4.33	1.53	0.856	1.03	2.61	4.01
33	8.39	6.73	4.17	48.4	1.092	0.56	0.27	0.68	4.90	1.71	0.784	0.930	2.57	4.00
34	7.92	7.36	4.98	49.6	1.522	0.33	0.22	0.39	3.05	1.08	0.828	1.02	3.17	4.79
35	9.21	8.05	5.27	48.1	1.217	0.39	0.22	0.47	3.40	1.19	0.686	0.832	3.30	5.06
36	10.4	8.18	4.84	50.5	1.077	0.47	0.22	0.56	4.56	1.60	0.636	0.740	2.95	4.62



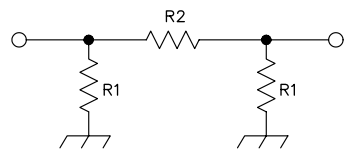
The schematic for a 5-branch elliptic high-pass filter is shown at A. At B is the typical attenuation response curve.

Relationship Between Noise Figure and Noise Temperature



Pi-Network Resistive Attenuators (50 Ω)

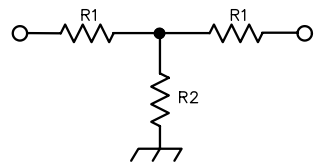
dB Atten.	*R1 (Ohms)*	*R2 (Ohms)*
1	870.0	5.8
2	436.0	11.6
3	292.0	17.6
4	221.0	23.8
5	178.6	30.4
6	150.5	37.3
7	130.7	44.8
8	116.0	52.8
9	105.0	61.6
10	96.2	71.2
11	89.2	81.6
12	83.5	93.2
13	78.8	106.0
14	74.9	120.3
15	71.6	136.1
16	68.8	153.8
17	66.4	173.4
18	64.4	195.4
19	62.6	220.0
20	61.0	247.5
21	59.7	278.2
22	58.6	312.7
23	57.6	351.9
24	56.7	394.6
25	56.0	443.1
30	53.2	789.7
35	51.8	1405.4
40	51.0	2500.0
45	50.5	4446.0
50	50.3	7905.6
55	50.2	14,058.0
60	50.1	25,000.0



Note: A PC board kit for the Low-Power Step Attenuator (Sep 1982 *QST*) is available from FAR Circuits. Project details are in the Handbook template package STEP ATTENUATOR.

T-Network Resistive Attenuators (50 Ω)

dB	*Atten.*	*R1 (Ohms)*	*R2 (Ohms)*
1		2.9	433.3
2		5.7	215.2
3		8.5	141.9
4		11.3	104.8
5		14.0	82.2
6		16.6	66.9
7		19.0	55.8
8		21.5	47.3
9		23.8	40.6
10		26.0	35.0
11		28.0	30.6
12		30.0	26.8
13		31.7	23.5
14		33.3	20.8
15		35.0	18.4
16		36.3	16.2
17		37.6	14.4
18		38.8	12.8
19		40.0	11.4
20		41.0	10.0
21		41.8	9.0
22		42.6	8.0
23		43.4	7.1
24		44.0	6.3
25		44.7	5.6
30		47.0	3.2
35		48.2	1.8
40		49.0	1.0
45		49.4	0.56
50		49.7	0.32
55		49.8	0.18
60		49.9	0.10



Tower Manufacturers

Contact information appears in the Handbook Address List elsewhere in this chapter. Send updates to the Handbook Editor at ARRL Headquarters.

Aluma Tower
Glen Martin Engineering
Hy-Gain Division, Telex Communications, Inc
M² Enterprises
National Tower Co
Rohn
Texas Towers
Tri-Ex Tower Corp
Universal Manufacturing Co
US Tower Corp

Antenna Wire Strength

American	***Recommended Tension[1] (pounds)***		***Weight (pounds per 1000 feet)***	
Wire Gauge	*Copper-clad steel[2]*	*Hard-drawn copper*	*Copper-clad steel[2]*	*Hard-drawn copper*
4	495	214	115.8	126
6	310	130	72.9	79.5
8	195	84	45.5	50
10	120	52	28.8	31.4
12	75	32	18.1	19.8
14	50	20	11.4	12.4
16	31	13	7.1	7.8
18	19	8	4.5	4.9
20	12	5	2.8	3.1

[1] Approximately one-tenth the breaking load. Might be increased 50% if end supports are firm and there is no danger of ice loading.
[2] "Copperweld," 40% copper.

Impedance of Various Two-Conductor Lines

	—— Twists per Inch ——				
Wire Size	***2.5***	***5***	***7.5***	***10***	***12.5***
no. 20	43	39	35		
no. 22	46	41	39	37	32
no. 24	60	45	44	43	41
no. 26	65	57	54	48	47
no. 28	74	53	51	49	47
no. 30			49	46	47

Measured in ohms at 14.0 MHz.

This chart illustrates the impedance of various two-conductor lines as a function of the wire size and number of twists per inch.

Standard vs American Wire Gauge

SWG	***Diam (in.)***	***Nearest AWG***
12	0.104	10
14	0.08	12
16	0.064	14
18	0.048	16
20	0.036	19
22	0.028	21
24	0.022	23
26	0.018	25
28	0.0148	27
30	0.0124	28
32	0.0108	29
34	0.0092	31
36	0.0076	32
38	0.006	34
40	0.0048	36
42	0.004	38
44	0.0032	40
46	0.0024	—

Attenuation per Foot for Lines

	——— Twists per Inch ———				
Wire Size	***2.5***	***5***	***7.5***	***10***	***12.5***
no. 20	0.11	0.11	0.12		
no. 22	0.11	0.12	0.12	0.12	0.12
no. 24	0.11	0.12	0.12	0.13	0.13
no. 26	0.11	0.13	0.13	0.13	0.13
no. 28	0.11	0.13	0.13	0.16	0.16
no. 30			0.25	0.27	0.27

Measured in decibels at 14.0 MHz.

Attenuation in dB per foot for the same lines as shown above.

Equivalent Values of Reflection Coefficient, Attenuation, SWR and Return Loss

Reflection Coefficient (%)	*Attenuation (dB)*	*Max SWR*	*Return Loss*	*Reflection Coefficient (%)*	*Attenuation (dB)*	*Max SWR*	*Return Loss*
1.000	0.000434	1.020	40.00	27.000	0.3287	1.740	11.37
1.517	0.001000	1.031	36.38	28.000	0.3546	1.778	11.06
2.000	0.001738	1.041	33.98	30.000	0.4096	1.857	10.46
3.000	0.003910	1.062	30.46	31.623	0.4576	1.925	10.00
4.000	0.006954	1.083	27.96	32.977	0.5000	1.984	9.64
4.796	0.01000	1.101	26.38	33.333	0.5115	2.000	9.54
5.000	0.01087	1.105	26.02	34.000	0.5335	2.030	9.37
6.000	0.01566	1.128	24.44	35.000	0.5675	2.077	9.12
7.000	0.02133	1.151	23.10	36.000	0.6028	2.125	8.87
7.576	0.02500	1.164	22.41	37.000	0.6394	2.175	8.64
8.000	0.02788	1.174	21.94	38.000	0.6773	2.226	8.40
9.000	0.03532	1.198	20.92	39.825	0.75000	2.324	8.00
10.000	0.04365	1.222	20.00	40.000	0.7572	2.333	7.96
10.699	0.05000	1.240	19.41	42.000	0.8428	2.448	7.54
11.000	0.05287	1.247	19.17	42.857	0.8814	2.500	7.36
12.000	0.06299	1.273	18.42	44.000	0.9345	2.571	7.13
13.085	0.07500	1.301	17.66	45.351	1.0000	2.660	6.87
14.000	0.08597	1.326	17.08	48.000	1.1374	2.846	6.38
15.000	0.09883	1.353	16.48	50.000	1.2494	3.000	6.02
15.087	0.10000	1.355	16.43	52.000	1.3692	3.167	5.68
16.000	0.1126	1.381	15.92	54.042	1.5000	3.352	5.35
17.783	0.1396	1.433	15.00	56.234	1.6509	3.570	5.00
18.000	0.1430	1.439	14.89	58.000	1.7809	3.762	4.73
19.000	0.1597	1.469	14.42	60.000	1.9382	4.000	4.44
20.000	0.1773	1.500	13.98	60.749	2.0000	4.095	4.33
22.000	0.2155	1.564	13.15	63.000	2.1961	4.405	4.01
23.652	0.2500	1.620	12.52	66.156	2.5000	4.909	3.59
24.000	0.2577	1.632	12.40	66.667	2.5528	5.000	3.52
25.000	0.2803	1.667	12.04	70.627	3.0000	5.809	3.02
26.000	0.3040	1.703	11.70	70.711	3.0103	5.829	3.01

$$\rho = \frac{SWR - 1}{SWR + 1}$$

where ρ = 0.01 × (reflection coefficient in %)

$$\rho = 10^{\frac{-RL}{20}}$$

where RL = return loss (dB)

$$\rho = \sqrt{1 - \left(0.1^{x}\right)}$$

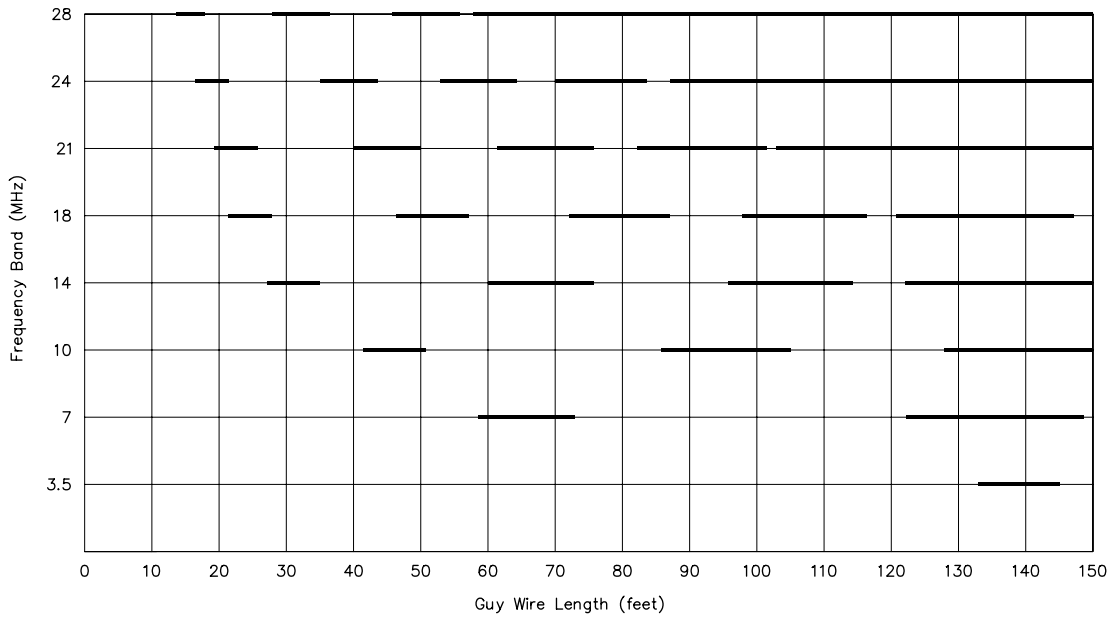
where X = A/10 and A = attenuation (dB)

$$SWR = \frac{1 + \rho}{1 - \rho}$$

Return loss (dB) = –8.68589 ln (ρ)
where ln is the natural log (log to the base e)

Attenuation (dB) = –4.34295 ln ($1-\rho^2$)
where ln is the natural log (log to the base e)

Guy Wire Lengths to Avoid



The black bars indicate ungrounded guy wire lengths to avoid for the eight HF amateur bands. This chart is based on resonance within 10% of any frequency in the band. Grounded wires will exhibit resonance at odd multiples of a quarter wavelength. ***(Jerry Hall, K1TD)***

Morse Code Character Set[1]

A	didah	• –
B	dahdididit	– •••
C	dahdidahdit	– • – •
D	dahdidit	– ••
E	dit	•
F	dididahdit	•• – •
G	dahdahdit	– – •
H	didididit	••••
I	didit	••
J	didahdahdah	•– – –
K	dahdidah	– •–
L	didahdidit	• – ••
M	dahdah	– –
N	dahdit	– •
O	dahdahdah	– – –
P	didahdahdit	• – – •
Q	dahdahdidah	– – • –
R	didahdit	• – •
S	dididit	•••
T	dah	–
U	dididah	•• –
V	didididah	••• –
W	didahdah	•– –
X	dahdididah	– •• –
Y	dahdidahdah	– • – –
Z	dahdahdidit	– – ••
1	didahdahdahdah	• – – – –
2	dididahdahdah	•• – – –
3	didididahdah	••• – –
4	dididididah	•••• –
5	dididididit	•••••
6	dahdididididit	– ••••
7	dahdahdididit	– – •••
8	dahdahdahdidit	– – – ••
9	dahdahdahdahdit	– – – – •
0	dahdahdahdahdah	– – – – –

Period [.]:	didahdidahdidah	• – • – • –
Comma [,]:	dahdahdididahdah	– – •• – –
Question mark or request for repetition [?]:	dididahdahdidit	•• – – ••
Error:	dididididididit	••••••••
Hyphen or dash [–]:	dahdididididah	– •••• –
Double dash [=]	dahdididididah	– ••• –
Colon [:]:	dahdahdahdididit	– – – •••
Semicolon [;]:	dahdidahdidahdit	– • – • – •
Left parenthesis [(]:	dahdidahdahdit	– • – – •
Right parenthesis [)]:	dahdidahdahdddidah	– • – – • –
Fraction bar [/]:	dahdididahdit	– •• – •
Quotation marks [“]:	didahdididahdit	• – • • – •
Dollar sign [$]:	dididididahdididah	••• – • •–
Apostrophe [’]:	didahdahdahdahdit	• – – – – •
Paragraph [¶]:	didahdidahdidit	• – • – ••
Underline [_]:	dididahdahdidah	•• – – • –
Starting signal:	dahdidahdidah	– • – •–
Wait:	didahdididit	• – •••
End of message or cross [+]:	didahdidahdit	• – • – •
Invitation to transmit [K]:	dahdidah	– • –
End of work:	didididahdidah	••• – • –
Understood:	didididahdit	••• – •

Notes:

1. Not all Morse characters shown are used in FCC code tests. License applicants are responsible for knowing, and may be tested on, the 26 letters, the numerals 0 to 9, the period, the comma, the question mark, AR, SK, BT and fraction bar [DN].

2. The following letters are used in certain European languages which use the Latin alphabet:

Ä, Ą	didahdidah	• – • –
Á, Å, À, Â	didahdahdidah	• – – • –
Ç, Ć	dahdidahdidit	– • – ••
É, È, Ę	dididahdidit	•• – ••
È	didahdididah	• – ••–
Ê	dahdididahdit	– •• – •
Ö, Ó, Ó	dahdahdahdit	– – –•
Ñ	dahdahdidahdah	– – • – –
Ü	dididahdah	•• – –
Ź	dahdahdidit	– –••
Z	dahdahdididah	– –•• –
CH, Ş	dahdahdahdah	– – – –

3. Special Esperanto characters:

Ĉ	dahdidahdidit	– • – ••
Ŝ	dididididahdit	••• – •
Ĵ	didahdahdahdit	• – – –•
Ĥ	dahdidahdahdit	–• – –•
Ŭ	dididahdah	•• – –
Ĝ	dahdahdidahdit	– – • – •

4. Signals used in other radio services:

Interrogatory	dididahdidah	•• – • –	INT
Emergency silence	dididididahdah	•••• – –	HM
Executive follows	dididahdididah	•• – •• –	IX
Break–in signal	dahdahdahdahdah	– – – – –	TTTTT
Emergency signal	dididididahdahdahdididit	••• – – – •••	SOS
Relay of distress	dahdididahdididahdidit	– •• – •• – ••	DDD

Morse Abbreviated Numbers

Numeral		*Long Number*		*Abbreviated Number*	*Equivalent Character*
1	didahdahdahdah	• – – – –	didah	• –	A
2	dididahdahdah	•• – – –	dididah	•• –	U
3	didididahdah	••• – –	didididah	••• –	V
4	dididididah	•••• –	dididididah	•••• –	4
5	dididididit	•••••	dididididit	••••• or •	5 or E
6	dahdididididit	– ••••	dahdididididit	– ••••	6
7	dahdahdididit	– – •••	dahdididit	– •••	B
8	dahdahdahdidit	– – – ••	dahdidit	– ••	D
9	dahdahdahdahdit	– – – – •	dahdit	– •	N
0	dahdahdahdahdah	– – – – –	dah	–	T

Note: These abbreviated numbers are not legal for use in call signs. They should be used only where there is agreement between operators and when no confusion will result.

The ASCII Coded Character Set

					6	0	0	0	0	1	1	1	1
Bit					5	0	0	1	1	0	0	1	1
Number					4	0	1	0	1	0	1	0	1
				Hex	1st	0	1	2	3	4	5	6	7
3	2	1	0	2nd									
0	0	0	0	0		NUL	DLE	SP	0	@	P	`	p
0	0	0	1	1		SOH	DC1	!	1	A	Q	a	q
0	0	1	0	2		STX	DC2	“	2	B	R	b	r
0	0	1	1	3		ETX	DC3	#	3	C	S	c	s
0	1	0	0	4		EOT	DC4	$	4	D	T	d	t
0	1	0	1	5		ENQ	NAK	%	5	E	U	e	u
0	1	1	0	6		ACK	SYN	&	6	F	V	f	v
0	1	1	1	7		BEL	ETB	′	7	G	W	g	w
1	0	0	0	8		BS	CAN	(	8	H	X	h	x
1	0	0	1	9		HT	EM	)	9	I	Y	i	y
1	0	1	0	A		LF	SUB	*	:	J	Z	j	z
1	0	1	1	B		VT	ESC	+	;	K	[	k	{
1	1	0	0	C		FF	FS	,	<	L	\	l	|
1	1	0	1	D		CR	GS	-	=	M	]	m	}
1	1	1	0	E		SO	RS	.	>	N	^	n	~
1	1	1	1	F		SI	US	/	?	O	—	o	DEL

ACK	acknowledge	FF	form feed
BEL	bell	FS	file separator
BS	backspace	GS	group separator
CAN	cancel	HT	horizontal tab
CR	carriage return	LF	line feed
DC1	device control 1	NAK	negative acknowledge
DC2	device control 2	NUL	null
DC3	device control 3	RS	record separator
DC4	device control 4	SI	shift in
DEL	(delete)	SO	shift out
DLE	data link escape	SOH	start of heading
ENQ	enquiry	SP	space
EM	end of medium	STX	start of text
EOT	end of transmission	SUB	substitute
ESC	escape	SYN	synchronous idle
ETB	end of block	US	unit separator
ETX	end of text	VT	vertical tab

Notes

1. “1” = mark, “0” = space.
2. Bit 6 is the most-significant bit (MSB). Bit 0 is the least-significant bit (LSB).

ITA2 (Baudot) and AMTOR Codes

Combination No.	ITA2[1] Code Bit No. 43210	Hex	CCIR 476[2] Code Bit No. 6543210	Hex	Character Set Letters Case	Figures Case ITA2	Figures Case U.S. TTYs[3]
1	00011	03	1000111	47	A	—	—
2	11001	19	1110010	72	B	?	?
3	01110	0E	0011101	1D	C	:	:
4	01001	09	1010011	53	D	[5]	$
5	00001	01	1010110	56	E	3	3
6	01101	0D	0011011	1B	F	[4]	!
7	11010	1A	0110101	35	G	[4]	&
8	10100	14	1101001	69	H	[4]	# or motor stop
9	00110	06	1001101	4D	I	8	8
10	01011	0B	0010111	17	J	BELL	´
11	01111	0F	0011110	1E	K	(	(
12	10010	12	1100101	65	L	)	)
13	11100	1C	0111001	39	M	.	.
14	01100	0C	1011001	59	N	,	,
15	11000	18	1110001	71	0	9	9
16	10110	16	0101101	2D	P	0	0
17	10111	17	0101110	2E	Q	1	1
18	01010	0A	1010101	55	R	4	4
19	00101	05	1001011	4B	S	'	BELL
20	10000	10	1110100	74	T	5	5
21	00111	07	1001110	4E	U	7	7
22	11110	1E	0111100	3C	V	=	;
23	10011	13	0100111	27	W	2	2
24	11101	1D	0111010	3A	X	/	/
25	10101	15	0101011	2B	Y	6	6
26	10001	11	1100011	63	Z	+	"
27	01000	08	1111000	78	← CR (Carriage return)		
28	00010	02	1101100	6C	≡ LF (Line feed)		
29	11111	1F	1011010	5A	↓ LTRS (Letter shift)		
30	11011	1B	0110110	36	↑ FIGS (Figure shift)		
31	00100	04	1011100	5C	SP (Space)		
32	00000	00	1101010	6A	BLK (Blank)		

Notes

[1] 1 represents the mark condition (shown as Z in ITU recommendations) which is the higher emitted radio frequency for FSK, the lower audio frequency for AFSK. 0 represents the space condition (shown as A in ITU documents). Bits are numbered 0 (least-significant bit) through 4 (most-significant bit). The order of bit transmission is LSB first, MSB last. Symbols A and Z are defined in CCIR Rec. R.140.

[2] 1 represents the mark condition (shown as B in CCIR recommendations), which is the higher emitted radio frequency for FSK, the lower audio frequency for AFSK. 0 represents the space condition (shown as Y in CCIR recommendations). Bits are numbered 0 (LSB) through 6 (MSB). The order of bit transmission is LSB first, MSB last.

[3] Many U.S. teletypewriters have these figures case characters.

[4] At present unassigned. Reception of these signals, however, should not initiate a request for repetition.

[5] The pictorial representations of ☒ or ✠ indicate WRU (Who are you?), which is used for an answer-back function in telex networks.

Baudot Signaling Rates and Speeds

Signaling Rate (bauds)	*Data Pulse (ms)*	*Stop Pulse (ms)*	*Speed (WPM)*	*Common Name*
45.45	22.0	22.0	65.00	Western Union
	22.0	31.0	61.33	“60 speed”
	22.0	33.0	60.61	45 bauds
50.00	20.0	30.0	66.67	European; 50 bauds
56.92	17.57	25.00	76.68	“75 speed”
	17.57	26.36	75.89	57 bauds
74.20	13.47	19.18	100.00	“100 speed”
	13.47	20.21	98.98	74 bauds
100.0	10.00	15.00	133.33	100 bauds

Code Conversion, ITA1 through 4 (Notes 1 and 2)

Combination number	*ITA1 Bit No. 43210*	*Figure Case ITA1*	*Letter Case All Codes*	*Figure Case ITA2-4*	*ITA2 Bit No. 43210*	*ITA3 Bit No. 6543210*	*ITA4 Bit No. 543210*
1	++++−	1	A	—	00011	0101100	000110
2	+−−++	8	B	?	11001	1001100	110010
3	+−−+−	9	C	:	01110	0011001	011100
4	+−−−−	0	D	Note 4	01001	0011100	010010
5	+++−+	2	E	3	00001	0001110	000010
6	+−−−+	Note 3	F	Note 4	01101	1100100	011010
7	+−+−+	7	G	Note 4	11010	1000011	110100
8	+−+−−	+	H	Note 4	10100	0100101	101000
9	++−−+	Note 3	I	8	00110	0000111	001100
10	+−++−	6	J	BELL	01011	1100010	010110
11	−−++−	(	K	(	01111	1101000	011110
12	−−+−−	=	L	)	10010	0100011	100100
13	−−+−+	)	M	.	11100	1000101	111000
14	−−−−+	Note 3	N	,	01100	0010101	011000
15	++−−−−	5	O	9	11000	0110001	110000
16	−−−−−	%	P	0	10110	0101001	101100
17	−−−+−	/	Q	1	10111	1011000	101110
18	−−−++	—	R	4	01010	0010011	010100
19	−+−++	.	S	'	00101	0101010	001010
20	−+−+−	Note 3	T	5	10000	1010001	100000
21	++−+−	4	U	7	00111	0100110	001110
22	−+−−−	'	V	=	11110	1001001	111100
23	−+−−+	?	W	2	10011	1010010	100110
24	−++−+	,	X	/	11101	0110100	111010
25	++−+++	3	Y	6	10101	1010100	101010
26	−++−−	:	Z	+	10001	1000110	100010
27	+++−−	Carriage return		Carriage return	01000	1100001	010000
28	−+++−	Line feed		Line feed	00010	0001101	000100
29	−++++	Letter blank (space)		Letter shift	11111	0111000	111110
30	+−+++	Figure blank (space)		Figure shift	11011	0110010	110110
31	−−+++	Error		Space	00100	0001011	001000
32	+++++	Instrument at rest		Blank	00000	1110000	000001
—				Phasing signal	—	—	110011
—				Signal repetition	—	0010110	—
—				Signal alpha	Note 5	1001010	000000
—				Signal beta	Note 6	0011010	111111

Notes

Note 1: For complete specifications of these codes see the following International Telecommunication Union documents: ITA1 and 2—Telegraph Regulations (Geneva Revision, 1958), ITA3—CCITT Rec. S.13, ITA4—CCITT Rec. R.44.

Note 2: In ITA1, + indicates positive current, – negative current. In ITA2 through ITA4, 1 represents mark condition (shown as Z in ITU recommendations, which is the higher emitted radio frequency for FSK, the lower for AFSK). 0 represents the space dondition (shown as A in ITU recommendations). For meanings of A and Z see CCITT Rec. 140. The normal order of bit transmission is lowest significang bit (LSB) first.

Note 3: At the disposal of each administration for its internal service.

Note 4: At present unassigned. Reception of these signals, however, should not initiate a request for repetition. See CCITT Rec S.4.

Note 5: Permanent 0 polarity.

Note 6: Permanent 1 plarity.

Conversion from ASCII to Morse and Baudot

ASCII		*Int'l Morse*		*Baudot*	
Code 6543210	*Char*	*Code*	*Char*	*Code [1] 43210*	*Char[2]*
0000000	NUL			↑↓ 00000	Blank
0000001	SOH				
0000010	STX				
0000011	ETX				
0000100	EOT				
0000101	ENQ			↑ 01001	WRU (ITA)
0000110	ACK				
0000111	BEL			↑ 01011	Bell (ITA)
				↑ 00101	Bell (U.S.)
0001000	BS				
0001001	HT				
0001010	LF			↑↓ 00010	LF
0001011	VT				
0001100	FF				
0001101	CR			↑↓ 01000	CR
0001110	SO				
0001111	SI				
0010000	DLE				
0010001	DC1				
0010010	DC2				
0010011	DC3				
0010100	DC4				
0010101	NAK				
0010110	SYN				
0010111	ETB				
0011000	CAN				
0011001	EM				
0011010	SUB				
0011011	ESC				
0011100	FS				
0011101	GS				
0011110	RS				
0011111	US				
0100000	SP	Space		00100	SP
0100001	!				
0100010	“	• – •• – •	AF ”	↑ 10001	” (U.S.)
0100011	#			↑ 10100	# (U.S.)
0100100	$	••• – •• –	SX $	↑ 01001	$ (U.S.)
0100101	%				
0100110	&				
0100111	‘	• – – – – •	WG ’	↑ 00101	’ (ITA)
				↑ 01011	’ (U.S)
0101000	(	– • – – •	KN (	↑ 01111	(
0101001	)	– • – – • –	KK)	↑ 10010	)
0101010	*				
0101011	+	• – • – •	AR +	↑ 10001	+ (ITA)
0101100	,	— •• —	MIM ,	↑ 01100	,
0101101	-	– ••••• –	DU –	↑ 00011	–
0101110	.	• – • – • –	AAA .	↑ 11100	.
0101111	/	– •• – •	DN /	↑ 11101	/
0110000	0	– – – – –	0	↑ 10110	0
0110001	1	• – – – –	1	↑ 10111	1
0110010	2	•• – – –	2	↑ 10011	2
0110011	3	••• – –	3	↑ 00001	3
0110100	4	•••• –	4	↑ 01010	4
0110101	5	•••••	5	↑ 10000	5

Continued on next page.

Conversion from ASCII to Morse and Baudot

Continued from previous page.

ASCII		Int'l Morse		Baudot	
Code 6543210	Char	Code	Char	Code [1] 43210	Char [2]
0110110	6	– ••••	6	↑ 10101	6
0110111	7	– – •••	7	↑ 00111	7
0111000	8	– – – ••	8	↑ 00110	8
0111001	9	– – – – •	9	↑ 11000	9
0111010	:	– – – •••	OS :	↑ 01110	:
0111011	;	– • – • – •	KR ;	↑ 11110	; (U.S.)
0111100	<				
0111101	=	– ••• –	BT =	↑ 11110	= (ITA)
0111110	>				
0111111	?	•• – – ••	IMI ?	↑ 11001	?
1000000	@				
1000001	A	• –	A	↓ 00011	A
1000010	B	– •••	B	↓ 11001	B
1000011	C	– • – •	C	↓ 01110	C
1000100	D	– ••	D	↓ 01001	D
1000101	E	•	E	↓ 00001	E
1000110	F	•• – •	F	↓ 01101	F
1000111	G	– – •	G	↓ 11010	G
1001000	H	••••	H	↓ 10100	H
1001001	I	••	I	↓ 00110	I
1001010	J	• – – –	J	↓ 01011	J
1001011	K	– • –	K	↓ 01111	K
1001100	L	• – ••	L	↓ 10010	L
1001101	M	– –	M	↓ 11100	M
1001110	N	– •	N	↓ 01100	N
1001111	O	– – –	O	↓ 11000	O
1010000	P	• – – •	P	↓ 10110	P
1010001	Q	– – • –	Q	↓ 10111	Q
1010010	R	• – •	R	↓ 01010	R
1010011	S	•••	S	↓ 00101	S
1010100	T	–	T	↓ 10000	T
1010101	U	•• –	U	↓ 00111	U
1010110	V	••• –	V	↓ 11110	V
1010111	W	• – –	W	↓ 10011	W
1011000	X	– •• – –	X	↓ 11101	X
1011001	Y	– • – –	Y	↓ 10101	Y
1011010	Z	– – ••	Z	↓ 10001	Z
1011011	[				
1011100	\				
1011101	]				
1011110	^				
1011111	_	•• – – • –	IQ_		
1100000	`				
1100001	a	• –	A	↓ 00011	A
1100010	b	– •••	B	↓ 11001	B
1100011	c	– • – •	C	↓ 01110	C
1100100	d	– ••	D	↓ 01001	D
1100101	e	•	E	↓ 00001	E
1100110	f	•• – •	F	↓ 01101	F
1100111	g	– – •	G	↓ 11010	G
1101000	h	••••	H	↓ 10100	H
1101001	i	••	I	↓ 00110	I
1101010	j	• – – –	J	↓ 01011	J
1101011	k	– • –	K	↓ 01111	K
1101100	1	• – ••	L	↓ 10010	L

Continued on next page.

Conversion from ASCII to Morse and Baudot

Continued from previous page.

ASCII		Int'l Morse		Baudot	
Code 6543210	Char	Code	Char	Code [1] 43210	Char [2]
1101101	m	– –	M	↓ 11100	M
1101110	n	– •	N	↓ 01100	N
1101111	o	– – –	O	↓ 11000	O
1110000	p	• – – •	P	↓ 10110	P
1110001	q	– – • –	Q	↓ 10111	Q
1110010	r	• – •	R	↓ 01010	R
1110011	s	•••	S	↓ 00101	S
1110100	t	–	T	↓ 10000	T
1110101	u	•• –	U	↓ 00111	U
1110110	v	•••–	V	↓ 11110	V
1110111	w	• – –	W	↓ 10011	W
1111000	x	– •• –	X	↓ 11101	X
1111001	y	– • ––	Y	↓ 10101	Y
1111010	z	– – ••	Z	↓ 10001	Z
1111011	{				
1111100	|				
1111101	}				
1111110	~				
1111111	DEL				

Notes

[1] In Baudot code, it is necessary to check to see what the current case is before conversion (↓ = letters, ↑ = figures, ↓↑ = either case).

[2] Figures–case characters are the same for both ITA2 and U.S. teletypewriters except where indicated.

Data Interface Connections

Pin	*Ckt*	*EIA-232-D Description*	*V. 24 No.*	*V. 24 Name*	*Common Abbr.**
1	—	Shield			
2	BA	Transmitted Data	103	Transmitted Data	TxD
3	BB	Received Data	104	Received Data	RxD
4	CA	Request to Send	105	Request to Send	RTS
5	CB	Clear to Send	106	Clear to Send	CTS
6	CC	DCE Ready	107	Data Set Ready	DSR
7	AB	Signal Ground	102	Signal Ground	SG
8	CF	Received Line Signal Detector	109	Data Carrier Detect	CD
9	—	(Reserved for Testing)			
10	—	(Reserved for Testing)			
11	—	Unassigned			
12	SCF/CI	Sec. Rec'd Line Sig. Detector/Data Sig. Rate Select (DCE Source)	122	Backward Channel Received Line Signal Detector	SCD
13	SCB	Sec. Clear to Send	121	Backward Channel Ready	SCTS
14	SBA	Sec. Transmitted Data	118	Transmitted Backward Channel Data	STxD
15	DB	Transmission Signal Element Timing (DCE Source)	114	Transmitter Signal Element Timing (DCE Source)	TxC
16	SSB	Sec. Received Data	119	Received Backward Channel Data	SRxD
17	DD	Receiver Signal Element Timing (DCE Source)	115	Receiver Signal Element	RxC
18	LL	Local Loopback			
19	SCA	Sec. Request to Send	120	Transmitted Backward Line Signal	SRTS
20	CD	DTE Ready	108/2	Data Terminal Ready	DTR
21	RL/CG	Remote Loopback/Signal Quality Detector	110	Data Signal Quality Detector	SQ
22	CE	Ring Indicator	125	Calling Indicator	RI
23	CH/CI	Data Signal Rate Select (DTE/DCE Source)	111 112	Data Rate Selector Data Rate Selector	
24	DA	Transmit Signal Element Timing (DTE Source)	113	Transmitter Signal Element Timing, (DTE Source)	ETxC
25	TM	Test Mode			

* Most abbreviations in this column are generally recognized by association with their full names. Exceptions are: ETxC=External Transmitter Clock, RxC=Receiver Clock and TxC=Transmitter Clock.

EIA-449 37-Pin Connector Assignments

Pin	*Direction*	*Mnemonic*	*Circuit name*
1	—	SHIELD	
2	from DCE	SI	Signaling rate indicator
3	—	SPARE	
4	to DCE	SD	Send data
5	from DCE	ST	Send timing
6	from DCE	RD	Receive data
7	to DCE	RS	Request to send
8	from DCE	RT	Receive timing
9	from DCE	CS	Clear to send
10	to DCE	LL	Local loopback
11	from DCE	DM	Data mode
12	to DCE	TR	Terminal ready
13	from DCE	RR	Receiver ready
14	to DCE	RL	Remote loopback
15	from DCE	IC	Incoming call
16	to DCE	SF/SR	Select frequency Signaling rate selector
17	to DCE	TT	Terminal timing
18	from DCE	TM	Test mode
19	—	SG	Signal ground
20	from DCE	RC	Receive common
21	—	SPARE	
22	to DCE	SD	Send data
23	from DCE	ST	Send timing
24	from DCE	RD	Receive data
25	to DCE	RS	Request to send
26	from DCE	RT	Receive timing
27	from DCE	CS	Clear to send
28	to DCE	IS	Terminal in service
29	from DCE	DM	Data mode
30	to DCE	TR	Terminal ready
31	from DCE	RR	Receiver ready
32	to DCE	SS	Select standby
33	from DCE	SQ	Signal quality
34	to DCE	NS	New signal
35	to DCE	TT	Terminal timing
36	from DCE	SB	Standby indicator
37	to DCE	SC	Send common

EIA-449 9-Pin Connector Assignments

Pin	*Direction*	*Mnemonic*	*Circuit Name*
1	—	SHIELD	
2	from DCE	SRR	Secondary receiver ready
3	to DCE	SSD	Secondary send data
4	from DCE	SRF	Secondary receive data
5	—	SG	Signal ground
6	—	RC	Receive common
7	to DCE	SRS	Secondary request to send
8	from DCE	SCS	Secondary clear to send
9	to DCE	SC	Send common

ISO 2593 Pin Allocations for V.35 Interfaces

Pin	*Circuit*	*Direction*	*Function*
A	101	Common	Protective ground or earth
B	102	Common	Signal ground or common return
C	105	from DTE	Request to send
D	106	to DTE	Ready for sending
E	107	to DTE	Data set ready
F	109	from DTE	Data channel received line signal detector
H	108/1	from DTE	Connect data set to line
	108/2	from DTE	Data terminal ready
	125	to DTE	Calling indicator
K	—	—	F_1
L	—	—	F_2
M	—	—	F_1
N	—	—	F_2
R	104	to DTE	Received data A-wire
T	104	to DTE	Received data B-wire
V	115	to DTE	Receiver signal element timing A-wire
X	115	to DTE	Receiver signal element timing B-wire
Y	114	to DTE	Transmitter signal element timing A-wire

N = Pins permanently reserved for national use. Pins HH, JJ and KK are used in the U.K. for transmitter-clock control.

AA	114	to DTE	Transmitter signal element timing B-wire
P	103	from DTE	Transmitted data A-wire
S	103	from DTE	Transmitted data B-wire
U	113	from DTE	Transmitter signal element timing A-wire
Z	—	—	F_3
W	113	from DTE	Transmitter signal element timing B-wire
BB	—	—	F_3
CC	—	—	F_4
DD	—	—	F_5
EE	—	—	F_4
FF	—	—	F_5
HH	—	—	N_1
JJ	—	—	N_2
KK	—	—	N_1
LL	—	—	N_2
MM	—	—	F
NN	—	—	F

F = Pins reserved by ISO, not for national use. Subscripts indicate pins to form pairs.

RTTY Control Sequences (from CCITT Recommendation S.4)

Sequence	*Meaning*
ZCZC	start of message
NNNN	end of message
CCCC	enable remote reperforator (or other device)
SSSS	enable remote terminal
FFFF	disable remote reperforator
KKKK	ready for test
KLKL	enable remote reader
XXXXX	error signal

EME Software

See the *ARRL Handbook* Address List for contact information.

EME Tracker

RealTrak

SkymooN

VHF PAK

VK3UM EME Planner

Z-TRAK

Voluntary HF Band Plans for Considerate US Operators

The following frequencies are generally recognized for certain modes or activities (all frequencies are in MHz).

Nothing in the rules recognizes a net's, group's or any individual's special privilege to any specific frequency. Section 97.101(b) of the Rules states that "Each station licensee and each control operator must cooperate in selecting transmitting channels and in making the most effective use of the amateur service frequencies. No frequency will be assigned for the exclusive use of any station." No one "owns" a frequency.

It's good practice—and plain old common sense—for any operator, regardless of mode, to check to see if the frequency is in use prior to engaging operation. If you are there first, other operators should make an effort to protect you from interference to the extent possible given that 100% interference-free operation is an unrealistic expectation in today's congested bands.

1.800-1.830	CW, data and other narrowband modes
1.810	QRP CW calling frequency
1.830-1.840	CW, data and other narrowband modes, intercontinental QSOs only
1.840-1.850	CW; SSB, SSTV and other wideband modes, intercontinental QSOs only
1.850-2.000	CW; phone, SSTV and other wideband modes
3.500-3.510	CW DX
3.590	RTTY DX
3.580-3.620	Data
3.620-3.635	Automatically controlled data stations
3.710	QRP Novice/Technician CW calling frequency
3.790-3.800	DX window
3.845	SSTV
3.885	AM calling frequency
3.985	QRP SSB calling frequency
7.040	RTTY DX QRP CW calling frequency
7.075-7.100	Phone in KH/KL/KP *only*
7.080-7.100	Data
7.100-7.105	Automatically controlled data stations
7.110	QRP Novice/Technician CW calling frequency
7.171	SSTV
7.285	QRP SSB calling frequency
7.290	AM calling frequency
10.106	QRP CW calling frequency
10.130-10.140	Data
10.140-10.150	Automatically controlled data stations
14.060	QRP CW calling frequency
14.070-14.095	Data
14.095-14.0995	Automatically controlled data stations
14.100	IBP/NCDXF beacons
14.1005-14.112	Automatically controlled data stations
14.230	SSTV
14.285	QRP SSB calling frequency
14.286	AM calling frequency
18.100-18.105	Data
18.105-18.110	Automatically controlled data stations
21.060	QRP CW calling frequency
21.070-21.090	Data
21.090-21.100	Automatically controlled data stations
21.340	SSTV
21.385	QRP SSB calling frequency
24.920-24.925	Data
24.925-24.930	Automatically controlled data stations
28.060	QRP CW calling frequency
28.070-28.120	Data
28.120-28.189	Automatically controlled data stations
28.190-28.225	Beacons
28.385	QRP SSB calling frequency
28.680	SSTV
29.000-29.200	AM
29.300-29.510	Satellite downlinks
29.520-29.580	Repeater inputs
29.600	FM simplex
29.620-29.680	Repeater outputs

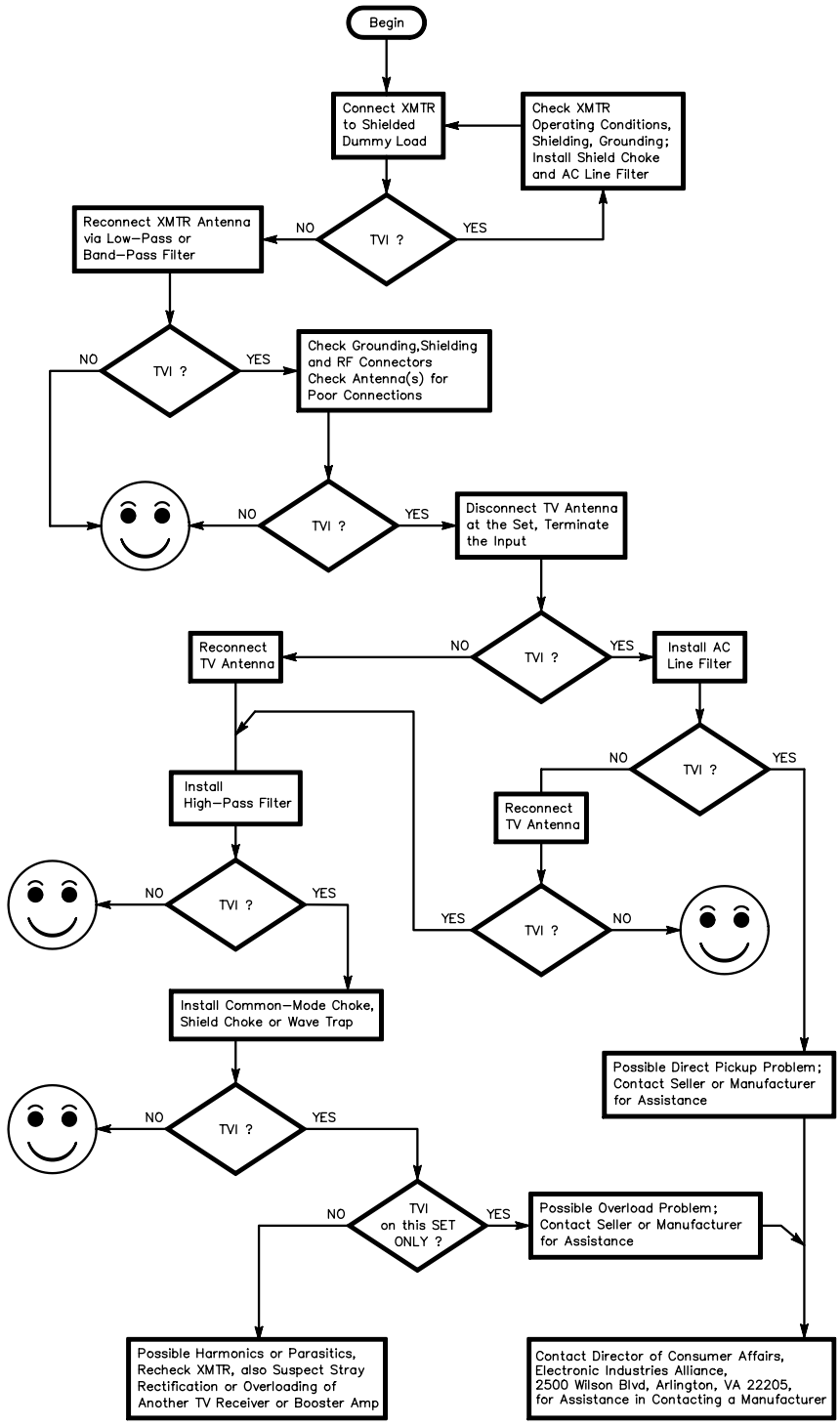
Notes

ARRL band plans for frequencies above 28.300 MHz are shown in *The ARRL Repeater Directory* and *The FCC Rule Book*. For detailed packet frequencies, see *QST*, September 1987, page 54, and March 1988, page 51.

IBP/NCDXF beacons operate on 14.100, 18.110, 21.150, 24.930 and 28.200 MHz.

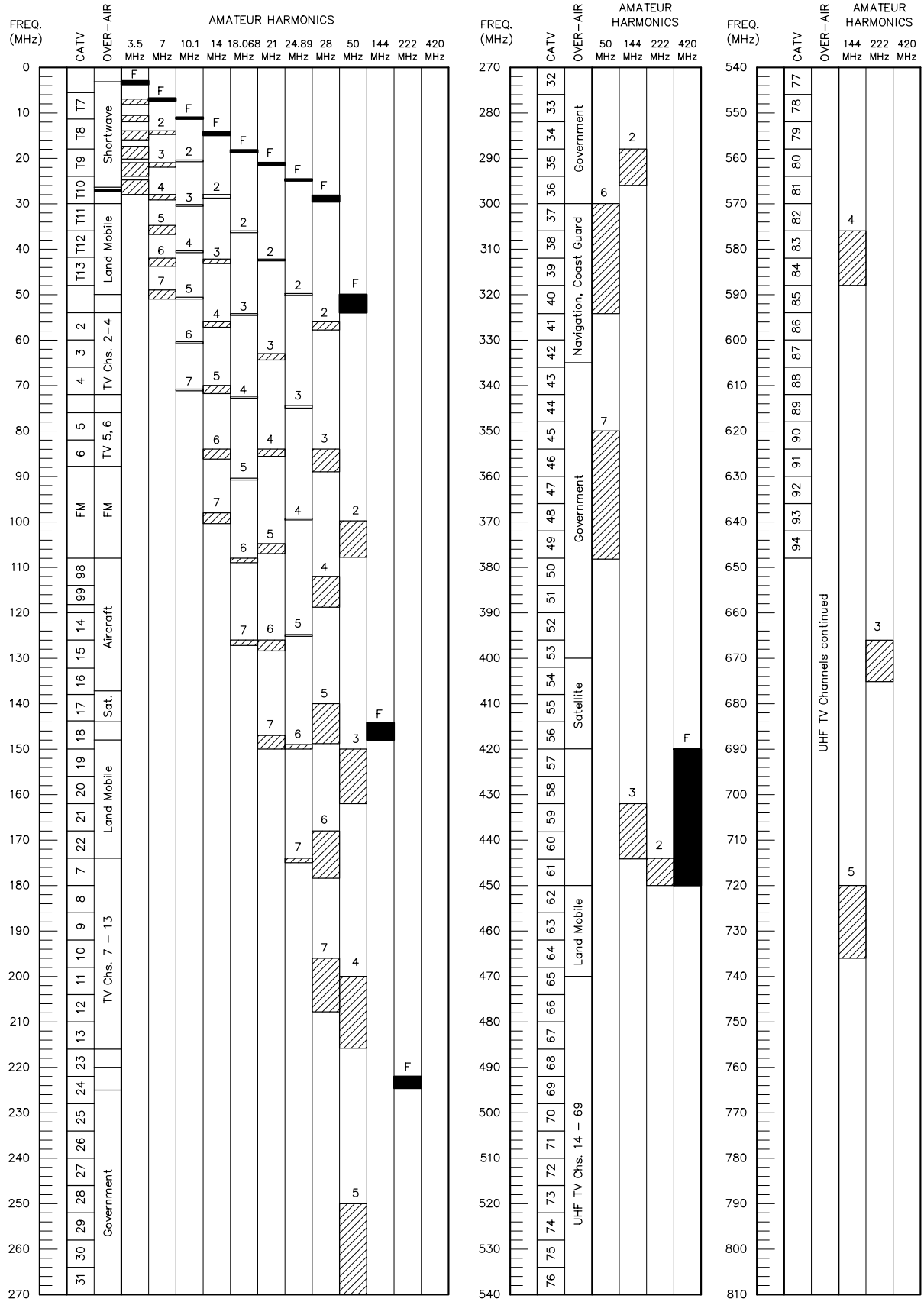
TVI Troubleshooting Flowchart

(also see EMI chapter)



TV Channels vs Harmonics

This chart shows CATV and broadcast channels used in the United States and their relationship to the harmonics of MF, HF, VHF and UHF amateur bands.



US Amateur Bands

April 15, 2000

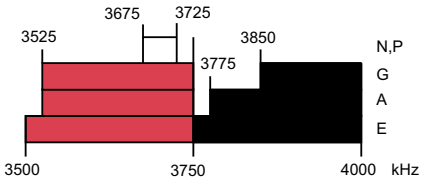
Novice, Advanced and Technician Plus Allocations

Novice, Advanced and Technician Plus licenses will not be issued after April 15, 2000. However, the FCC has allowed the frequency allocations for these license classes to remain in effect.

160 METERS

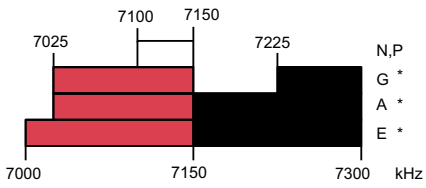
Amateur stations operating at 1900-2000 kHz must not cause harmful interference to the radiolocation service and are afforded no protection from radiolocation operations.

80 METERS



5167.5 kHz (SSB only): Alaska emergency use only.

40 METERS

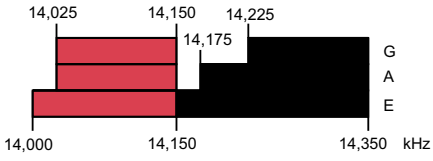


* Phone and Image modes are permitted between 7075 and 7100 kHz for FCC licensed stations in ITU Regions 1 and 3 and by FCC licensed stations in ITU Region 2 West of 130 degrees West longitude or South of 20 degrees North latitude. See Sections 97.305(c) and 97.307(f)(11). Novice and Technician Plus licensees outside ITU Region 2 may use CW only between 7050 and 7075 kHz. See Section 97.301(e). These exemptions do not apply to stations in the continental US.

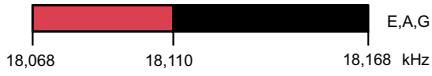
30 METERS

Maximum power on 30 meters is 200 watts PEP output. Amateurs must avoid interference to the fixed service outside the US.

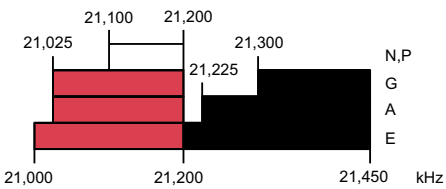
20 METERS



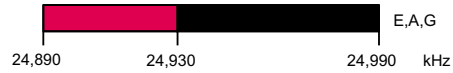
17 METERS



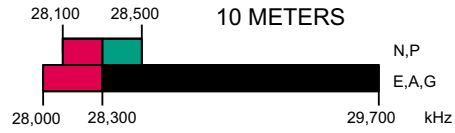
15 METERS



12 METERS

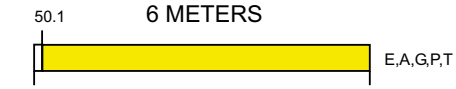


10 METERS

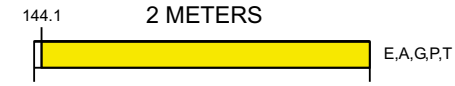


Novices and Technician Plus Licensees are limited to 200 watts PEP output on 10 meters.

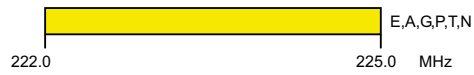
6 METERS



2 METERS

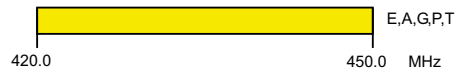


1.25 METERS



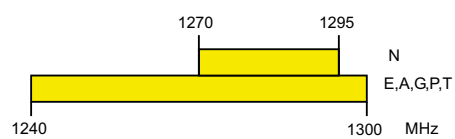
Novices are limited to 25 watts PEP output from 222 to 225 MHz.

70 CENTIMETERS **



33 CENTIMETERS **

23 CENTIMETERS **



Novices are limited to 5 watts PEP output from 1270 to 1295 MHz.

US AMATEUR POWER LIMITS

At all times, transmitter power should be kept down to that necessary to carry out the desired communications. Power is rated in watts PEP output. Unless otherwise stated, the maximum power output is 1500 W. Power for all license classes is limited to 200 W in the 10,100-10,150 kHz band and in all Novice subbands below 28,100 kHz. Novices and Technicians are restricted to 200 W in the 28,100-28,500 kHz subbands. In addition, Novices are restricted to 25 W in the 222-225 MHz band and 5 W in the 1270-1295 MHz subband.

Operators with Technician class licenses and above may operate on all bands above 50 MHz. For more detailed information see *The FCC Rule Book*.

KEY

- = CW, RTTY and data
- = CW, RTTY, data, MCW, test, phone and image
- = CW, phone and image
- = CW and phone
- = CW, RTTY, data, phone, and image
- = CW only

N = NOVICE
T = TECHNICIAN
G = GENERAL
A = ADVANCED
E = EXTRA CLASS
P = TECHNICIAN PLUS

** Geographical and power restrictions apply to these bands. See The FCC Rule Book for more information about your area.

Above 23 Centimeters:

All licensees except Novices are authorized all modes on the following frequencies:
2300-2310 MHz
2390-2450 MHz
3300-3500 MHz
5650-5925 MHz
10.0-10.5 GHz
24.0-24.25 GHz
47.0-47.2 GHz
75.5-81.0 GHz
119.98-120.02 GHz
142-149 GHz
241-250 GHz
All above 300 GHz

For band plans and sharing arrangements, see *The ARRL Operating Manual* or *The FCC Rule Book*.

VHF/UHF/EHF Calling Frequencies

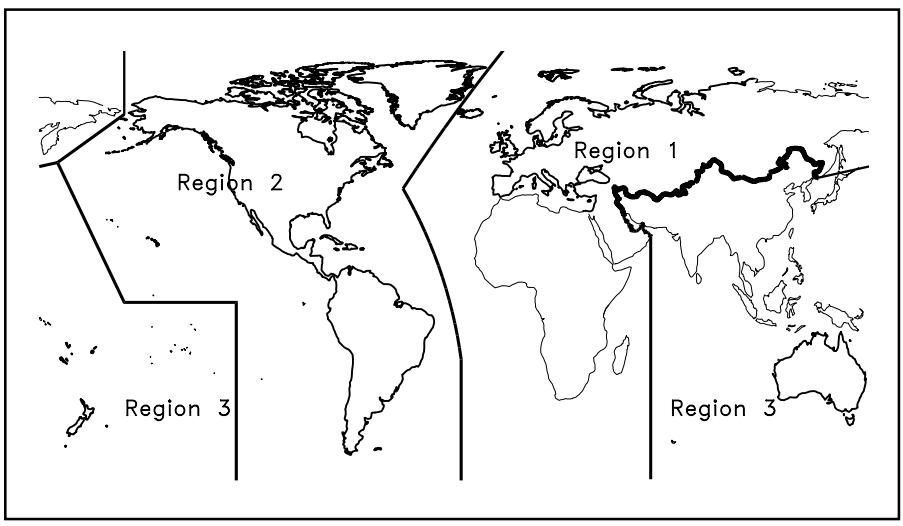
Band (MHz)	*Calling Frequency*
50	50.125 SSB 50.620 digital (packet) 52.525 National FM simplex frequency
144	144.010 EME 144.100, 144.110 CW 144.200 SSB 146.520 National FM simplex frequency
222	222.100 CW/SSB 223.500 National FM simplex frequency
432	432.010 EME 432.100 CW/SSB 446.000 National FM simplex frequency
902	902.100 CW/SSB 903.1 Alternate CW, SSB 906.500 National FM simplex frequency
1296	1294.500 National FM simplex frequency 1296.100 CW/SSB
2304	2304.4 2305.2 FM simplex frequency
10000	10368.1 Narrow-band

VHF/UHF Activity Nights

Some areas do not have enough VHF/UHF activity to support contacts at all times. This schedule is intended to help VHF/UHF operators make contact. This is only a starting point; check with others in your area to see if local hams have a different schedule.

Band (MHz)	*Day*	*Local Time*
50	Sunday	6 PM
144	Monday	7 PM
222	Tuesday	8 PM
432	Wednesday	9 PM
902	Friday	9 PM
1296	Thursday	10 PM

ITU Regions



The International Telecommunication Union divides the world into three regions. Geographic details appear in *The FCC Rule Book.*

Allocation of International Call Signs

Call Sign Series	Allocated to
AAA-ALZ	United States of America
AMA-AOZ	Spain
APA-ASZ	Pakistan
ATA-AWZ	India
AXA-AXZ	Australia
AYA-AZZ	Argentina
A2A-A2Z	Botswana
A3A-A3Z	Tonga
A4A-A4Z	Oman
A5A-A5Z	Bhutan
A6A-A6Z	United Arab Emirates
A7A-A7Z	Qatar
A8A-A8Z	Liberia
A9A-A9Z	Bahrain
BAA-BZZ	China
CAA-CEZ	Chile
CFA-CKZ	Canada
CLA-CMZ	Cuba
CNA-CNZ	Morocco
COA-COZ	Cuba
CPA-CPZ	Bolivia
CQA-CUZ	Portugal
CVA-CXZ	Uruguay
CYA-CZZ	Canada
C2A-C2Z	Nauru
C3A-C3Z	Andorra
C4A-C4Z	Cyprus
C5A-C5Z	Gambia
C6A-C6Z	Bahamas
* C7A-C7Z	World Meteorological Organization
C8A-C9Z	Mozambique
DAA-DRZ	Germany
DSA-DTZ	South Korea
DUA-DZZ	Philippines
D2A-D3Z	Angola
D4A-D4Z	Cape Verde
D5A-D5Z	Liberia
D6A-D6Z	Comoros
D7A-D9Z	South Korea
EAA-EHZ	Spain
EIA-EJZ	Ireland
EKA-EKZ	Armenia
ELA-ELZ	Liberia
EMA-EOZ	Ukraine
EPA-EQZ	Iran
ERA-ERZ	Moldova
ESA-ESZ	Estonia
ETA-ETZ	Ethiopia
EUA-EWZ	Belarus
EXA-EXZ	Kyrgyzstan
EYA-EYZ	Tajikistan
EZA-EZZ	Turkmenistan
E2A-E2Z	Thailand
E3A-E3Z	Eritrea
† E4A-E4Z	Palestinian Authority
FAA-FZZ	France
GAA-GZZ	United Kingdom of Great Britain and Northern Ireland
HAA-HAZ	Hungary
HBA-HBZ	Switzerland
HCA-HDZ	Ecuador
HEA-HEZ	Switzerland
HFA-HFZ	Poland
HGA-HGZ	Hungary
HHA-HHZ	Haiti
HIA-HIZ	Dominican Republic
HJA-HKZ	Colombia
HLA-HLZ	South Korea
HMA-HMZ	North Korea
HNA-HNZ	Iraq
HOA-HPZ	Panama
HQA-HRZ	Honduras
HSA-HSZ	Thailand
HTA-HTZ	Nicaragua
HUA-HUZ	El Salvador
HVA-HVZ	Vatican City
HWA-HYZ	France
HZA-HZZ	Saudi Arabia
H2A-H2Z	Cyprus
H3A-H3Z	Panama
H4A-H4Z	Solomon Islands
H6A-H7Z	Nicaragua
H8A-H9Z	Panama
IAA-IZZ	Italy
JAA-JSZ	Japan
JTA-JVZ	Mongolia
JWA-JXZ	Norway
JYA-JYZ	Jordan
JZA-JZZ	Indonesia
J2A-J2Z	Djibouti
J3A-J3Z	Grenada
J4A-J4Z	Greece
J5A-J5Z	Guinea-Bissau
J6A-J6Z	Saint Lucia
J7A-J7Z	Dominica
J8A-J8Z	St. Vincent and the Grenadines
KAA-KZZ	United States of America
LAA-LNZ	Norway
LOA-LWZ	Argentina
LXA-LXZ	Luxembourg
LYA-LYZ	Lithuania
LZA-LZZ	Bulgaria
L2A-L9Z	Argentina
MAA-MZZ	United Kingdom of Great Britain and Northern Ireland
NAA-NZZ	United States of America
OAA-OCZ	Peru
ODA-ODZ	Lebanon
OEA-OEZ	Austria
OFA-OJZ	Finland
OKA-OLZ	Czech Republic
OMA-OMZ	Slovak Republic
ONA-OTZ	Belgium
OUA-OZZ	Denmark
PAA-PIZ	Netherlands
PJA-PJZ	Netherlands Antilles
PKA-POZ	Indonesia
PPA-PYZ	Brazil
PZA-PZZ	Suriname
P2A-P2Z	Papua New Guinea
P3A-P3Z	Cyprus
P4A-P4Z	Aruba
P5A-P9Z	North Korea
RAA-RZZ	Russian Federation
SAA-SMZ	Sweden
SNA-SRZ	Poland
• SSA-SSM	Egypt
• SSN-SSZ	Sudan
STA-STZ	Sudan
SUA-SUZ	Egypt
SVA-SZZ	Greece
S2A-S3Z	Bangladesh
S5A-S5Z	Slovenia
S6A-S6Z	Singapore
S7A-S7Z	Seychelles
S8A-S8Z	South Africa
S9A-S9Z	Sao Tome and Principe
TAA-TCZ	Turkey
TDA-TDZ	Guatemala
TEA-TEZ	Costa Rica
TFA-TFZ	Iceland
TGA-TGZ	Guatemala
THA-THZ	France
TIA-TIZ	Costa Rica
TJA-TJZ	Cameroon
TKA-TKZ	France
TLA-TLZ	Central African Republic
TMA-TMZ	France
TNA-TNZ	Congo Republic
TOA-TQZ	France
TRA-TRZ	Gabon
TSA-TSZ	Tunisia
TTA-TTZ	Chad
TUA-TUZ	Ivory Coast
TVA-TXZ	France
TYA-TYZ	Benin
TZA-TZZ	Mali
T2A-T2Z	Tuvalu
T3A-T3Z	Kiribati
T4A-T4Z	Cuba
T5A-T5Z	Somalia
T6A-T6Z	Afghanistan
T7A-T7Z	San Marino

Continued on next page.

Allocation of International Call Signs

Continued from previous page.

Call Sign Series	Allocated to
T8A-T8Z	Palau
T9A-T9Z	Bosnia and Herzegovina
UAA-UIZ	Russian Federation
UJA-UMZ	Uzbekistan
UNA-UQZ	Kazakhstan
URA-UZZ	Ukraine
VAA-VGZ	Canada
VHA-VNZ	Australia
VOA-VOZ	Canada
VPA-VQZ	United Kingdom of Great Britain and Northern Ireland
† VRA-VRZ	China—Hong Kong
VSA-VSZ	United Kingdom of Great Britain and Northern Ireland
VTA-VWZ	India
VXA-VYZ	Canada
VZA-VZZ	Australia
V2A-V2Z	Antigua and Barbuda
V3A-V3Z	Belize
V4A-V4Z	Saint Kitts and Nevis
V5A-V5Z	Namibia
V6A-V6Z	Micronesia
V7A-V7Z	Marshall Islands
V8A-V8Z	Brunei
WAA-WZZ	United States of America
XAA-XIZ	Mexico
XJA-XOZ	Canada
XPA-XPZ	Denmark
XQA-XRZ	Chile
XSA-XSZ	China
XTA-XTZ	Burkina Faso
XUA-XUZ	Cambodia
XVA-XVZ	Viet Nam
XWA-XWZ	Laos
XXA-XXZ	Portugal
XYA-XZZ	Myanmar
YAA-YAZ	Afghanistan
YBA-YHZ	Indonesia
YIA-YIZ	Iraq
YJA-YJZ	Vanuatu
YKA-YKZ	Syria
YLA-YLZ	Latvia
YMA-YMZ	Turkey
YNA-YNZ	Nicaragua
YOA-YRZ	Romania
YSA-YSZ	El Salvador
YTA-YUZ	Yugoslavia
YVA-YYZ	Venezuela
YZA-YZZ	Yugoslavia
Y2A-Y9Z	Germany
ZAA-ZAZ	Albania
ZBA-ZJZ	United Kingdom of Great Britain and Northern Ireland
ZKA-ZMZ	New Zealand
ZNA-ZOZ	United Kingdom of Great Britain and Northern Ireland
ZPA-ZPZ	Paraguay
ZQA-ZQZ	United Kingdom of Great Britain and Northern Ireland
ZRA-ZUZ	South Africa
ZVA-ZZZ	Brazil
Z2A-Z2Z	Zimbabwe
Z3A-Z3Z	Macedonia (Former Yugoslav Republic)
2AA-2ZZ	United Kingdom of Great Britain and Northern Ireland
3AA-3AZ	Monaco
3BA-3BZ	Mauritius
3CA-3CZ	Equatorial Guinea
• 3DA-3DM	Swaziland
• 3DN-3DZ	Fiji
3EA-3FZ	Panama
3GA-3GZ	Chile
3HA-3UZ	China
3VA-3VZ	Tunesia
3WA-3WZ	Viet Nam
3XA-3XZ	Guinea
3YA-3YZ	Norway
3ZA-3ZZ	Poland
4AA-4CZ	Mexico
4DA-4IZ	Philippines
4JA-4KZ	Azerbaijan
4LA-4LZ	Georgia
4MA-4MZ	Venezuela
4NA-4OZ	Yugoslavia
4PA-4SZ	Sri Lanka
4TA-4TZ	Peru
* 4UA-4UZ	United Nations
4VA-4VZ	Haiti
4XA-4XZ	Israel
* 4YA-4YZ	International Civil Aviation Organization
4ZA-4ZZ	Israel
5AA-5AZ	Libya
5BA-5BZ	Cyprus
5CA-5GZ	Morocco
5HA-5IZ	Tanzania
5JA-5KZ	Colombia
5LA-5MZ	Liberia
5NA-5OZ	Nigeria
5PA-5QZ	Denmark
5RA-5SZ	Madagascar
5TA-5TZ	Mauritania
5UA-5UZ	Niger
5VA-5VZ	Togo
5WA-5WZ	Western Samoa
5XA-5XZ	Uganda
5YA-5ZZ	Kenya
6AA-6BZ	Egypt
6CA-6CZ	Syria
6DA-6JZ	Mexico
6KA-6NZ	South Korea
6OA-6OZ	Somalia
6PA-6SZ	Pakistan
6TA-6UZ	Sudan
6VA-6WZ	Senegal
6XA-6XZ	Madagascar
6YA-6YZ	Jamaica
6ZA-6ZZ	Liberia
7AA-7IZ	Indonesia
7JA-7NZ	Japan
7OA-7OZ	Yemen
7PA-7PZ	Lesotho
7QA-7QZ	Malawi
7RA-7RZ	Algeria
7SA-7SZ	Sweden
7TA-7YZ	Algeria
7ZA-7ZZ	Saudi Arabia
8AA-8IZ	Indonesia
8JA-8NZ	Japan
8OA-8OZ	Botswana
8PA-8PZ	Barbados
8QA-8QZ	Maldives
8RA-8RZ	Guyana
8SA-8SZ	Sweden
8TA-8YZ	India
8ZA-8ZZ	Saudi Arabia
9AA-9AZ	Croatia
9BA-9DZ	Iran
9EA-9FZ	Ethiopia
9GA-9GZ	Ghana
9HA-9HZ	Malta
9IA-9JZ	Zambia
9KA-9KZ	Kuwait
9LA-9LZ	Sierra Leone
9MA-9MZ	Malaysia
9NA-9NZ	Nepal
9OA-9TZ	Democratic Republic of Congo
9UA-9UZ	Burundi
9VA-9VZ	Singapore
9WA-9WZ	Malaysia
9XA-9XZ	Rwanda
9YZ-9ZZ	Trinidad and Tobago

Notes:

- • Half series
- * Series allocated to an international organization
- † Provisional allocation in accordance with S19.33

FCC-Allocated Prefixes for Areas Outside the Continental US

Prefix	*Location*
AH1, KH1, NH1, WH1	Baker, Howland Is
AH2, KH2, NH2, WH2	Guam
AH3, KH3, NH3, WH3	Johnston I
AH4, KH4, NH4, WH4	Midway I
AH5K, KH5K, NH5K, WH5K	Kingman Reef
AH5, KH5, NH5, WH5 (except K suffix)	Palmyra, Jarvis Is
AH6-7, KH6-7, NH6-7, WH6-7	Hawaii
AH7K, KH7K, NH7K, WH7K	Kure I
AH8, KH8, NH8, WH8	American Samoa
AH9, KH9, NH9, WH9	Wake, Wilkes, Peale Is
AHØ, KHØ, NHØ, WHØ	Northern Mariana Is
AL, KL, NL, WL	Alaska
KP1, NP1, WP1	Navassa
KP2, NP2, WP2	Virgin Is
KP3-4, NP3-4, WP3-4	Puerto Rico
KP5, NP5, WP5	Desecheo

DX Operating Code

For W/VE Amateurs

Some DXers have caused considerable confusion and interference in their efforts to work DX stations. The points below, if observed by all W/VE amateurs, will help make DX more enjoyable for all.

1) *Call* DX only after he calls CQ, QRZ? or signs $\overline{\text{SK}}$, or voice equivalents thereof. Make your calls short.

2) Do not call a DX station:

a) On the frequency of the station he is calling until you are sure the QSO is over ($\overline{\text{SK}}$).

b) Because you hear someone else calling him.

c) When he signs $\overline{\text{KN}}$, $\overline{\text{AR}}$ or CL.

d) Exactly on his frequency.

e) After he calls a directional CQ, unless of course you are in the right direction or area.

3) Keep within frequency band limits. Some DX stations can get away with working outside, but you cannot.

4) Observe calling instructions given by DX stations. Example: 15U means "call 15 kHz up from my frequency." 15D means down, etc.

5) Give honest reports. Many DX stations depend on W/VE reports for adjustment of station and equipment.

6) Keep your signal clean. Key clicks, ripple, feedback or splatter gives you a bad reputation and may get you a citation from the FCC.

7) *Listen* and call the station you want. Calling CQ DX is not the best assurance that the rare DX will reply.

8) When there are several W or VE stations waiting, avoid asking DX to "listen for a friend." Also avoid engaging him in a ragchew against his wishes.

For Overseas Amateurs

To all overseas amateur stations:

In their eagerness to work you, many W and VE amateurs resort to practices that cause confusion and QRM. Most of this is good-intentioned but ill-advised; some of it is intentional and selfish. The key to the cessation of unethical DX operating practices is in your hands. We believe that your adoption of certain operating habits will increase your enjoyment of Amateur Radio and that of amateurs on this side who are eager to work you. We recommend your adoption of the following principles:

1) Do not answer calls on your own frequency.

2) Answer calls from W/VE stations only when their signals are of good quality.

3) Refuse to answer calls from other stations when you are already in contact with someone, and do not acknowledge calls from amateurs who indicate they wish to be "next."

4) Give *everybody* a break. When many W/VE amateurs are patiently and quietly waiting to work you, avoid complying with requests to "listen for a friend."

5) Tell listeners where to call you by indicating how many kilohertz up (U) or down (D) from your frequency you are listening.

6) Use the ARRL-recommended ending signals, especially $\overline{\text{KN}}$ to indicate to impatient listeners the status of the QSO. $\overline{\text{KN}}$ means "Go ahead (specific station); all others keep out."

7) Let it be known that you avoid working amateurs who are constant violators of these principles.

W1AW's schedule is at the same local time throughout the year. The schedule according to your local time will change if your local time does not have seasonal adjustments that are made at the same time as North American time changes between standard time and daylight time. From the first Sunday in April to the last Sunday in October, UTC = Eastern Time + 4 hours. For the rest of the year, UTC = Eastern Time + 5 hours.

W1AW SCHEDULE

Pacific	Mtn	Cent	East	Mon	Tue	Wed	Thu	Fri
6 AM	7 AM	8 AM	9 AM		Fast Code	Slow Code	Fast Code	Slow Code
7 AM-1 PM	8 AM-2 PM	9 AM-3 PM	10 AM-4 PM	Visiting Operator Time (12 PM - 1 PM closed for lunch)				
1 PM	2 PM	3 PM	4 PM	Fast Code	Slow Code	Fast Code	Slow Code	Fast Code
2 PM	3 PM	4 PM	5 PM	Code Bulletin				
3 PM	4 PM	5 PM	6 PM	Teleprinter Bulletin				
4 PM	5 PM	6 PM	7 PM	Slow Code	Fast Code	Slow Code	Fast Code	Slow Code
5 PM	6 PM	7 PM	8 PM	Code Bulletin				
6 PM	7 PM	8 PM	9 PM	Teleprinter Bulletin				
6:45 PM	7:45 PM	8:45 PM	9:45 PM	Voice Bulletin				
7 PM	8 PM	9 PM	10 PM	Fast Code	Slow Code	Fast Code	Slow Code	Fast Code
8 PM	9 PM	10 PM	11 PM	Code Bulletin				

Morse code transmissions:

Frequencies are 1.818, 3.5815, 7.0475, 14.0475, 18.0975, 21.0675, 28.0675 and 147.555 MHz.

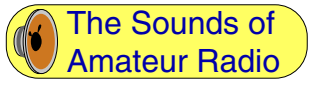
Slow Code = practice sent at 5, $7^1/_2$, 10, 13 and 15 wpm.

Fast Code = practice sent at 35, 30, 25, 20, 15, 13 and 10 wpm.

Code practice text is from the pages of *QST*. The source is given at the beginning of each practice session and alternate speeds within each session. For example, "Text is from July 1992 *QST*, pages 9 and 81," indicates that the plain text is from the article on page 9 and mixed number/letter groups are from page 81.

Code bulletins are sent at 18 wpm.

W1AW qualifying runs are sent on the same frequencies as the Morse code transmissions. West Coast qualifying runs are transmitted on approximately 3.590 MHz by W6OWP, with K6YR as an alternate. At the beginning of each code practice session, the schedule for the next qualifying run is presented. Underline one minute of the highest speed you copied, certify that your copy was made without aid, and send it to ARRL for grading. Please include your name, call sign (if any) and complete mailing address. Send a 9 × 12-inch SASE for a certificate, or a business-size SASE for an endorsement.



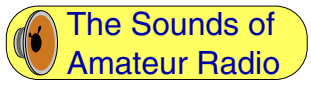
Here's a short excerpt from a slow-speed Morse Code-practice transmission.

Teleprinter transmissions:

Frequencies are 3.625, 7.095, 14.095, 18.1025, 21.095, 28.095 and 147.555 MHz.

Bulletins are sent at 45.45-baud Baudot and 100-baud AMTOR, FEC Mode B. 110-baud ASCII will be sent only as time allows.

On Tuesdays and Fridays at 6:30 PM Eastern Time, Keplerian elements for many amateur satellites are sent on the regular teleprinter frequencies.



Listen to a Baudot RTTY transmission from W1AW.

Voice transmissions:

Frequencies are 1.855, 3.99, 7.29, 14.29, 18.16, 21.39, 28.59 and 147.555 MHz.

Miscellanea:

On Fridays, UTC, a DX bulletin replaces the regular bulletins.

W1AW is open to visitors from 10 AM until noon and from 1 PM until 3:45 PM on Monday through Friday. FCC licensed amateurs may operate the station during that time. Be sure to bring your current FCC amateur license or a photocopy.

In a communication emergency, monitor W1AW for special bulletins as follows: voice on the hour, teleprinter at 15 minutes past the hour, and CW on the half hour.

Headquarters and W1AW are closed on New Year's Day, President's Day, Good Friday, Memorial Day, Independence Day, Labor Day, Thanksgiving and the following Friday, and Christmas Day.

ARRL Procedural Signals (Prosigns)

In general, the CW prosigns are used on all data modes as well, although word abbreviations may be spelled out. That is, "CLEAR" might be used rather than "CL" on radioteletype. Additional radioteletype conventions appear at the end of the table.

Situation	*CW*	*Voice*
check for a clear frequency	QRL?	Is the frequency in use?
seek contact with any station	CQ	CQ
after a call to a specific named station or to indicate the end of a message	AR	over, end of message
invite any station to transmit	K	go
invite a specific named station to transmit	KN	go only
invite receiving station to transmit	BK	back to you
all received correctly	R	received
please stand by	AS	wait, stand by
end of contact (sent before call sign)	SK	clear
going off the air	CL	closing station

Additional RTTY prosigns

SK QRZ—Ending contact, but listening on frequency.
SK KN—Ending contact, but listening for one last transmission from the other station.
SK SZ—Signing off and listening on the frequency for any other calls.

The RST System

Readability

1—Unreadable.
2—Barely readable, occasional words distinguishable.
3—Readable with considerable difficulty.
4—Readable with practically no difficulty.
5—Perfectly readable.

Signal Strength

1—Faint signals, barely perceptible.
2—Very weak signals.
3—Weak signals.
4—Fair signals.
5—Fairly good signals.
6—Good signals.
7—Moderately strong signals.
8—Strong signals.
9—Extremely strong signals.

Tone

1—Sixty-cycle ac or less, very rough and broad.
2—Very rough ac, very harsh and broad.
3—Rough ac tone, rectified but not filtered.
4—Rough note, some trace of filtering.
5—Filtered rectified ac but strongly ripple-modulated.
6—Filtered tone, definite trace of ripple modulation.
7—Near pure tone, trace of ripple modulation.
8—Near perfect tone, slight trace of modulation.
9—Perfect tone, no trace of ripple of modulation of any kind.

If the signal has the characteristic steadiness of crystal control, add the letter X to the RST report. If there is a chirp, add the letter C. Similarly for a click, add K. (See FCC Regulations §97.307, Emissions Standards.) The above reporting system is used on both CW and voice; leave out the "tone" report on voice.

Q Signals

These Q signals most often need to be expressed with brevity and clarity in amateur work. (Q abbreviations take the form of questions only when each is sent followed by a question mark.)

QRA What is the name of your station? The name of your station is _____.

QRG Will you tell me my exact frequency (or that of _____)?
Your exact frequency (or that of _____) is _____ kHz.

QRH Does my frequency vary? Your frequency varies.

QRI How is the tone of my transmission? The tone of your transmission is _____ (1. Good; 2. Variable; 3. Bad).

QRJ Are you receiving me badly? I cannot receive you. Your signals are too weak.

QRK What is the intelligibility of my signals (or those of _____)? The intelligibility of your signals (or those of _____) is _____ (1. Bad; 2. Poor; 3. Fair; 4. Good; 5. Excellent).

QRL Are you busy? I am busy (or I am busy with _____). Please do not interfere.

QRM Is my transmission being interfered with? Your transmission is being interfered with (1. Nil; 2. Slightly; 3. Moderately; 4. Severely; 5. Extremely.)

QRN Are you troubled by static? I am troubled by static _____ (1-5 as under QRM).

QRO Shall I increase power? Increase power.

QRP Shall I decrease power? Decrease power.

QRQ Shall I send faster? Send faster (_____ WPM).

QRS Shall I send more slowly? Send more slowly (_____ WPM).

QRT Shall I stop sending? Stop sending.

QRU Have you anything for me? I have nothing for you.

QRV Are you ready? I am ready.

QRW Shall I inform _____ that you are calling on _____ kHz? Please inform _____ that I am calling on _____ kHz.

QRX When will you call me again? I will call you again at _____ hours (on _____ kHz).

QRY What is my turn? Your turn is numbered _____

QRZ Who is calling me? You are being called by _____ (on _____ kHz).

QSA What is the strength of my signals (or those of ____)?
The strength of your signals (or those of _____) is _____ (1. Scarcely perceptible; 2. Weak; 3. Fairly good; 4. Good; 5. Very good).

QSB Are my signals fading? Your signals are fading.

QSD Is my keying defective? Your keying is defective.

QSG Shall I send _____ messages at a time? Send _____ messages at a time.

QSK Can you hear me between your signals and if so can I break in on your transmission? I can hear you between my signals; break in on my transmission.

QSL Can you acknowledge receipt? I am acknowledging receipt.

QSM Shall I repeat the last message which I sent you, or some previous message? Repeat the last message which you sent me [or message(s) number(s) _____].

QSN Did you hear me (or _____) on _____ kHz? I did hear you (or _____) on _____ kHz.

QSO Can you communicate with _____ direct or by relay? I can communicate with _____ direct (or by relay through _____).

QSP Will you relay to _____? I will relay to _____

QST General call preceding a message addressed to all amateurs and ARRL members. This is in effect "CQ ARRL."

QSU Shall I send or reply on this frequency (or on _____ kHz)? Send or reply on this frequency (or _____ kHz).

QSV Shall I send a series of Vs on this frequency (or on _____ kHz)? Send a series of Vs on this frequency (or on _____ kHz).

QSW Will you send on this frequency (or on _____ kHz)? I am going to send on this frequency (or on ____ kHz).

Continued on next page.

Q Signals

Continued from previous page.

QSX Will you listen to _____ on _____ kHz? I am listening to _____ on _____ kHz.
QSY Shall I change to transmission on another frequency? Change to transmission on another frequency (or on _____ kHz).
QSZ Shall I send each word or group more than once? Send each word or group twice (or _____ times).
QTA Shall I cancel message number _____? Cancel message number _____
QTB Do you agree with my counting of words? I do not agree with your counting of words. I will repeat the first letter or digit of each word or group.
QTC How many messages have you to send? I have _____ messages for you (or for _____).
QTH What is your location? My location is _____
QTR What is the correct time? The correct time is _____
QTV Shall I stand guard for you? Stand guard for me.
QTX Will you keep your station open for further communication with me? Keep your station open for me.
QUA Have you news of _____? I have news of _____.

ARRL QN Signals

QNA* Answer in prearranged order.
QNB Act as relay between _____ and _____.
QNC All net stations copy. I have a message for all net stations.
QND* Net is Directed (Controlled by net control station.)
QNE* Entire net stand by.
QNF Net is Free (not controlled).
QNG Take over as net control station
QNH Your net frequency is High.
QNI Net stations report in. I am reporting into the net. (Follow with a list of traffic or QRU.)
QNJ Can you copy me?
QNK* Transmit messages for _____ to _____.
QNL Your net frequency is Low.
QNM* You are QRMing the net. Stand by.
QNN Net control station is _____. What station has net control?
QNO Station is leaving the net.
QNP Unable to copy you. Unable to copy _____.
QNQ* Move frequency to _____ and wait for _____ to finish handling traffic. Then send him traffic for _____.
QNR* Answer _____ and Receive traffic.
QNS Following Stations are in the net.* (follow with list.) Request list of stations in the net.
QNT I request permission to leave the net for _____ minutes.
QNU* The net has traffic for *you*. Stand by.
QNV* Establish contact with _____ on this frequency. If successful, move to _____ and send him traffic for _____.
QNW How do I route messages for _____?
QNX You are excused from the net.*
QNY* Shift to another frequency (or to _____ kHz) to clear traffic with _____.
QNZ Zero beat your signal with mine.

***For use only by the Net Control Station.**

Notes on Use of QN Signals

These QN signals are special ARRL signals for use in amateur CW nets *only*. They are not for use in casual amateur conversation. Other meanings that may be used in other services do not apply. Do not use QN signals on phone nets. *Say it with words*. QN signals need not be followed by a question mark, even though the meaning may be interrogatory.

CW Abbreviations

Although abbreviations help to cut down unnecessary transmission, make it a rule not to abbreviate unnecessarily when working an operator of unknown experience.

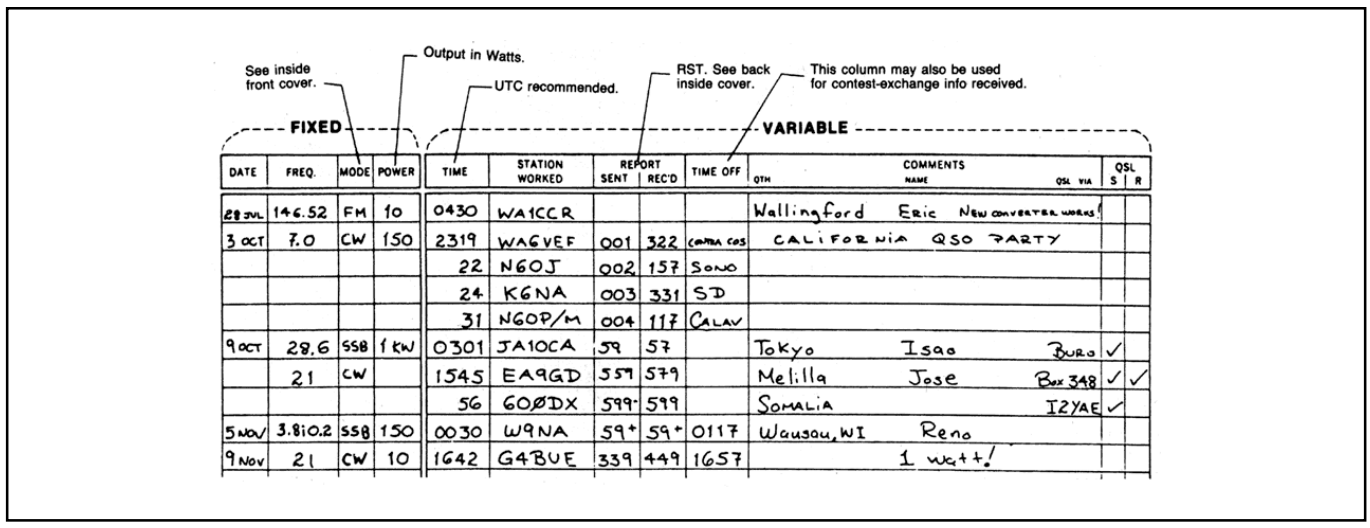
AA	All after
AB	All before
AB	About
ADR	Address
AGN	Again
ANT	Antenna
BCI	Broadcast interference
BCL	Broadcast listener
BK	Break; break me; break in
BN	All between; been
BUG	Semi-automatic key
B4	Before
C	Yes
CFM	Confirm; I confirm
CK	Check
CL	I am closing my station; call
CLD-CLG	Called; calling
CQ	Calling any station
CUD	Could
CUL	See you later
CW	Continuous wave (i.e., radiotelegraph)
DE	From
DLD-DLVD	Delivered
DR	Dear
DX	Distance, foreign countries
ES	And, &
FB	Fine business, excellent
FM	Frequency modulation
GA	Go ahead (or resume sending)
GB	Good-by
GBA	Give better address
GE	Good evening
GG	Going
GM	Good morning
GN	Good night
GND	Ground
GUD	Good
HI	The telegraphic laugh; high
HR	Here, hear
HV	Have
HW	How
LID	A poor operator
MA, MILS	Milliamperes
MSG	Message; prefix to radiogram
N	No
NCS	Net control station
ND	Nothing doing
NIL	Nothing; I have nothing for you
NM	No more
NR	Number
NW	Now; I resume transmission
OB	Old boy
OC	Old chap
OM	Old man
OP-OPR	Operator
OT	Old timer; old top
PBL	Preamble
PSE	Please
PWR	Power
PX	Press
R	Received as transmitted; are
RCD	Received
RCVR (RX)	Receiver
REF	Refer to; referring to; reference
RFI	Radio Frequency Interference
RIG	Station equipment
RPT	Repeat; I repeat; report
RTTY	Radioteletype
RX	Receiver
SASE	Self-addressed, stamped envelope
SED	Said
SIG	Signature; signal
SINE	Operator's personal initials or nickname
SKED	Schedule
SRI	Sorry
SSB	Single sideband
SVC	Service; prefix to service message
T	Zero
TFC	Traffic
TMW	Tomorrow
TNX-TKS	Thanks
TT	That
TU	Thank you
TVI	Television interference
TX	Transmitter
TXT	Text
UR-URS	Your; you're; yours
VFO	Variable-frequency oscillator
VY	Very
WA	Word after
WB	Word before
WD-WDS	Word; words
WKD-WKG	Worked; working
WL	Well; will
WUD	Would
WX	Weather
XCVR	Transceiver
XMTR (TX)	Transmitter
XTAL	Crystal
XYL (YF)	Wife
YL	Young lady
73	Best regards
88	Love and Kisses

ITU Recommended Phonetics

A — Alfa (**AL** FAH)
B — Bravo **(BRAH** VOH)
C — Charlie (**CHAR** LEE OR **SHAR** LEE)
D — Delta (**DELL** TAH)
E — Echo (**ECK** OH)
F — Foxtrot (**FOKS** TROT)
G — Golf (GOLF)
H — Hotel (HOH **TELL**)
I — India (**IN** DEE AH)
J — Juliet (**JEW** LEE ETT)
K — Kilo (**KEY** LOH)
L — Lima (**LEE** MAH)
M — Mike (MIKE)
N — November (NO **VEM** BER)
O — Oscar (**OSS** CAH)
P — Papa (PAH **PAH**)
Q — Quebec (KEH **BECK**)
R — Romeo (**ROW** ME OH)
S — Sierra (SEE *AIR* RAH)
T — Tango (**TANG** GO)
U — Uniform (**YOU** NEE FORM or **OO** NEE FORM)
V — Victor (**VIK** TAH)
W — Whiskey (**WISS** KEY)
X — X-Ray (**ECKS** RAY)
Y — Yankee (**YANG** KEY)
Z — Zulu (**ZOO** LOO)

Note: The **Boldfaced** syllables are emphasized. The pronunciations shown in the table were designed for speakers from all international languages. The pronunciations given for “Oscar” and “Victor” may seem awkward to English-speaking people in the U.S.

ARRL Log

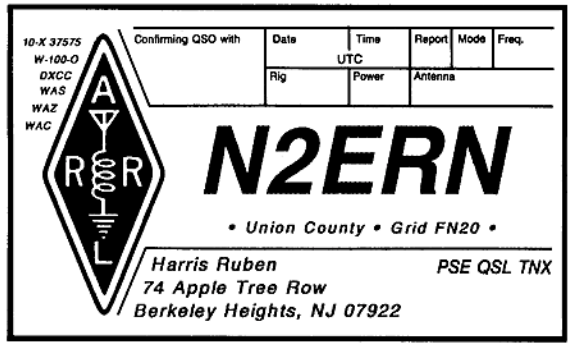


The ARRL Log is adaptable for all types of operating—ragchewing, contesting, DXing. References are to pages in the ARRL Log.

ARRL Operating Awards

Award	*Qualification*
Friendship Award	Contact 26 stations with calls ending A through Z.
Rag Chewer's Club	A single contact $^1/_2$ hour or longer
Worked All States (WAS)	QSLs from all 50 US states
Worked All Continents (WAC)	QSLs from all six continents
DX Century Club (DXCC)	QSLs from at least 100 different countries
VHF/UHF Century Club (VUCC)	QSLs from many grid squares
A-1 Operator Club	Recommendation by two A-1 operators
Code Proficiency	One minute of perfect copy from W1AW qualifying run
Old Timers Club	Held an Amateur Radio license at least 20 years prior
ARRL Membership	ARRL membership for 25, 40, 50, 60 or 70 years

ARRL Membership QSL Card



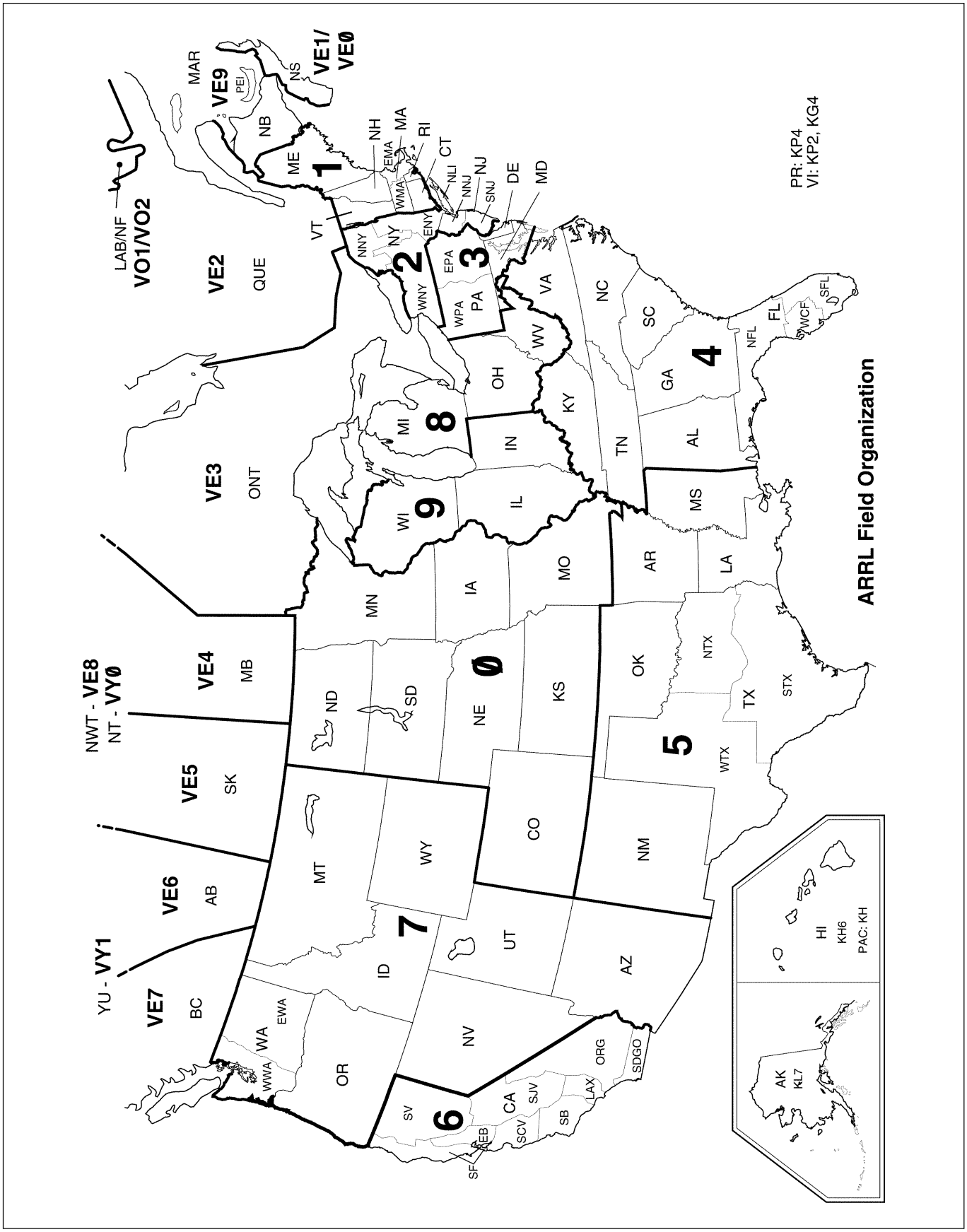
The ARRL membership QSL card. This example is from Harris Ruben, N2ERN, who designed the card. Your card would reflect your own call sign and address; awards and VUCC grid-square are optional. ARRL does not print or sell the cards. Inquire with printers who advertise in the *QST* Ham Ads.

Mode Abbreviations for QSL Cards

Abbreviation	*Explanation*
CW	Telegraphy
DATA	Telemetry, telecommand and computer communications (includes packet radio)
IMAGE	Facsimile and television
MCW	Tone-modulated telegraphy
PHONE	Speech and other sound
PULSE	Modulated main carrier
RTTY	Direct-printing telegraphy (includes AMTOR)
SS	Spread Spectrum
TEST	Emissions containing no information

Note: For additional information on emission types refer to latest edition of *The FCC Rule Book.*

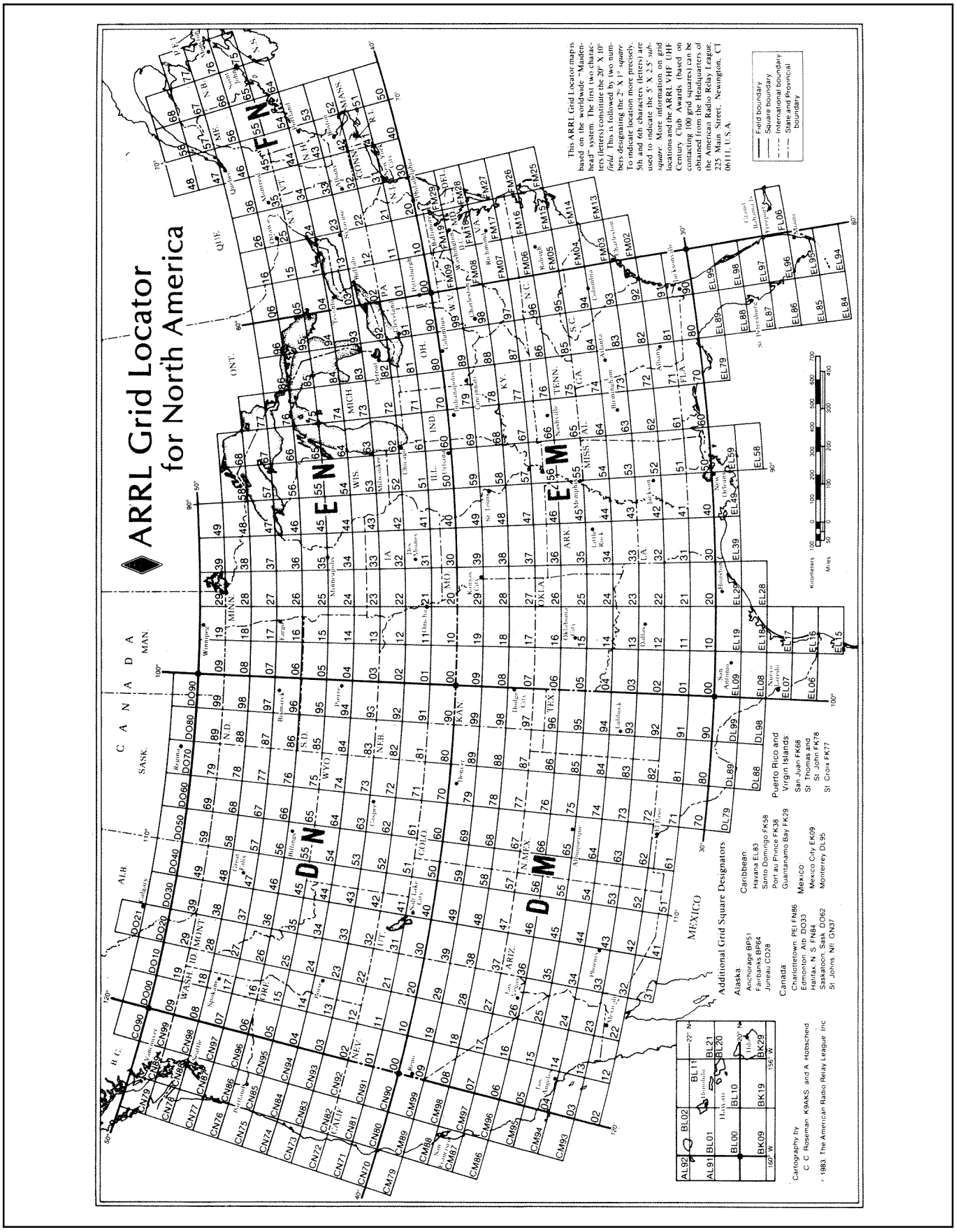
US/Canada Map



A map showing US states, Canadian provinces and ARRL/RAC Sections.

ARRL Grid Locator Map for North America

This and a World Grid Locator Map are available from ARRL.



Operating Aids for Public Service

ARRL HQ makes available the following free operating aids for public service communications:

Public Service Communications Manual	FSD-235
ARRL numbered radiograms	FSD-3
Sample emergency plan	FSD-27
ARES registration form	FSD-98
Amateur message form	FSD-218
Emergency Reference information	FSD-255
Field Organization Brochure	FSD-300

This entire Public Service Package can be obtained by sending a large (9 × 12-inch) envelope with First-Class postage for 6 ounces.

Principles of Emergency Communication

1) *Keep the QRM level down:* Remain silent unless called upon. There are only two reasons to check into an emergency net: (1) You have a bona fide emergency; (2) the Net Control Station (NCS) is requesting help that only you can provide.
2) *Monitor established emergency frequencies:* Many areas have established emergency frequencies that should be monitored for possible distress calls.
3) *Avoid spreading rumors:* Transmit only facts, not speculation. Do not repeat messages unless so authorized by the originator, and then only word for word.
4) *Authenticate all messages:* Any messages of an official nature should be written and signed.
5) *Strive for efficiency:* You are more effective as part of a team than as a lone individual.
6) *Select the mode and band to suit the need:* Advantages of several modes are listed below.
7) *Use all communications channels intelligently:* The object is to protect lives and property. Use emergency or normal communications channels where available.
8) *Don't broadcast:* Our job is to communicate for, not with, the general public. See §97.113 of *The FCC Rule Book* for details.

Advantages of Various Amateur Modes for Emergency Communications

CW

1) Less QRM in most amateur bands.
2) Privacy of communications (less easily understood by the public).
3) Simpler transmitting equipment.
4) Greater accuracy than voice in record communications.
5) Longer range for a given transmitter power level.

Voice

1) More practical for portable and mobile work.
2) More widespread availability of operators.
3) Faster communication for tactical or "command" purposes.
4) More readily appreciated and understood by the public.
5) Official-to-official and phone-patch communication.

Packet/AMTOR/PACTOR/CLOVER

1) Less QRM in most amateur bands.
2) Privacy of communications (less easily understood by the public).
3) More widespread availability of operators.
4) Greater speed and accuracy of record communication than any other modes.

ARES Personal Checklist

The following represents recommendations of equipment and supplies ARES members should consider having available for use during an emergency or public-service activity.

1) ARES Identification Card

2) FCC Amateur Radio License

3) Radio Gear
   - rig (2 meters)
   - microphone
   - headphones
   - power supply/extra batteries
   - antennas with mounts
   - spare fuses
   - patch cords/adapters (BNC to PL259/RCA phono to PL259)
   - SWR meter
   - extra coax

4) Writing Gear
   - pen/pencil/eraser
   - clipboard
   - message forms
   - logbook
   - note paper

5) Personal Gear (short duration)
   - snacks
   - liquid refreshments
   - throat lozenges
   - personal medicine
   - aspirin
   - extra pair of prescription glasses

6) Personal Gear (72-hour duration)
   - foul-weather gear
   - three-day supply of drinking water
   - cooler with three-day supply of food
   - mess kit with cleaning supplies
   - first-aid kit
   - personal medicine
   - aspirin
   - throat lozenges
   - sleeping bag
   - toilet articles
   - mechanical alarm clock
   - flashlight with batteries/lantern
   - candles
   - waterproof matches
   - extra pair of prescription glasses

7) Tool Box (72-hour duration)
   - screwdrivers
   - pliers
   - socket wrenches
   - electrical tape
   - 12/120-V soldering iron
   - solder
   - volt-ohm meter

8) Other (72-hour duration)
   - hatchet/ax
   - saw
   - pick
   - shovel
   - siphon
   - jumper cables
   - $^{3}/_{8}$-inch rope
   - highway flares
   - extra gasoline and oil

ARES/RACES

The Amateur Radio Emergency Service (ARES) and the Radio Amateur Civil Emergency Service (RACES) are the umbrella organizations of Amateur Radio public services. ARES is sponsored by ARRL (although ARRL membership is not required for participation) and handles all kinds of public-service activities. RACES is administered by the Federal Emergency Management Agency (FEMA) and operates only for civil preparedness and in times of civil emergency. RACES is activated at the request of a state or federal official.

The ARRL advocates dual membership and cooperative efforts between ARES and RACES whenever possible. RACES rules now make it possible for ARES and RACES to use the same frequencies, so that an ARES group also enrolled as RACES can "switch hats" from ARES to RACES and RACES to ARES as the situation develops. In many areas, however, the two organizations exist separately. Contact local ARRL Leadership Officials to determine the situation in your area.

ARES officials operate under the ARRL Section Manager. **Figs A and B** show the Section and the local ARES structures, respectively.

The Radio Amateur Civil Emergency Services (RACES) comprises certain Amateur Radio operators and stations that are registered with civil defense organizations or licensed as RACES stations by the FCC. RACES frequencies are normally shared with the Amateur Radio Service, but in times of civil emergency and for limited periods of testing and practice RACES operation is limited to the frequencies shown below. During times of official RACES operation, RACES stations may only contact other RACES stations and certain other stations as listed in §97.407(c). Official RACES operation does not allow radio contact with the general amateur population.

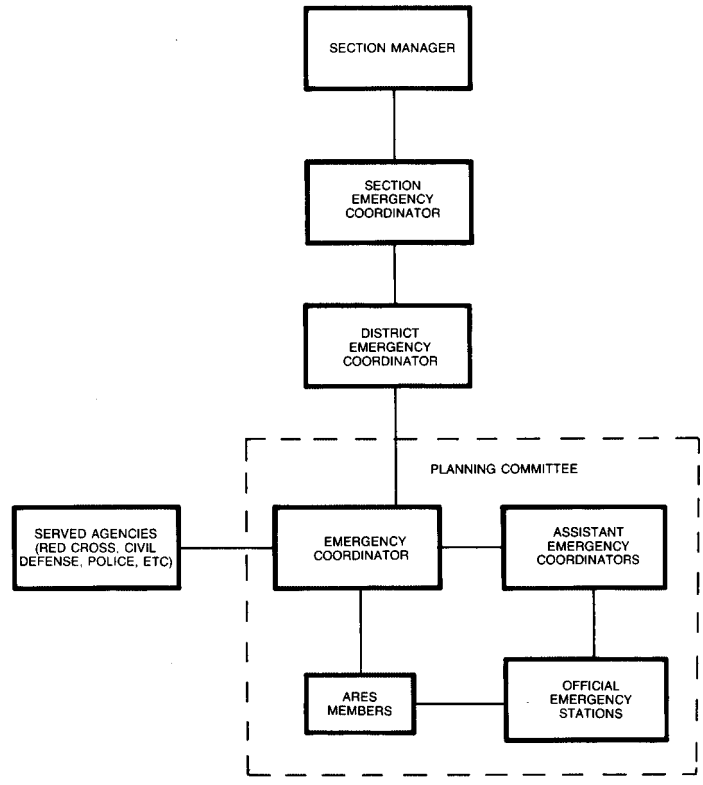


Fig A—Section-level ARES structure.

Dedicated RACES Operating Frequencies

RACES frequencies are shared with amateurs except in certain emergencies. See *The FCC Rule Book* (§97.407) for details on RACES operation.

kHz	*MHz*	*MHz*
1800-1825	10.100-10.150	50.350-50.750
1975-2000	14.047-14.053	52.000-54.000
3500-3550	14.220-14.230	144.50-145.71
3930-3980	14.331-14.350	146.00-148.00
3984-4000	21.047-21.053	222.00-225.00
7079-7125	21.228-21.267	420.00-450.00
7245-7255	28.550-28.750	1240.00-1300.00
	29.237-29.273	2390.00-2450.00
		29.450-29.650

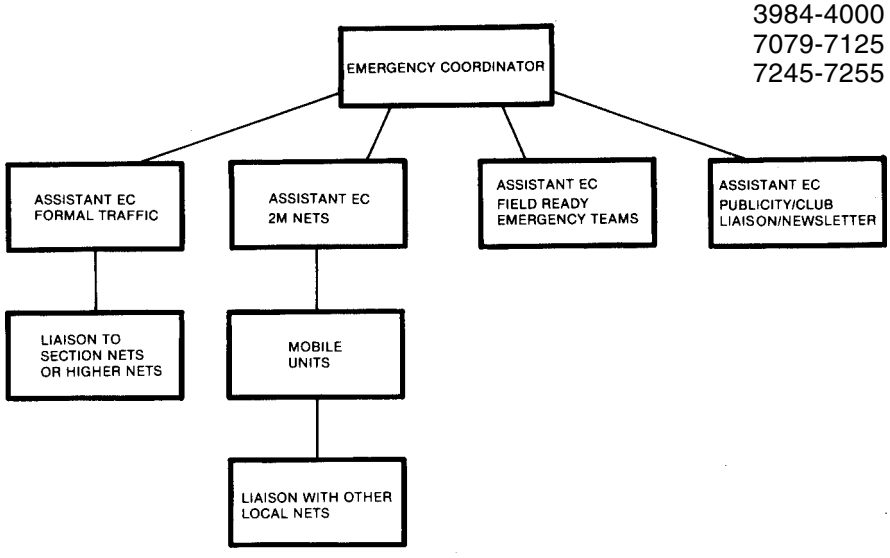
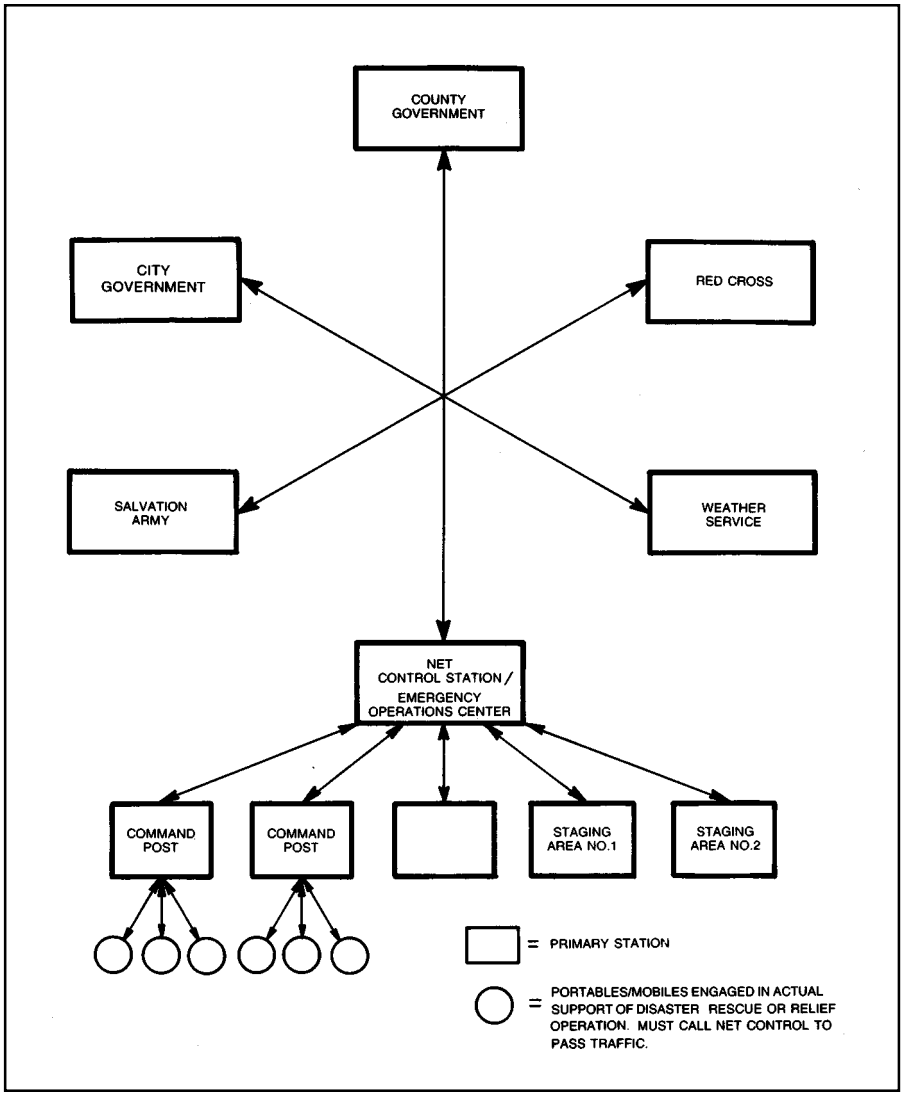
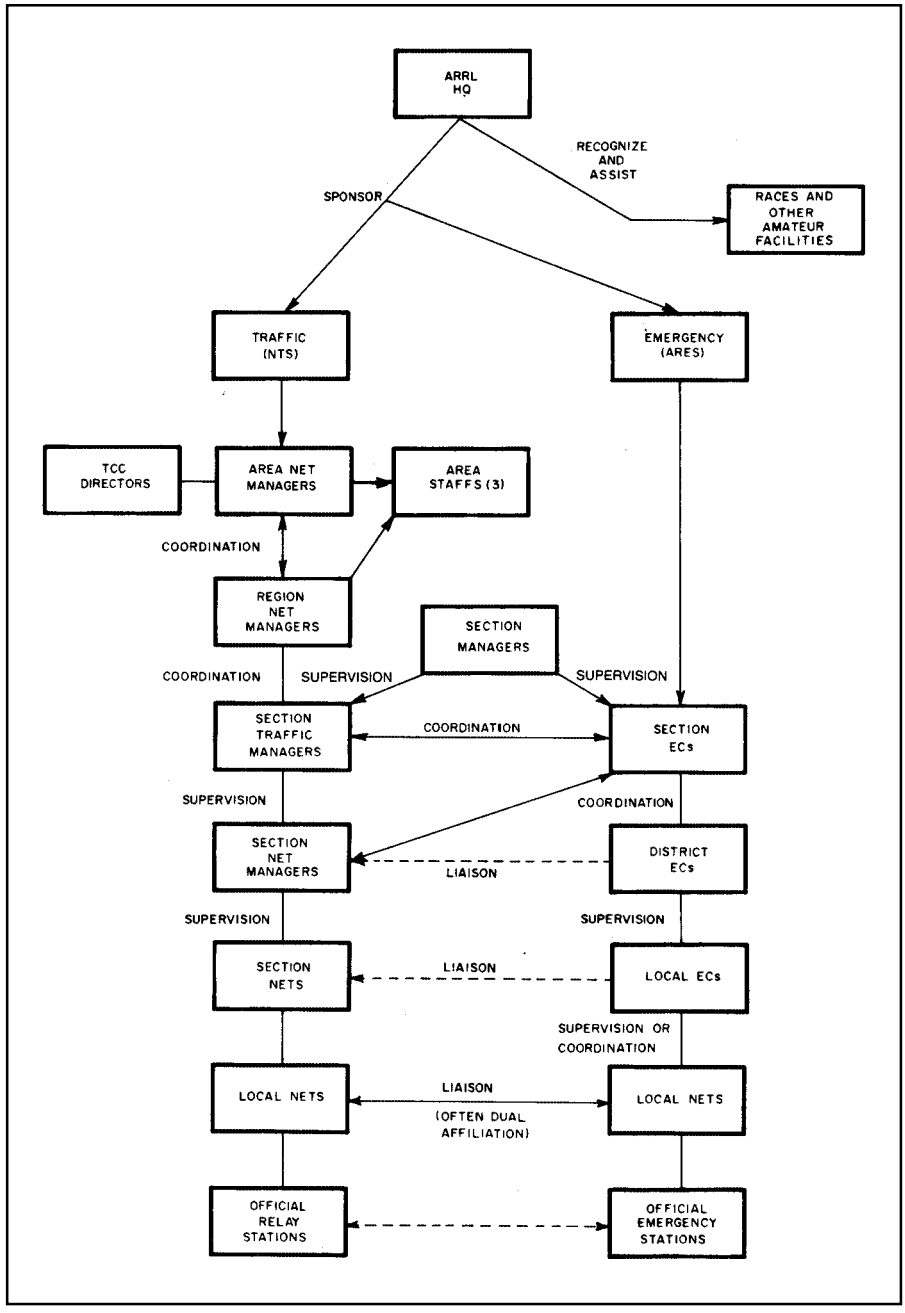


Fig B—Local ARES structure for a county, city or other area of coverage.

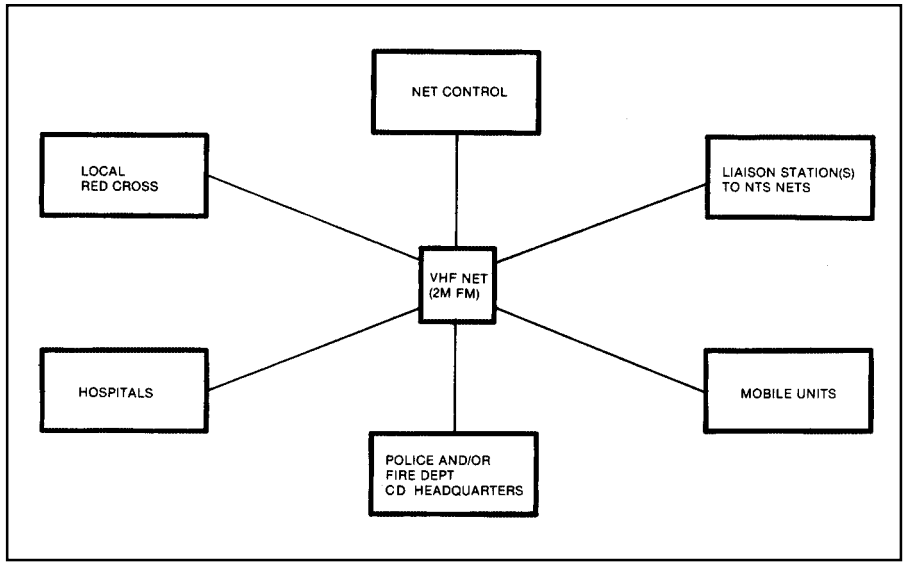
The Interaction Between the EOC/NCS and the Command Post(s) in a Local Emergency



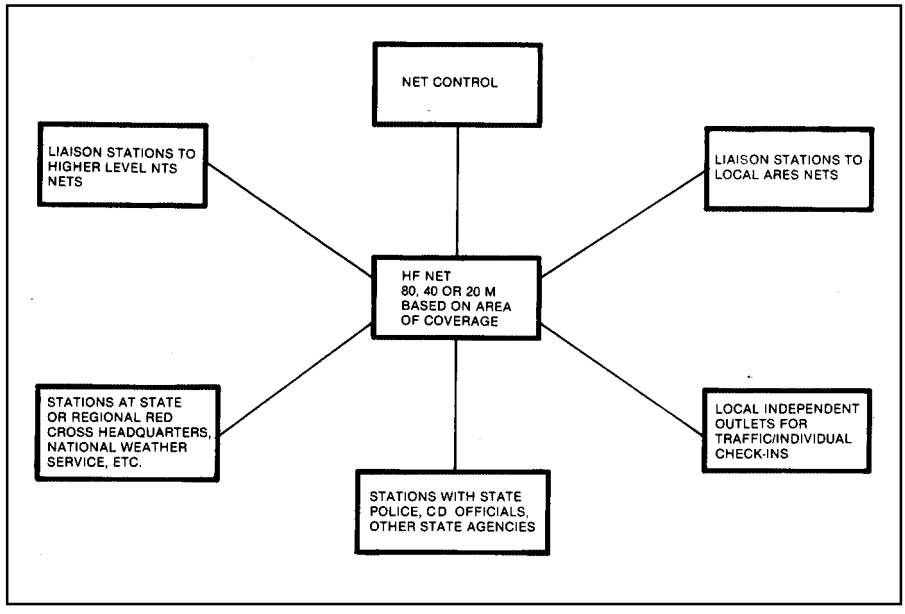
Organization and Interaction of ARES and NTS



Typical Station Deployment for Local ARES Net Coverage in an Emergency



Typical Structure of an HF Network for Emergency Communication



Amateur Message Form

Every formal radiogram message originated and handled should contain the following compnent parts in the order given.

I PREAMBLE
- *a.* Number (begin with 1 each month or year)
- *b.* Precedence (R, W, P or EMERGENCY)
- *c.* Handling Instructions (optional, see text)
- *d.* Station of Origin (first amateur handler)
- *e.* Check (number of words/groups in text only)
- *f.* Place of Origin (not necessarily location of station of origin)
- *g.* Time Filed (optional with originating station)
- *h.* Date (must agree with date of time filed)

II ADDRESS (as complete as possible, include zip code and telephone number)

III TEXT (limit to 25 words or less, if possible)

IV SIGNATURE

CW MESSAGE EXAMPLE

I NR 1 R HXG W1AW 8 NEWINGTON CONN 1830Z JULY 1
a b c d e f g h

II DONALD SMITH AA
164 EAST SIXTH AVE AA
NORTH RIVER CITY MO 00789 AA
733 4968 BT

III HAPPY BIRTHDAY X SEE YOU SOON X LOVE BT

IV DIANA AR

Note that X, when used in the text as punctuation, counts as a word.

CW: The prosign AA separates the parts of the address. BT separates the address from the text and the text from the signature. AR marks end of message; this is followed by B if there is another message to follow, by N if this is the only or last message. It is customary to copy the preamble, parts of the address, text and signature on separate lines.

RTTY: Same as cw procedure above, except (1) use extra space between parts of address, instead of AA; (2) omit cw procedure sign BT to separate text from address and signature, using line spaces instead; (3) add a CFM line under the signature, consisting of all names, numerals and unusual works in the message in the order transmitted.

PACKET/AMTOR BBS: Same format as shown in the cw message example above, except that the AA and AR prosigns may be omitted. Most amtor and packet BBS software in use today allows formal message traffic to be sent with the "ST" command. Always avoid the use of spectrum-wasting multiple line feeds and indentations.

PHONE: Use *prowords* instead of prosigns, but it is not necessary to name each part of the message as you send it. For example, the above message would be sent on phone as follows: "Number one routine HX Golf W1AW eight Newington Connecticut one eight three zero zulu July one Donald Smith *Figures* one six four East Sixth Avenue North River City Missouri zero zero seven eight nine *Telephone* seven three three four nine six eight *Break* Happy birthday X-ray see you soon X-ray love *Break* Diana *End of Message Over.* "End of Message" is followed by "More" if there is another message to follow, "No More" if it is the only or last message. Speak clearly using VOX (or pause frequently on push-to-talk) so that the receiving station can get fills. Spell phonetically all difficult or unusual words—do *not* spell out common words. Do not use cw abbreviations or Q-signals in phone traffic handling.

PRECEDENCES

The precedence will follow the message number. For example, on cw 207 R or 207 EMERGENCY. On phone, "Two Zero Seven, Routine (or Emergency)."

EMERGENCY—Any message having life and death urgency to any person or group of persons, which is transmitted by Amateur Radio in the absence of regular commercial facilities. This includes official messages of welfare agencies during emergencies requesting supplies, materials or instructions vital to relief of stricken populace in emergency areas. During normal times, it will be *very rare*. On cw, RTTY and other digital modes this designation will always be spelled out. When in doubt, *do not* use it.

PRIORITY—Important messages having a specific time limit. Official messages not covered in the Emergency category. Press dispatches and other emergency-related traffic not of the utmost urgency. Notification of death or injury in a disaster area, personal or official. Use the abbreviation P on cw.

WELFARE—A message that is either a) an inquiry as to the health and welfare of an individual in the disaster area b) an advisory or reply from the disaster area that indicates all is well should carry this precedence, which is abbreviated W on cw. These messages are handled *after* Emergency and Priority traffic but before Routine.

ROUTINE—Most traffic normal times will bear this designation. In disaster situations, traffic labeled Routine (R on cw) should be handled *last*, or not at all when circuits are busy with Emergency, Priority or Welfare traffic.

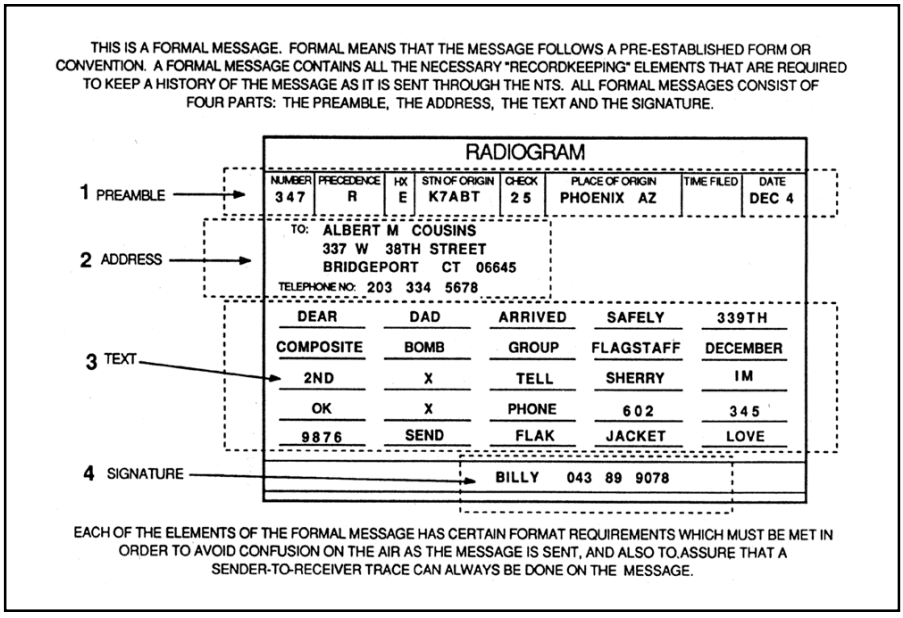
Handling Instructions (Optional)

HXA—(Followed by number.) Collect landline delivery authorized by addressee within.....miles. (If no number, authorization is unlimited.)
HXB—(Followed by number.) Cancel message if not delivered within.....hours of filing time; service originating station.
HXC—Report date and time of delivery (TOD) to originating station.
HXD—Report to originating station the identity of station from which received, plus date and time. Report identity of station to which relayed, plus date and time, or if delivered report date, time and method of delivery.
HXE—Delivering station get reply from addressee, originate message back.
HXF—(Followed by number.) Hold delivery until.....(date).
HXG—Delivery by mail or landline toll call not required. If toll or other expense involved, cancel message and service orginating station.

For further information on traffic handling, consult the Public Service Communications Manual or the ARRL Operating Manual, both published by ARRL.

FSD-218 (2/91) ARRL HQ., 225 Main St., Newington, CT 06111

A Simple NTS Formal Message



Handling Instructions

HXA—(Followed by number.) Collect landline delivery authorized by addressee within _____ miles. (If no number, authorization is unlimited.)
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HXC—Report date and time of delivery (TOD) to originating station.
HXD—Report to originating station the identity of station from which received, plus date and time. Report identity of station to which relayed, plus date and time, or if delivered report date, time and method of delivery.
HXE—Delivering station get reply from addressee, originate message back.
HXF—(Followed by number.) Hold delivery until _____ (date).
HXG—Delivery by mail or landline toll call not required. If toll or other expense involved, cancel message and service originating station.

An HX prosign (when used) will be inserted in the message preamble before the station of origin, thus: NR 207 R HXA50 W1AW 12…(etc). If more than one HX prosign is used they can be combined if no numbers are to be inserted; otherwise the HX should be repeated, thus: NR 207 R HXAC W1AW... (etc), but: NR 207 R HXA50 HXC W1AW…(etc). On phone, use phonetics for the letter or letters following the HX, to ensure accuracy.

ARL Numbered Radiograms

The letters ARL are inserted in the preamble in the check and in the text before spelled out numbers, which represent texts from this list. Note that some ARL texts include insertion of numerals. *Example*: NR 1 R W1AW ARL 5 NEWINGTON CONN DEC 25 DONALD R SMITH AA 164 EAST SIXTH AVE AA NORTH RIVER CITY MO AA PHONE 733 3968 BT ARL FIFTY ARL SIXTY ONE BT DIANA AR.

Group One—For possible "Relief Emergency" Use

ONE	Everyone safe here. Please don't worry.
TWO	Coming home as soon as possible.
THREE	Am in _____ hospital. Receiving excellent care and recovering fine.
FOUR	Only slight property damage here. Do not be concerned about disaster reports.
FIVE	Am moving to new location. Send no further mail or communication. Will inform you of new address when relocated.
SIX	Will contact you as soon as possible.
SEVEN	Please reply by Amateur Radio through the amateur delivering this message. This is a free public service.
EIGHT	Need additional _____ mobile or portable equipment for immediate emergency use.
NINE	Additional _____ radio operators needed to assist with emergency at this location.
TEN	Please contact _____. Advise to standby and provide further emergency information, instructions or assistance.
ELEVEN	Establish Amateur Radio emergency communications with _____ on _____ MHz.
TWELVE	Anxious to hear from you. No word in some time. Please contact me as soon as possible.
THIRTEEN	Medical emergency situation exists here.
FOURTEEN	Situation here becoming critical. Losses and damage from _____ increasing.
FIFTEEN	Please advise your condition and what help is needed.
SIXTEEN	Property damage very severe in this area.
SEVENTEEN	REACT communications services also available. Establish REACT communications with _____ on channel _____.
EIGHTEEN	Please contact me as soon as possible at _____.
NINETEEN	Request health and welfare report on _____. (State name, address and telephone number.)
TWENTY	Temporarily stranded. Will need some assistance. Please contact me at _____.
TWENTY ONE	Search and Rescue assistance is needed by local authorities here. Advise availability.
TWENTY TWO	Need accurate information on the extent and type of conditions now existing at your location. Please furnish this information and reply without delay.
TWENTY THREE	Report at once the accessibility and best way to reach your location.
TWENTY FOUR	Evacuation of residents from this area urgently needed. Advise plans for help.
TWENTY FIVE	Furnish as soon as possible the weather conditions at your location.
TWENTY SIX	Help and care for evacuation of sick and injured from this location needed at once.

Emergency/priority messages originating from official sources must carry the signature of the originating official.

Group Two—Routine messages

FORTY SIX	Greetings on your birthday and best wishes for many more to come.
FIFTY	Greetings by Amateur Radio.
FIFTY ONE	Greetings by Amateur Radio. This message is sent as a free public service by ham radio operators here at _____. Am having a wonderful time.
FIFTY TWO	Really enjoyed being with you. Looking forward to getting together again.
FIFTY THREE	Received your _____. It's appreciated; many thanks.
FIFTY FOUR	Many thanks for your good wishes.
FIFTY FIVE	Good news is always welcome. Very delighted to hear about yours.

Continued on next page.

ARL Numbered Radiograms

Continued from previous page.

FIFTY SIX	Congratulations on your _____, a most worthy and deserved achievement.
FIFTY SEVEN	Wish we could be together.
FIFTY EIGHT	Have a wonderful time. Let us know when you return.
FIFTY NINE	Congratulations on the new arrival. Hope mother and child are well.
*SIXTY	Wishing you the best of everything on _____.
SIXTY ONE	Wishing you a very merry Christmas and a happy New Year.
*SIXTY TWO	Greetings and best wishes to you for a pleasant _____ holiday season.
SIXTY THREE	Victory or defeat, our best wishes are with you. Hope you win.
SIXTY FOUR	Arrived safely at _____.
SIXTY FIVE	Arriving _____ on _____. Please arrange to meet me there.
SIXTY SIX	DX QSLs are on hand for you at the _____ QSL Bureau. Send _____ self-addressed envelopes.
SIXTY SEVEN	Your message number _____ undeliverable because of _____. Please advise.
SIXTY EIGHT	Sorry to hear you are ill. Best wishes for a speedy recovery.
SIXTY NINE	Welcome to the _____. We are glad to have you with us and hope you will enjoy the fun and fellowship of the organization.

* Can be used for all holidays.

Note: ARL numbers should be spelled out at all times.

How to be the Kind of Net Operator the Net Control Station (NCS) Loves

As a net operator, you have a duty to be self-disciplined. A net is only as good as its worst operator. You can be an exemplary net operator by following a few easy guidelines.

1) *Zero beat the NCS.* The NCS doesn't have time to chase all over the band for you. Make sure you're on frequency, and you will never be known at the annual net picnic as "old so-and-so who's always off frequency."

2) *Don't be late.* There's no such thing as "fashionably late" on a net. Liaison stations are on a tight timetable. Don't hold them up by checking in 10 minutes late with three pieces of traffic.

3) *Speak only when spoken to by the NCS.* Unless it is a bona fide emergency situation, you don't need to "help" the NCS unless asked. If you need to contact the NCS, make it brief. Resist the urge to help clear the frequency for the NCS or to "advise" the NCS. The NCS, not you, is boss.

4) Unless otherwise instructed by the NCS, *transmit only to the NCS*. Side comments to another station in the net are out of order.

5) *Stay until you are excused*. If the NCS calls you and you don't respond because you're getting a "cold one" from the fridge, the NCS may assume you've left the net, and net business may be stymied. If you need to leave the net prematurely, contact the NCS and simply ask to be excused (QNX PSE ON CW).

6) *Be brief when transmitting to the NCS.* A simple "yes" (C) or "no" (N) will usually suffice. Shaggy dog tales only waste valuable net time.

7) *Know how the net runs.* The NCS doesn't have time to explain procedure to you. After you have been on the net for a while, you should already know these things.

Checking Your Message

Traffic handlers don't have to dine out to fight over the check! Even good ops find much confusion when counting up the text of a message. You can eliminate some of this confusion by remembering these basic rules:

1) Punctuation ("X-rays," "Querys") count separately as a word.
2) Mixed letter-number groups (1700Z, for instance) count as one word.
3) Initial or number groups count as one word if sent together, two if sent separately.
4) The signature does not count as part of the text, but any closing lines, such as "Love" or "Best wishes" do.

Here are some examples:

- Charles J McClain—3 words
- W B Stewart—3 words
- St Louis—2 words
- 3 PM—2 words
- SASE—1 word
- ARL FORTY SIX—3 words
- 2N1601—1 word
- Seventy-three—2 words
- 73—1 word

Telephone numbers count as 3 words (area code, prefix, number), and ZIP codes count as one, ZIP + 4 codes count as two words. Canadian postal codes count as two words (first three characters, last three characters.)

Although, it is improper to change the text of a message, you may change the check. Always do this by following the original check with a slash bar, then the corrected check. On phone, use the words "corrected to."

Tips on Handling NTS Traffic by Packet Radio

Listing Messages

• After logging on to your local NTS-supported bulletin board, type the command LT, meaning List Traffic. The BBS will sort and display an index of all NTSXX traffic awaiting delivery.

Receiving Messages

• To take a message off the Bulletin Board for telephone delivery to the third party, or for relay to a NTS Local or Section Net, type the R command, meaning Read Traffic, and the message number. R 188 will cause the BBS to find the BBS message number 188. This RADIOGRAM will look like any other, with preamble, address, text and signature; only some additional packet-related message header information is added. This information includes the routing path of the message for auditing purposes; e.g., to discern any excessive delays in the system.

• After the message is saved to the printer or disk, the message should be KILLED by using the KT command, meaning Kill Traffic, and the message number. In the above case, at the BBS prompt, type KT 188. This prevents the message from being delivered twice. Some of the newer BBS software requires use of K rather than KT.

• At the time the message is killed, many BBSs will automatically send a message back to the station in the FROM field with information on who took the traffic, and when it was taken!

Delivering or Relaying A Message

• A downloaded RADIOGRAM should, of course, be handled expeditiously in the traditional way: telephone delivery, or relay to another net.

Sending Messages

• To send a RADIOGRAM, use the ST command meaning Send Traffic. The BBS will prompt you for the NTS routing (0611@NTSCT, for example), the message title which should contain the city in the address of the RADIOGRAM (QTC 1 Dayton), and the text of the message in RADIOGRAM format. The BBS, usually within the hour, will check its outgoing mailpouch, find the NTSCT message and automatically forward it to the next packet station in line to the NTSCT node. Note: Some states have more than one ARRL Section. If you do not know the destination ARRL Section (“Is San Angelo in the ARRL North, South or West Texas Section?”), then simply use the state designator NTSTX.

*Note: While NTS/packet radio message forwarding is evolving rapidly, there are still some gaps. When uploading an NTS message destined for a distant state, use handling instruction “HXC” to ask the delivering station to report back to you the date and time of delivery.

We Want You!

Local and Section BBSs need to be checked daily for NTS traffic. SYSOPs and STMs can’t do it alone. They need your help to clear NTS RADIOGRAMs every day, seven days a week, for delivery and relay. If you are a traffic handler/packeteer, contact your Section Traffic Manager or Section Manager for information on existing NTS/packet procedures in your Section.

If you are a packeteer, and know nothing of NTS traffic handling, contact ARRL HQ, your Section Manager or Section Traffic Manager for information on how you can put your packet radio gear to use in serving the public in routine times, but especially in time of emergency!

And, if you enjoy phone/CW traffic handling, but aren’t on packet yet, discover the incredible speed and accuracy of packet radio traffic handling. You probably already have a small computer and 2-meter rig; all you need is a packet radio “black box” to connect between your 2-meter rig and computer. For more information on packet radio, see *Practical Packet Radio*, published by the ARRL.

Templates

Template packages are available for many ARRL Handbook projects and some text discussions. They may include full-size etching patterns, more-detailed information on the subject, the author's corrections or updates and other useful information. They are updated as new information is received at ARRL Headquarters.

All of these template packages are available on this CD-ROM in the \TEMPLATE directory. With *Acrobat Reader* installed, simply open the \TEMPLATE\INDEX.PDF file on the CD-ROM to read any of the templates. You also can open an individual template file using the file name in the table below. These files are located in the \TEMPLATE\PDF directory of the CD-ROM.

Template packages are also available in hard-copy form from the Technical Secretary, ARRL HQ, 225 Main St, Newington, CT 06111-1494, USA. The minimum handling charge is $2 for ARRL members and $4 for nonmembers. The cost is higher for some larger packages. If you live in the US, enclose a check or money order made out to ARRL. A self-addressed 9 × 12 envelope will help expedite your request. For requests from outside the US, call 860-594-0278 (8 AM - 4 PM Eastern time). The fax number is 860-594-0259.

Template Reference Chapter and Topic	***Template Name***	***PDF File Name***	***Hard-Copy Cost***
11—A Series-Regulated 4.5- to 25-V, 2.5-A Power Supply	Sabin Power Supply	SABINPS	$2/$4
11—A 13.8-V, 40-A Power Supply	13.8-V, 40-A Power Supply	13V40APS	$2/$4
11—28-V, High-Current Power Supply	28-V Power Supply	28VSUP	$2/$4
13—A 2-M Brick Amp for Handhelds	2-M Brick Amp for Hand-helds	BRICK	$2/$4
13—Pi and Pi-L Network Tables	Wingfield Tables	HBKMATCH	$3/$5
16—Crystal-Filter Evaluation	Crystal Filter Evaluation	XFEVAL	$2/$4
16—A Continuously Variable Bandwidth Audio Filter	Bramwell Variable Audio Filter	BRAMWELL	$2/$4
17—NB Match Diagrams	NB Match	NBMATCH	$2/$4
17—A Rock-Bending Receiver for 7 MHz	Rock Bending Receiver	RBR	$2/$4
17—The NorCal Sierra: An 80-15 M CW Transceiver	NorCal Sierra	SIERRA	$3/$5
17—A Broadband HF Amplifier	Kossor Amp	KOSSOR	$2/$4
22—Vintage Radio T/R Adapter	T/R Switch	TRSW	$2/$4
22—Quick and Easy CW with Your PC	Taggart CW Interface	TAGGART	$2/$4
22—An Expandable Headphone Mixer	Headphone Mixer	HEADMIX	$2/$4
22—Audio Break-Out Box	Spencer Audio Break-out Box	SPENCEBO	$2/$4
22—An SWR Detector Audio Adapter	Spencer Audible SWR Adaptor	SPENCSWR	$2/$4
22—A Trio of Transceiver/Computer Interfaces	Interfaces	IFACE	$2/$4
22—TR Time-Delay Generator	N6CA TR Time-Delay Generator	N6CA-TR	$2/$4
23—Frequency Coordination and Band Plans	Repeaters	RPTRS	$2/$4
23—Mode-S Receive Converter	S-Band Converter	S-BAND	$2/$4
23—L-Band Satellite Antenna/Amplifier	Krome Amp	KROME	$2/$4
23—Azimuth and Elevation Information	EME	EME	$2/$4
23—An Active Attenuator for VHF-FM	Eenhoorn Active Attenuator	EEN-ATT	$2/$4
26—A Marker Generator with Selectable Output	Marker Generator	MARKGEN	$2/$4

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Templates

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Template Reference Chapter and Topic	*Template Name*	*PDF File Name*	*Hard-Copy Cost*
26—Measure Inductance and Capacitance with a DVM	Rainbow Inductance Meter	LMETER	$2/$4
26—A Six-Digit Programmable Frequency Counter and Digital Dial	Six Digit Programmable Frequency Counter/Digital Dial	COUNTER	$2/$4
26—A Calibrated Noise Source	Sabin Noise Source	SABINNS	$2/$4
26—A Noise Bridge for 1.8 Through 30 MHz	RX Noise Bridge	RXBRIDGE	$2/$4
27—Bench Equipment	Dip Meter Sources	DIPS	$2/$4
27—Signal Generator	Crystal Controlled Signal Source	XTALSRC	$2/$4
30—Pi-Network Resistive Attenuators (50 Ω)	Step Attenuator	STEPATT	$2/$4