

Chapter 7

Component Data and References

Component Data

None of us has the time or space to collect all the literature available on the many different commercially available manufactured components. Even if we did, the task of keeping track of new and obsolete devices would surely be formidable. Fortunately, amateurs tend to use a limited number of component types. This section, by Douglas Heacock, AAØMS, provides information on the components most often used by the Amateur Radio experimenter.

COMPONENT VALUES

Throughout this Handbook, resistors and small-value capacitors are specified in terms of a system of “preferred values.” This system allows manufacturers to supply these components in a standard set of values, which, when considered along with component tolerances, satisfy the vast majority of circuit requirements.

The preferred values are based on a roughly logarithmic scale of numbers between 1 and 10. One decade of these values for three common tolerance ratings is shown in **Table 7.1**.

Table 7.1 represents the two significant digits in a resistor or capacitor value. Multiply these numbers by multiples of ten to get other standard values. For example, 22 pF, 2.2 μ F, 220 μ F, and 2200 μ F are all standard capacitance values, available in all three tolerances. Standard resistor values include 3.9 Ω , 390 Ω , 39000 Ω and 3.9 M Ω in $\pm 5\%$ and $\pm 10\%$ tolerances. All standard resistance values, from less than 1 Ω to about 5 M Ω are based on this table.

Each value is greater than the next smaller value by a multiplier factor that depends on the tolerance. For $\pm 5\%$

devices, each value is approximately 1.1 times the next lower one. For $\pm 10\%$ devices, the multiplier is 1.21, and for $\pm 20\%$ devices, the multiplier is 1.47. The resultant values are rounded to make up the series.

Tolerance refers to a range of acceptable values above and below the specified component value. For example, a 4700- Ω resistor rated for $\pm 20\%$ tolerance can have an actual value anywhere between 3760 Ω and 5640 Ω . You may always substitute a

closer-tolerance device for one with a wider tolerance. For projects in this Handbook, assume a 10% tolerance if none is specified.

COMPONENT MARKINGS

The values, tolerances or types of most small components are typically marked with a color code or an alphanumeric code according to standards agreed upon by component manufacturers. The Electronic Industries Alliance (EIA) is a US agency that sets standards for electronic components, testing procedures, performance and device markings. The EIA cooperates with other standards agencies such as the International Electrotechnical Commission (IEC), a worldwide standards agency. You can often find published EIA standards in the engineering library of a college or university.

The standard EIA color code is used to identify a variety of electronic components. Most resistors are marked with color bands according to the code, shown in **Table 7.2**. Some types of capacitors and inductors are also marked using this color code.

Resistor Markings

Carbon-composition, carbon-film, and metal-film resistors are typically manufactured in roughly cylindrical cases with axial leads. They are marked with color bands as shown in **Fig 7.1** with the color codes detailed in Table 7.2. The markings in Fig 7.1A are typically used for 2%, 5% and 10% tolerance resistors. There are four bands, with the fourth band spaced widely from the first three. The first two bands

Table 7.1
Standard Values for Resistors and Capacitors

$\pm 5\%$	$\pm 10\%$	$\pm 20\%$
1.0	1.0	1.0
1.1		
1.2	1.2	
1.3		
1.5	1.5	1.5
1.6		
1.8	1.8	
2.0		
2.2	2.2	2.2
2.4		
2.7	2.7	
3.0		
3.3	3.3	3.3
3.6		
3.9	3.9	
4.3		
4.7	4.7	4.7
5.1		
5.6	5.6	
6.2		
6.8	6.8	6.8
7.5		
8.2	8.2	
9.1		
10.0	10.0	10.0

Table 7.2
Resistor Color Codes

Color	Significant Figure	Decimal Multiplier	Tolerance (%)
Black	0	1	
Brown	1	10	1
Red	2	100	2
Orange	3	1,000	
Yellow	4	10,000	
Green	5	100,000	0.5
Blue	6	1,000,000	0.25
Violet	7	10,000,000	0.1
Gray	8	100,000,000	0.05
White	9	1,000,000,000	
Gold		0.1	5
Silver		0.01	10
No color			20

represent the two significant digits of the component value, the third band represents the multiplier, and the fourth band represents the tolerance. If the fourth (tolerance) band is not present, the tolerance is $\pm 20\%$. For example, if a resistor of the type shown in Fig 7.1A is marked with the bands red, red, orange and silver, the significant figures are 2 and 2, the multiplier is 1000, and the tolerance is $\pm 10\%$. The device is a 22,000- Ω , $\pm 10\%$ unit.

Precision resistors (0.1%, 0.25%, 0.5% and 1% tolerance) are marked with five bands, as shown in Fig 7.1B. Note that the fifth band is spaced widely from the first four bands. For example, if a resistor of the type shown in Fig 7.1A is marked with the bands red, red, orange, black and brown, the significant figures are 2, 2 and 3, the multiplier is 1, and the tolerance is $\pm 1\%$. The device is a 223- Ω , $\pm 1\%$ unit.

Some military (mil-spec) resistors (Fig 7.1C) are marked with a fifth band that represents reliability information. On these resistors, the fifth band is spaced closely with the first four and represents the percentage of resistance change per 1000 hours of operation: brown = 1%; red = 0.1%; orange = 0.01%; and yellow = 0.001%.

Some resistors are made with radial leads (Fig 7.1D) and are marked with a color code in a slightly different scheme. For example, a resistor as shown in Fig 7.1D is marked as follows: body (A) = blue; end (B) = gray; dot (C) = red; end (D) = gold. The significant figures are 6 and 8, the multiplier is 100, and the tolerance is $\pm 5\%$; 6800 Ω with $\pm 5\%$ tolerance.

Resistor Power Ratings

Carbon-film and metal-film are the most commonly available resistors today, having largely replaced the less-stable carbon-composition resistors. Carbon-film and metal-film resistors are available in standard

power ratings of $\frac{1}{6}$, $\frac{1}{4}$, $\frac{1}{2}$, 1 and 2 W and generally have tolerances of 5% or better. Carbon-composition resistors are available in $\frac{1}{10}$, $\frac{1}{8}$, $\frac{1}{4}$, $\frac{1}{2}$, 1 and 2 W ratings, but are harder to find. The $\frac{1}{4}$, $\frac{1}{2}$, 1 and 2-W resistor

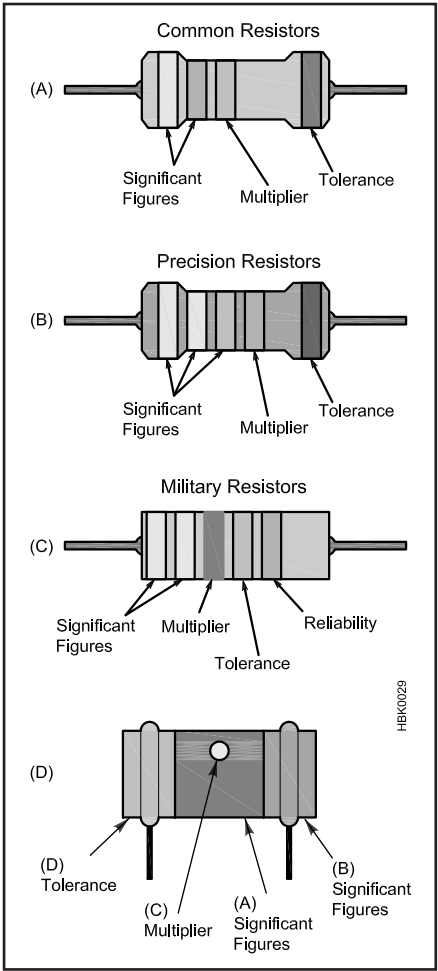


Fig 7.1 — Color codes for fixed resistors. See Table 7.2 and text for more information on identifying the resistor values.

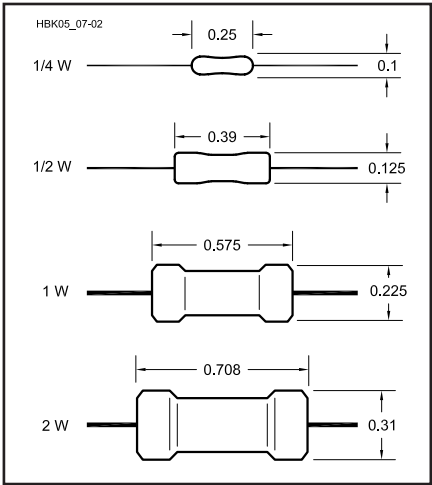


Fig 7.2—Typical resistor sizes.

packages are drawn to scale in Fig 7.2. Carbon- and metal-film resistors are typically slightly smaller than carbon-composition units of the same power rating. Film resistors can usually be identified by a glossy enamel coating and an hourglass profile.

Capacitor Markings

A variety of systems for capacitor markings are in use. Some use color bands, some use combinations of numbers and letters. Capacitors may be marked with their value, tolerance, temperature characteristics, voltage ratings or some subset of these specifications. Fig 7.3 shows several popular capacitor marking systems.

In addition to the value, ceramic disk capacitors may be marked with an alphanumeric code signifying temperature characteristics. Table 7.3 explains the EIA code for ceramic-disk capacitor temperature characteristics. The code is made up of one character from each column in the table. For example, a capacitor marked Z5U is suitable for use between +10 and +85°C, with a maximum change in capacitance of -56% or $+22\%$.

Capacitors with highly predictable temperature coefficients of capacitance are sometimes used in oscillators that must be frequency stable with temperature. If an application called for a temperature coefficient of -750 ppm/°C (N750), a capacitor marked U2J would be suitable. The older industry code for these ratings is being replaced with the EIA code shown in Table 7.4. NP0 (that is, N-P-zero) means “negative, positive, zero.” It is a characteristic often specified for RF circuits requiring temperature stability, such as VFOs. A capacitor of the proper value marked C0G is a suitable replacement for an NP0 unit.

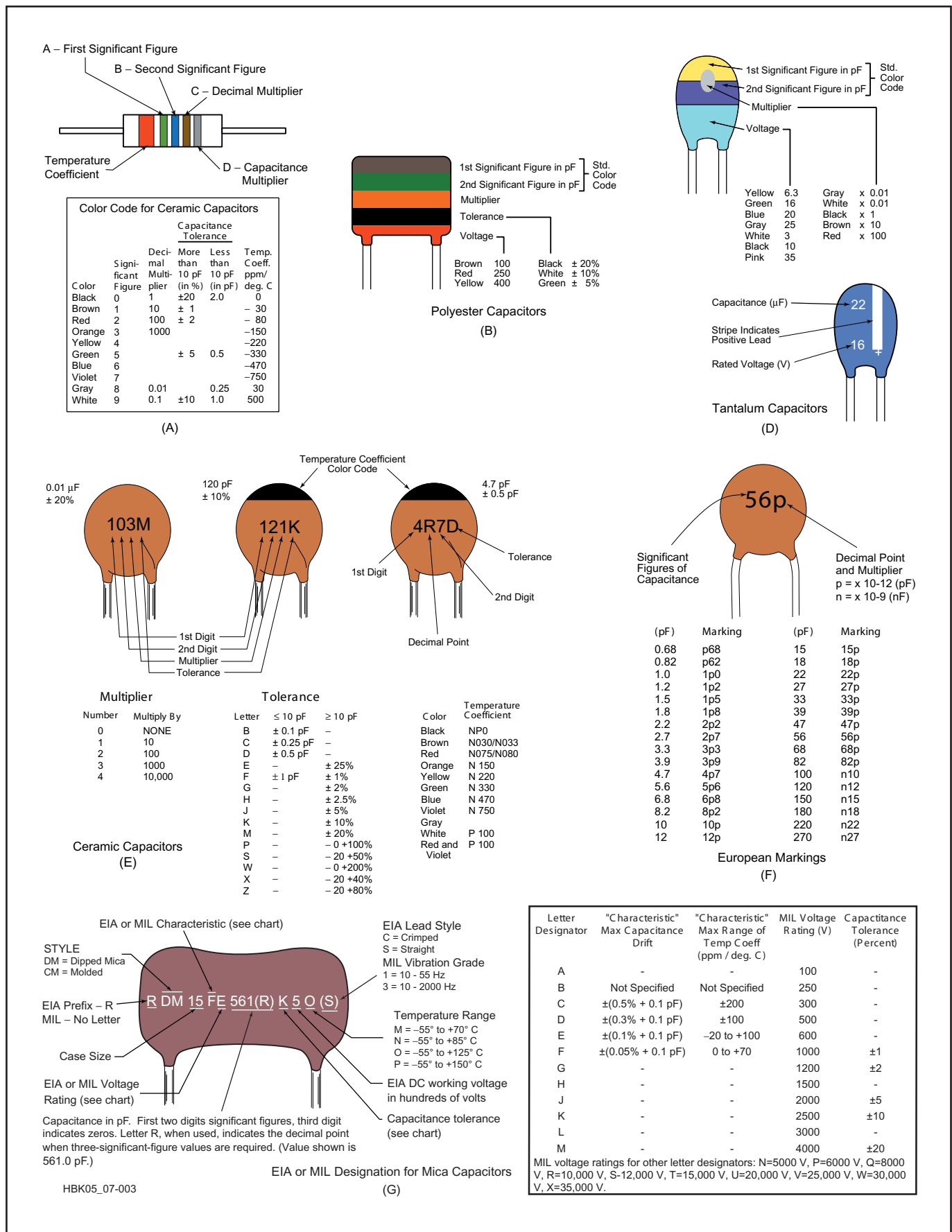


Fig 7.3—Capacitors can be identified by color codes and markings. Shown here are identifying markings found on many common capacitor types.

Some capacitors, such as dipped silver-mica units, have a letter designating the capacitance tolerance. These letters are deciphered in **Table 7.5**.

Surface-Mount Resistor and Capacitor Markings

Many different types of electronic components, both active and passive, are now available in surface-mount packages. These are commonly known as *chip* resistors and capacitors. The very small size of these components leaves little space for marking with conventional codes, so brief alphanumeric codes are used to convey the most information in the smallest possible space.

Surface-mount resistors are typically marked with a three- or four-digit value code and a character indicating tolerance. The nominal resistance, expressed in ohms, is identified by three digits for 2% (and greater) tolerance devices. The first two digits represent the significant figures; the last digit specifies the multiplier as the exponent of ten. (It may be easier to remember the multiplier as the number of zeros you must add to the significant figures.) For values less than 100 Ω , the letter R is substituted for one of the significant digits and represents a decimal point. Here are some examples:

Resistor

Code	Value
101	10 and 1 zero = 100 Ω
224	22 and 4 zeros = 220,000 Ω
1R0	1.0 and no zeros = 1 Ω
22R	22.0 and no zeros = 22 Ω
R10	0.1 and no zeros = 0.1 Ω

If the tolerance of the unit is narrower than $\pm 2\%$, the code used is a four-digit code where the first three digits are the significant figures and the last is the multiplier. The letter R is used in the same way to represent a decimal point. For example, 1001 indicates a 1000- Ω unit, and 22R0 indicates a 22- Ω unit. The tolerance rating for a surface-mount resistor is expressed with a single character at the end of the numeric value code in **Table 7.6**.

Surface-mount capacitors are marked with a two-character code consisting of a letter indicating the significant digits (see **Table 7.7**) and a number indicating the multiplier (see **Table 7.8**). The code represents the capacitance in picofarads. For example, a chip capacitor marked “A4” would have a capacitance of 10,000 pF, or 0.01 μF . A unit marked “N1” would be a 33-pF capacitor. If there is sufficient space on the device package, a tolerance code may be included (see Fig 7.3E for tolerance codes). Surface-mount capacitors

Table 7.3

EIA Temperature Characteristic Codes for Ceramic Disc Capacitors

Minimum temperature	Maximum temperature	Maximum capacitance change over temperature range
X -55°C	2 $+45^{\circ}\text{C}$	A $\pm 1.0\%$
Y -30°C	4 $+65^{\circ}\text{C}$	B $\pm 1.5\%$
Z $+10^{\circ}\text{C}$	5 $+85^{\circ}\text{C}$	C $\pm 2.2\%$
	6 $+105^{\circ}\text{C}$	D $\pm 3.3\%$
	7 $+125^{\circ}\text{C}$	E $\pm 4.7\%$
		F $\pm 7.5\%$
		P $\pm 10\%$
		R $\pm 15\%$
		S $\pm 22\%$
		T $-33\%, +22\%$
		U $-56\%, +22\%$
		V $-82\%, +22\%$

Table 7.4

EIA Capacitor Temperature-Coefficient Codes

Industry	EIA
NP0	C0G
N033	S1G
N075	U1G
N150	P2G
N220	R2G
Industry	EIA
N330	S2H
N470	U2J
N1500	P3K
N2200	R3L

Table 7.5

EIA Capacitor Tolerance Codes

Code	Tolerance
C	$\pm 1/4$ pF
D	$\pm 1/2$ pF
F	± 1 pF or $\pm 1\%$
G	± 2 pF or $\pm 2\%$
J	$\pm 5\%$
K	$\pm 10\%$
L	$\pm 15\%$
M	$\pm 20\%$
N	$\pm 30\%$
P or GMV*	$-0\%, +100\%$
W	$-20\%, +40\%$
Y	$-20\%, +50\%$
Z	$-20\%, +80\%$

*GMV = guaranteed minimum value.

can be very small; you may need a magnifying glass to read the markings.

INDUCTORS AND CORE MATERIALS

Inductors, both fixed and variable, are

Table 7.6

SMT Resistor Tolerance Codes

Letter	Tolerance
D	$\pm 0.5\%$
F	$\pm 1.0\%$
G	$\pm 2.0\%$
J	$\pm 5.0\%$

Table 7.7

SMT Capacitor Significant Figures Code

Character	Significant Figures	Character	Significant Figures
A	1.0	T	5.1
B	1.1	U	5.6
C	1.2	V	6.2
D	1.3	W	6.8
E	1.5	X	7.5
F	1.6	Y	8.2
G	1.8	Z	9.1
H	2.0	a	2.5
J	2.2	b	3.5
K	2.4	d	4.0
L	2.7	e	4.5
M	3.0	f	5.0
N	3.3	m	6.0
P	3.6	n	7.0
Q	3.9	t	8.0
R	4.3	y	9.0
S	4.7		

Table 7.8

SMT Capacitor Multiplier Codes

Numeric Character	Decimal Multiplier
0	1
1	10
2	100
3	1,000
4	10,000
5	100,000
6	1,000,000
7	10,000,000
8	100,000,000
9	0.1

Table 7.9

Powdered-Iron Toroidal Cores: Magnetic Properties**Inductance and Turns Formula**

The turns required for a given inductance or inductance for a given number of turns can be calculated from:

$$N = 100 \sqrt{\frac{L}{A_L}} \quad L = A_L \left(\frac{N^2}{10,000} \right)$$

where N = number of turns; L = desired inductance (μH); A_L = inductance index (μH per 100 turns).*

AL Values

	Mix										
Size	26**	3	15	1	2	7	6	10	12	17	0
T-12	na	60	50	48	20	18	17	12	7.5	7.5	3.0
T-16	145	61	55	44	22	na	19	13	8.0	8.0	3.0
T-20	180	76	65	52	27	24	22	16	10.0	10.0	3.5
T-25	235	100	85	70	34	29	27	19	12.0	12.0	4.5
T-30	325	140	93	85	43	37	36	25	16.0	16.0	6.0
T-37	275	120	90	80	40	32	30	25	15.0	15.0	4.9
T-44	360	180	160	105	52	46	42	33	18.5	18.5	6.5
T-50	320	175	135	100	49	43	40	31	18.0	18.0	6.4
T-68	420	195	180	115	57	52	47	32	21.0	21.0	7.5
T-80	450	180	170	115	55	50	45	32	22.0	22.0	8.5
T-94	590	248	200	160	84	na	70	58	32.0	na	10.6
T-106	900	450	345	325	135	133	116	na	na	na	19.0
T-130	785	350	250	200	110	103	96	na	na	na	15.0
T-157	870	420	360	320	140	na	115	na	na	na	na
T-184	1640	720	na	500	240	na	195	na	na	na	na
T-200	895	425	na	250	120	105	100	na	na	na	na

*The units of AL (μH per 100 turns) are an industry standard; however, to get a correct result use AL only in the formula above.

**Mix-26 is similar to the older Mix-41, but can provide an extended frequency range.

Magnetic Properties Iron Powder Cores

Mix	Color	Material	μ	Temp stability (ppm/°C)	f (MHz)	Notes
26	Yellow/white	Hydrogen reduced	75	825	dc - 1	Used for EMI filters and dc chokes
3	Gray	Carbonyl HP	35	370	0.05 - 0.50	Excellent stability, good Q for lower frequencies
15	Red/white	Carbonyl GS6	25	190	0.10 - 2	Excellent stability, good Q
1	Blue	Carbonyl C	20	280	0.50 - 5	Similar to Mix-3, but better stability
2	Red	Carbonyl E	10	95	2 - 30	High Q material
7	White	Carbonyl TH	9	30	3 - 35	Similar to Mix-2 and Mix-6, but better temperature stability
6	Yellow	Carbonyl SF	8	35	10 - 50	Very good Q and temp. stability for 20-50 MHz
10	Black	Powdered iron W	6	150	30 - 100	Good Q and stability for 40 - 100 MHz
12	Green/white	Synthetic oxide	4	170	50 - 200	Good Q, moderate temperature stability
17	Blue/yellow	Carbonyl	4	50	40 - 180	Similar to Mix-12, better temperature stability, Q drops about 10% above 50 MHz, 20% above 100 MHz
0	Tan	phenolic	1	0	100 - 300	Inductance may vary greatly with winding technique

Courtesy of Amidon Assoc and Micrometals

Note: Color codes hold only for cores manufactured by Micrometals, which makes the cores sold by most Amateur Radio distributors.

available in a wide variety of types and packages, and many offer few clues as to their values. Some coils and chokes are marked with the EIA color code shown in Table 7.2. See Fig 7.4 for another marking system for tubular encapsulated RF chokes.

Most powdered-iron toroid cores that we amateurs use are manufactured by Micrometals, who uses paint to identify the material used in the core. The Micrometals color code is part of Table 7.9. Table 7.10 gives the physical characteristics of powdered-iron toroids. Ferrite cores are not typically painted, so identification is more

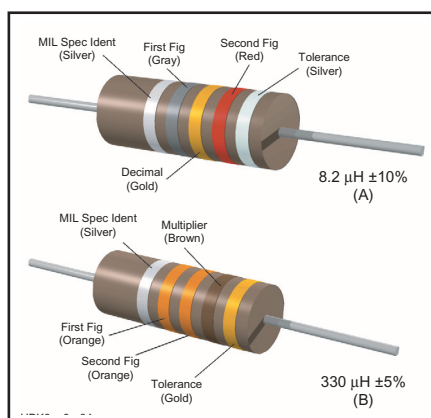


Fig 7.4—Color coding for tubular encapsulated RF chokes. At A, an example of the coding for an 8.2-μH choke is given. At B, the color bands for a 330-μH inductor are illustrated. The color code is given in Table 7.2.

Table 7.10

Powdered-Iron Toroidal Cores: Dimensions

Red E Cores—500 kHz to 30 MHz ($\mu = 10$)

No.	OD (in)	ID (in)	H (in)
T-200-2	2.00	1.25	0.55
T-94-2	0.94	0.56	0.31
T-80-2	0.80	0.50	0.25
T-68-2	0.68	0.37	0.19
T-50-2	0.50	0.30	0.19
T-37-2	0.37	0.21	0.12
T-25-2	0.25	0.12	0.09
T-12-2	0.125	0.06	0.05

Black W Cores—30 MHz to 200 MHz ($\mu=6$)

No.	OD (in)	ID (in)	H (in)
T-50-10	0.50	0.30	0.19
T-37-10	0.37	0.21	0.12
T-25-10	0.25	0.12	0.09
T-12-10	0.125	0.06	0.05

Yellow SF Cores—10 MHz to 90 MHz ($\mu=8$)

No.	OD (in)	ID (in)	H (in)
T-94-6	0.94	0.56	0.31
T-80-6	0.80	0.50	0.25
T-68-6	0.68	0.37	0.19
T-50-6	0.50	0.30	0.19
T-26-6	0.25	0.12	0.09
T-12-6	0.125	0.06	0.05

Number of Turns vs Wire Size and Core Size

Approximate maximum number of turns—single layer wound—enameled wire.

Wire Size	T-200	T-130	T-106	T-94	T-80	T-68	T-50	T-37	T-25	T-12
10	33	20	12	12	10	6	4	1		
12	43	25	16	16	14	9	6	3		
14	54	32	21	21	18	13	8	5	1	
16	69	41	28	28	24	17	13	7	2	
18	88	53	37	37	32	23	18	10	4	1
20	111	67	47	47	41	29	23	14	6	1
22	140	86	60	60	53	38	30	19	9	2
24	177	109	77	77	67	49	39	25	13	4
26	223	137	97	97	85	63	50	33	17	7
28	281	173	123	123	108	80	64	42	23	9
30	355	217	154	154	136	101	81	54	29	13
32	439	272	194	194	171	127	103	68	38	17
34	557	346	247	247	218	162	132	88	49	23
36	683	424	304	304	268	199	162	108	62	30
38	875	544	389	389	344	256	209	140	80	39
40	1103	687	492	492	434	324	264	178	102	51

Actual number of turns may differ from above figures according to winding techniques, especially when using the larger size wires. Chart prepared by Michel J. Gordon, Jr, WB9FHC.

Courtesy of Amidon Assoc.

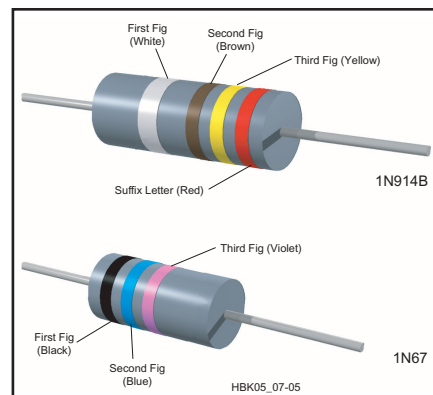


Fig 7.5—Color coding for semi-conductor diodes. At A, the cathode is identified by the double-width first band. At B, the bands are grouped toward the cathode. Two-figure designations are signified by a black first band. The color code is given in Table 7.2. The suffix-letter code is A—Brown, B—red, C—orange, D—yellow, E—green, F—blue. The 1N prefix is understood.

cases, a manufacturer's date code as well. Identification of semiconductors can be difficult, however, when the parts are "house-marked" (marked with codes used by an equipment manufacturer instead of the standard part numbers). In such cases, it is often possible to find the standard equivalent or a suitable replacement by using one of the semiconductor cross-reference directories available from various replacement-parts distributors. If you look up the house number and find the recommended replacement part, you can often find other standard parts that are replaced by that same part.

Diodes

Most diodes are marked with a part number and some means of identifying which lead is the cathode. Some diodes are marked with a color-band code (see Fig 7.5). Important diode parameters include maximum forward current, maximum peak inverse voltage (PIV) and the power-handling capacity.

Transistors

Some important parameters for transistor selection are voltage and current limits, power-handling capability, beta or gain characteristics and useful frequency range. The case style may also be an issue; some transistors are available in several different case styles.

Integrated Circuits

Integrated circuits (ICs) come in a variety of packages, including transistor-like metal cans, dual and single in-line pack-

difficult. See Table 7.11 for information about ferrite cores.

TRANSFORMERS

Many transformers, including power transformers, IF transformers and audio transformers, are made to be installed on PC boards, and have terminals designed for that purpose. Some transformers are manufactured with wire leads that are color-coded to identify each connection.

When colored wire leads are present, the color codes in Tables 7.12, 7.13 and 7.14 usually apply.

In addition, many miniature IF transformers are tuned with slugs that are color-coded to signify their application. Table 7.15 lists application vs slug color.

SEMICONDUCTORS

Most semiconductor devices are clearly marked with the part number and in some

Table 7.11**Ferrite Toroids: A_L Chart (mH per 1000 turns) Enameled Wire**

Core Size	63/67-Mix $\mu = 40$	61-Mix $m = 125$	43-Mix $\mu = 850$	77 (72)-Mix $\mu = 2000$	J (75)-Mix $\mu = 5000$
FT-23	7.9	24.8	188.0	396	980
FT-37	19.7	55.3	420.0	884	2196
FT-50	22.0	68.0	523.0	1100	2715
FT-82	22.4	73.3	557.0	1170	NA
FT-114	25.4	79.3	603.0	1270	3170

$$\text{Number of turns} = 1000 \sqrt{\text{desired } L \text{ (mH)} \div A_L \text{ value (above)}}$$

Ferrite Magnetic Properties

Property	Unit	63/67-Mix	61-Mix	43-Mix	77 (72)-Mix	J (75)-Mix
Initial perm.	(μ_i)	40	125	850	2000	5000
Max. perm.		125	450	3000	6000	8000
Saturation flux density @ 10 oer	Gauss	1850	2350	2750	4600	3900
Residual flux density	Gauss	750	1200	1200	1150	1250
Curie temp.	°C	450	350	130	200	140
Vol. resistivity	ohm/cm	1×10^8	1×10^8	1×10^5	1×10^2	5×10^2
Resonant circuit frequency	MHz	15-25	0.2-10	0.01-1	0.001-1	0.001-1
Specific gravity		4.7	4.7	4.5	4.8	4.8
Loss factor	$\frac{1}{\mu_i Q}$	110×10^{-6}	32×10^{-6}	120×10^{-6}	4.5×10^{-6}	15×10^{-6}
Coercive force	Oer	@25 MHz	@2.5 MHz	@1 MHz	@0.1 MHz	@0.1 MHz
Temp. Coef. of initial perm.	%/°C (20°-70°)	0.10	0.15	1.0	0.60	0.90

Ferrite Toroids—Physical Properties

Core Size	OD	ID	Height	A_e	l_e	V_e	A_S	A_W
FT-23	0.230	0.120	0.060	0.00330	0.529	0.00174	0.1264	0.01121
FT-37	0.375	0.187	0.125	0.01175	0.846	0.00994	0.3860	0.02750
FT-50	0.500	0.281	0.188	0.02060	1.190	0.02450	0.7300	0.06200
FT-82	0.825	0.520	0.250	0.03810	2.070	0.07890	1.7000	0.21200
FT-114	1.142	0.750	0.295	0.05810	2.920	0.16950	2.9200	0.43900

OD—Outer diameter (inches)

ID—Inner diameter (inches)

Height (inches)

 A_W —Total window area (in)² A_e —Effective magnetic cross-sectional area (in)² l_e —Effective magnetic path length (inches) V_e —Effective magnetic volume (in)³ A_S —Surface area exposed for cooling (in)²

Courtesy of Amidon Assoc.

Table 7.12**Power-Transformer Wiring Color Codes**

Non-tapped primary leads:	Black
Tapped primary leads:	Common: Black Tap: Black/yellow striped Finish: Black/red striped
High-voltage plate winding:	Red
Center tap:	Red/yellow striped
Rectifier filament winding:	Yellow
Center tap:	Yellow/blue striped
Filament winding 1:	Green
Center tap:	Green/yellow striped
Filament winding 2:	Brown
Center tap:	Brown/yellow striped
Filament winding 3:	Slate
Center tap:	Slate/yellow striped

Table 7.13**IF Transformer Wiring Color Codes**

Plate lead:	Blue
B+ lead:	Red
Grid (or diode) lead:	Green
Grid (or diode) return:	Black

Note: If the secondary of the IF transformer is center-tapped, the second diode plate lead is green-and-black striped, and black is used for the center-tap lead.

Table 7.14**IF Transformer Slug Color Codes**

Frequency	Application	Slug color
455 kHz	1st IF	Yellow
	2nd IF	White
	3rd IF	Black
	Osc tuning	Red
10.7 MHz	1st IF	Green
	2nd or 3rd IF	Orange, Brown or Black

Table 7.15**Audio Transformer Wiring Color Codes**

Plate lead of primary	Blue
B+ lead (plain or center-tapped)	Red
Plate (start) lead on center-tapped primaries	Brown (or blue if polarity is not important)
Grid (finish) lead to secondary	Green
Grid return (plain or center tapped)	Black
Grid (start) lead on center tapped secondaries	Yellow (or green if polarity not important)

Note: These markings also apply to line-to-grid and tube-to-line transformers.

ages (DIPs and SIPs), flat-packs and surface-mount packages. Most are marked with a part number and a four-digit manufacturer's date code indicating the year (first two digits) and week (last two digits) that the component was made. ICs are frequently house-marked, and the cross-reference directories mentioned above can be helpful in identification and replacement.

Another very useful reference tool for working with ICs is *IC Master*, a master selection guide that organizes ICs by type, function and certain key parameters. A part number index is included, along with application notes and manufacturer's information for millions of devices. See www.icmaster.com.

IC part numbers usually contain a few digits that identify the circuit die or

Table 7.16

Copper Wire Specifications

Bare and Enamel-Coated Wire

Wire Size (AWG)	Diam (Mils)	Area (CM ²)	Enamel Wire Coating Turns / Linear inch ²			Feet per Pound Bare	Ohms per 1000 ft 25° C	Current Carrying Capacity Continuous Duty ³			Nearest British SWG No.
			Single	Heavy	Triple			at 700 CM per Amp ⁴	Open air	Conduit or bundles	
1	289.3	83694.49				3.948	0.1239	119.564			1
2	257.6	66357.76				4.978	0.1563	94.797			2
3	229.4	52624.36				6.277	0.1971	75.178			4
4	204.3	41738.49				7.918	0.2485	59.626			5
5	181.9	33087.61				9.98	0.3134	47.268			6
6	162.0	26244.00				12.59	0.3952	37.491			7
7	144.3	20822.49				15.87	0.4981	29.746			8
8	128.5	16512.25				20.01	0.6281	23.589			9
9	114.4	13087.36				25.24	0.7925	18.696			11
10	101.9	10383.61				31.82	0.9987	14.834			12
11	90.7	8226.49				40.16	1.2610	11.752			13
12	80.8	6528.64				50.61	1.5880	9.327			13
13	72.0	5184.00				63.73	2.0010	7.406			15
14	64.1	4108.81	15.2	14.8	14.5	80.39	2.5240	5.870	32	17	15
15	57.1	3260.41	17.0	16.6	16.2	101.32	3.1810	4.658			16
16	50.8	2580.64	19.1	18.6	18.1	128	4.0180	3.687	22	13	17
17	45.3	2052.09	21.4	20.7	20.2	161	5.0540	2.932			18
18	40.3	1624.09	23.9	23.2	22.5	203.5	6.3860	2.320	16	10	19
19	35.9	1288.81	26.8	25.9	25.1	256.4	8.0460	1.841			20
20	32.0	1024.00	29.9	28.9	27.9	322.7	10.1280	1.463	11	7.5	21
21	28.5	812.25	33.6	32.4	31.3	406.7	12.7700	1.160			22
22	25.3	640.09	37.6	36.2	34.7	516.3	16.2000	0.914		5	22
23	22.6	510.76	42.0	40.3	38.6	646.8	20.3000	0.730			24
24	20.1	404.01	46.9	45.0	42.9	817.7	25.6700	0.577			24
25	17.9	320.41	52.6	50.3	47.8	1031	32.3700	0.458			26
26	15.9	252.81	58.8	56.2	53.2	1307	41.0200	0.361			27
27	14.2	201.64	65.8	62.5	59.2	1639	51.4400	0.288			28
28	12.6	158.76	73.5	69.4	65.8	2081	65.3100	0.227			29
29	11.3	127.69	82.0	76.9	72.5	2587	81.2100	0.182			31
30	10.0	100.00	91.7	86.2	80.6	3306	103.7100	0.143			33
31	8.9	79.21	103.1	95.2		4170	130.9000	0.113			34
32	8.0	64.00	113.6	105.3		5163	162.0000	0.091			35
33	7.1	50.41	128.2	117.6		6553	205.7000	0.072			36
34	6.3	39.69	142.9	133.3		8326	261.3000	0.057			37
35	5.6	31.36	161.3	149.3		10537	330.7000	0.045			38
36	5.0	25.00	178.6	166.7		13212	414.8000	0.036			39
37	4.5	20.25	200.0	181.8		16319	512.1000	0.029			40
38	4.0	16.00	222.2	204.1		20644	648.2000	0.023			
39	3.5	12.25	256.4	232.6		26969	846.6000	0.018			
40	3.1	9.61	285.7	263.2		34364	1079.2000	0.014			
41	2.8	7.84	322.6	294.1		42123	1323.0000	0.011			
42	2.5	6.25	357.1	333.3		52854	1659.0000	0.009			
43	2.2	4.84	400.0	370.4		68259	2143.0000	0.007			
44	2.0	4.00	454.5	400.0		82645	2593.0000	0.006			
45	1.8	3.10	526.3	465.1		106600	3348.0000	0.004			
46	1.6	2.46	588.2	512.8		134000	4207.0000	0.004			

Teflon Coated, Stranded Wire

(As supplied by Belden Wire and Cable)

Turns per Linear inch²
UL Style No.

Size	Strands ⁵	1180	1213	1371
16	19×29	11.2		
18	19×30	12.7		
20	7×28	14.7	17.2	
20	19×32	14.7	17.2	
22	19×34	16.7	20.0	23.8
22	7×30	16.7	20.0	23.8
24	19×36	18.5	22.7	27.8
24	7×32		22.7	27.8
26	7×34		25.6	32.3
28	7×36		28.6	37.0
30	7×38		31.3	41.7
32	7×40			47.6

Notes¹A circular mil (CM) is a unit of area equal to that of a one-mil-diameter circle ($\pi/4$ square mils). The CM area of a wire is the square of the mil diameter.²Figures given are approximate only; insulation thickness varies with manufacturer.³Maximum wire temperature of 212°F (100°C) with a maximum ambient temperature of 13°F (57°C) as specified by the manufacturer. The *National Electrical Code* or local building codes may differ.⁴700 CM per ampere is a satisfactory design figure for small transformers, but values from 500 to 1000 CM are commonly used. The *National Electrical Code* or local building codes may differ.⁵Stranded wire construction is given as "count" × "strand size" (AWG).

Table 7.17**Color Code for Hookup Wire**

<i>Wire Color</i>	<i>Type of Circuit</i>
Black	Grounds, grounded elements and returns
Brown	Heaters or filaments, off ground
Red	Power Supply B plus
Orange	Screen grids and base 2 of transistors
Yellow	Cathodes and transistor emitters
Green	Control grids, diode plates, and base 1 of transistors
Blue	Plates and transistor collectors
Violet	Power supply, minus leads
Gray	Ac power line leads
White	Bias supply, B or C minus, AGC

Note: Wires with tracers are coded in the same manner as solid-color wires, allowing additional circuit identification over solid-color wiring. The body of the wire is white and the color band spirals around the wire lead. When more than one color band is used, the widest band represents the first color.

function and several other letters and/or digits that identify the production process, manufacturer and package. For example, a '4066 IC contains four independent SPST switches. The 4066 is available from a number of different manufacturers in different configurations. Part numbers may be along the lines of CD74HC4066, CD4066B and CD4066BE, MM74HC4066, or MN4066B. Among the numbers listed, "CD" (CMOS Digital), "MM" (MOS Monolithic), and "MN" indicate CMOS parts. The number "74" indicates a commercial quality product (for applications from 0°C to 70°C), which is pin compatible with the 74/54 TTL families. "HC" means high-speed CMOS family, which is as fast as the LS TTL family. The "B" suffix, as is CD4066B, indicates a buffered output. This is only a small example of the conventions used in IC part numbers. For more information look at data books from the various manufacturers.

When choosing ICs that are not exact replacements, several operating needs and performance aspects should be considered. First, the replacement power requirements must be met: Some ICs require 5 V dc, others 12 V and some need both positive and negative supplies. Current requirements vary among the various IC families, so be sure that sufficient current is available from the power supply. If a replacement IC uses much more current than the device it replaces, a heat sink or blower may be needed to keep it cool.

Next consider how the replacement interacts with its neighboring components. Input capacitance and "fanout" are critical factors in digital circuits. Increased input capacitance may overload the driving circuits. Overload slows circuit operation,

which may prevent lines from reaching the "high" condition. Fanout tells how many inputs a device can drive. The fanout of a replacement should be equal to, or greater than, that required in the circuit. Operating speed and propagation delay are also significant. Choose a replacement IC that operates at or above the circuit clock speed. (Be careful: Increased speed can increase EMI and cause other problems.) Some circuits may not function if the propagation delay varies much from the specified part. Look at the **Electrical Signals and Components** chapter for details of how these operating characteristics relate to circuit performance.

Analog ICs have similar characteristics. Input and output capacities are often defined as how much current an analog IC can "sink" (accept at an input) or "source" (pass to a load). A replacement should be able to source or sink at least as much current as the device it replaces. Analog speed is sometimes listed as bandwidth (as in discrete-component circuits) or slew rate (common in op amps). Each of these quantities should meet or exceed that of the replaced component.

Some ICs are available in different operating temperature ranges. Op amps, for example, are commonly available in three standard ranges:

- Commercial: 0°C to 70°C
- Industrial: -25°C to 85°C
- Military: -55°C to 125°C

In some cases, part numbers reflect the temperature ratings. For example, an LM301A op amp is rated for the commercial temperature range; an LM201A op amp for the industrial range and an LM101A for the military range.

When necessary, you can add interface circuits or buffer amplifiers that improve the input and output capabilities of replacement ICs, but auxiliary circuits cannot improve basic device ratings, such as speed or bandwidth.

OTHER SOURCES OF COMPONENT DATA

There are many sources you can consult for detailed component data. These days, the best source of component information and data sheets is the Internet. Most manufacturers maintain extensive Web sites with information and data on their products. Distributors such as Digi-Key and Mouser include links to useful information in their online catalogs as well.

Some manufacturers publish data books for the components they make, and parts catalogs themselves are often good sources

Table 7.18**Aluminum Alloy Characteristics****Common Alloy Numbers**

<i>Type</i>	<i>Characteristic</i>
2024	Good formability, high strength
5052	Excellent surface finish, excellent corrosion resistance, normally not heat treatable for high strength
6061	Good machinability, good weldability, can be brittle at high temps
7075	Good formability, high strength

General Uses

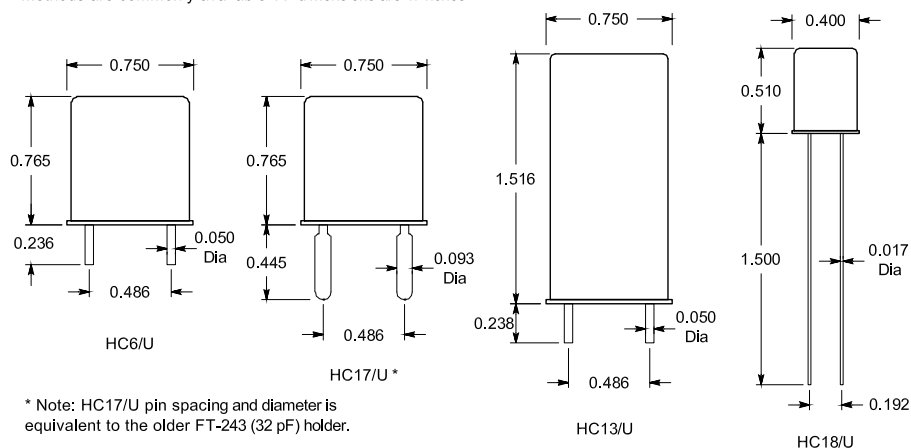
<i>Type</i>	<i>Uses</i>
2024-T3	Chassis boxes, antennas, anything that will be bent or flexed repeatedly
7075-T3	
6061-T6	Mounting plates, welded assemblies or machined parts

Common Tempers

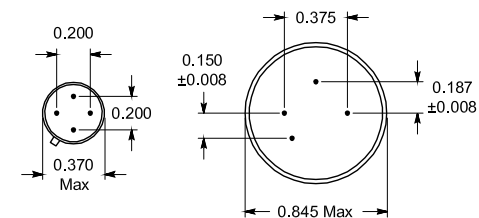
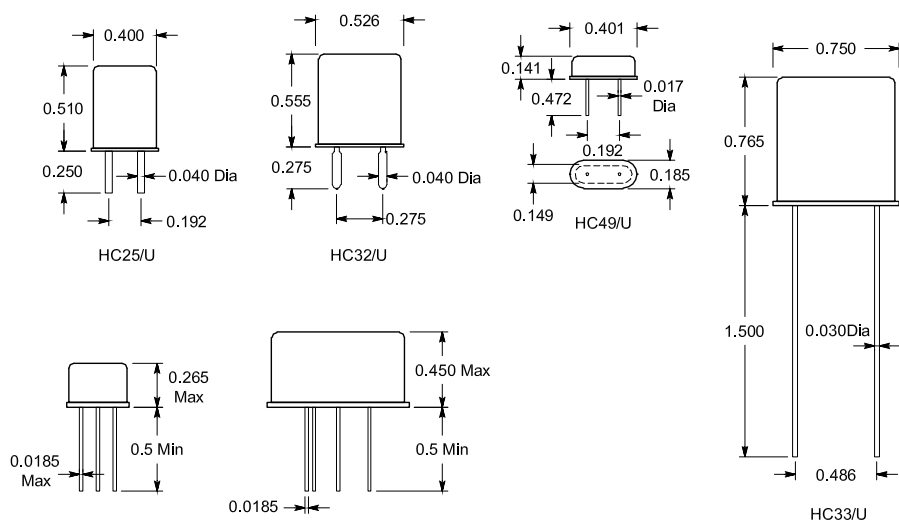
<i>Type</i>	<i>Characteristics</i>
T0	Special soft condition
T3	Hard
T6	Very hard, possibly brittle
TXXX	Three digit tempers—usually specialized high-strength heat treatments, similar to T6

Table 7.19
Crystal Holders

Note: Solder Seal, Cold Weld, and Resistance Weld sealing methods are commonly available. All dimensions are in inches



* Note: HC17/U pin spacing and diameter is equivalent to the older FT-243 (32 pF) holder.

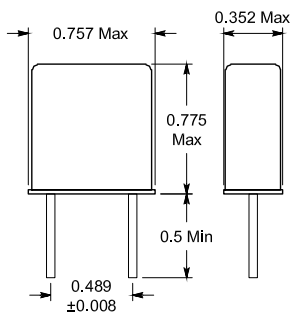


PIN	CONNECTION
1	No Connection
2	Crystal
3	Ground
4	Crystal

HC 35 (TO-5)

PIN	CONNECTION
1	No Connection
2	Crystal
3	Ground
4	Crystal

HC 40 (TL-90)



HBK05_07-06

* Note: HC17/U pin spacing and diameter is equivalent to the older FT-243 (32 pF) holder.

of component data.

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mail (TIS, ARRL, 225 Main St, Newington, CT 06111). The TIS also maintains a home page on ARRL Web site: www.arrl.org/tis. This site contains links to detailed, commonly needed information in many technical areas.

The *TISfind* 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*. This valuable software is included on the Handbook CD-ROM bundled with this book or online at www.arrl.org/tis/tisfind.html.

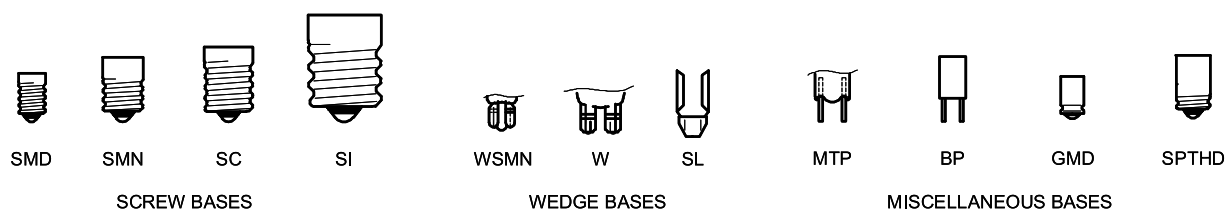
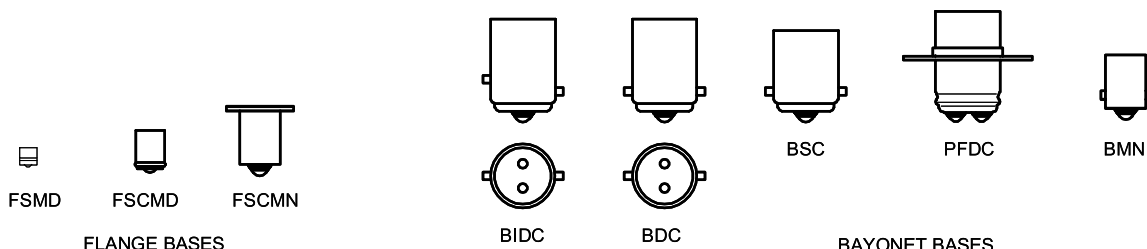
Table 7.20
Miniature Lamp Guide

HBK05_07-07



** Bulbs are described by a letter indicating shape and a number that is an approximation of diameter expressed in eighths of an inch. For example S - 8 is "S" shape, 8 eighths or 1 inch in diameter.

BULB STYLES



Lamp Base Legend	BDC	Bayonet, dual-contact	FSCMD	Flanged, midget single-contact	SI	Screw, intermediate
	BIDC	Bayonet, indexed dual-contact	FSMD	Flanged, submidget	SMD	Screw, midget
	BMN	Bayonet, miniature	GMD	Midget grooved	SMN	Screw, miniature
	BP	Bipin	MTP	Miniature two-pin	SPTH	Screw, special thread
	BSC	Bayonet, single-contact	PFDC	Prefocused dual-contact	W	Wedge
	FSCMN	Flanged, single-contact, miniature	SL	Slide (various sizes)	WSMN	Wedge, subminiature
			SC	Screw, candelabra	WT	Wire terminal

Type	Bulb	Base	V	A	Life	Type	Bulb	Base	V	A	Life
PR2	B-3 ¹ / ₂	FSCMN	2.38	0.500	15	82	G-6	BDC	6.50	1.020	500
PR3	B-3 ¹ / ₂	FSCMN	3.57	0.500	15	85	T-1 ³ / ₄	WSMN	28.00	0.040	7K
PR4	B-3 ¹ / ₂	FSCMN	2.33	0.270	10	86	T-1 ³ / ₄	WSMN	6.30	0.200	20K
PR6	B-3 ¹ / ₂	FSCMN	2.47	0.300	30	88	S-8	BDC	6.80	1.910	300
PR7	B-3 ¹ / ₂	FSCMN	3.70	0.300	30	93	S-8	BSC	12.80	1.040	700
PR12	B-3 ¹ / ₂	FSCMN	5.95	0.500	15	112	TL-3	SMN	1.20	0.220	5
PR13	B-3 ¹ / ₂	FSCMN	4.75	0.500	15	130	G-3 ¹ / ₂	BMN	6.30	0.150	5K
10	G-3 ¹ / ₂	MTP	2.50	0.500	3K	131	G-3 ¹ / ₂	SMN	1.30	0.100	50
12	G-3 ¹ / ₂	MTP	6.30	0.150	5K	158	T-3 ¹ / ₄	W	14.00	0.240	500
13	G-3 ¹ / ₂	SMN	3.70	0.300	15	159	T-3 ¹ / ₄	W	6.30	0.150	5K
14	G-3 ¹ / ₂	SMN	2.47	0.300	15	161	T-3 ¹ / ₄	W	14.00	0.190	4K
19	G-3 ¹ / ₂	MTP	14.4	0.100	1K	168	T-3 ¹ / ₄	W	14.00	0.350	1.5K
27	G-4 ¹ / ₂	SMN	4.90	0.300	30	219	G-3 ¹ / ₂	BMN	6.30	0.250	5K
37	T-1 ³ / ₄	WSMN	14.00	0.090	1.5K	222	TL-3	SMN	2.25	0.250	0.5
40	T-3 ¹ / ₄	SMN	6.30	0.150	3K	239	T-3 ¹ / ₄	BMN	6.30	0.360	5K
43	T-3 ¹ / ₄	BMN	2.50	0.500	3K	240	T-3 ¹ / ₄	BMN	6.30	0.360	5K
44	T-3 ¹ / ₄	BMN	6.30	0.250	3K	259	T-3 ¹ / ₄	W	6.30	0.250	5K
45	T-3 ¹ / ₄	BMN	3.20	0.350	3K	268	T-1 ³ / ₄	FSCMD	2.50	0.350	10K
46	T-3 ¹ / ₄	SMN	6.30	0.250	3K	305	S-8	BSC	28.00	0.510	300
47	T-3 ¹ / ₄	BMN	6.30	0.150	3K	307	S-8	BSC	28.00	0.670	300
48	T-3 ¹ / ₄	SMN	2.00	0.060	1K	308	S-8	BDC	28.00	0.670	300
49	T-3 ¹ / ₄	BMN	2.00	0.060	1K	313	T-3 ¹ / ₄	BMN	28.00	0.170	500
50	G-3 ¹ / ₂	SMN	7.50	0.220	1K	323	T-1 ¹ / ₄	SPTH	3.00	0.190	350
51	G-3 ¹ / ₂	BMN	7.50	0.220	1K	327	T-1 ³ / ₄	FSCMD	28.00	0.040	4K
52	G-3 ¹ / ₂	SMN	14.40	0.100	1K	327AS15	T-1 ³ / ₄	FSCMD	28.00	0.040	4K
53	G-3 ¹ / ₂	BMN	14.40	0.120	1K	328	T-1 ³ / ₄	FSCMD	6.00	0.200	1K
55	G-4 ¹ / ₂	BMN	7.00	0.410	500	330	T-1 ³ / ₄	FSCMD	14.00	0.080	1.5K
57	G-4 ¹ / ₂	BMN	14.00	0.240	500	331	T-1 ³ / ₄	FSCMD	1.35	0.060	3K
63	G-6	BSC	7.00	0.630	1K	334	T-1 ³ / ₄	GMD	28.00	0.040	4K
73	T-1 ³ / ₄	WSMN	14.00	0.080	15K	335	T-1 ³ / ₄	SMD	28.00	0.040	4K
74	T-1 ³ / ₄	WSMN	14.00	0.100	500	336	T-1 ³ / ₄	GMD	14.00	0.080	1.5K

Type	Bulb	Base	V	A	Life	Type	Bulb	Base	V	A	Life
337	T-1 ^{3/4}	GMD	6.00	0.200	1K	1866	T-3 ^{1/4}	BMN	6.30	0.250	5K
338	T-1 ^{3/4}	FSCMD	2.70	0.060	6K	1869	T-1 ^{3/4}	WT	10.00	0.014	50K
342	T-1 ^{3/4}	SMD	6.00	0.040	10K	1891	T-3 ^{1/4}	BMN	14.00	0.240	500
344	T-1 ^{3/4}	FSCMD	10.00	0.014	50K	1892	T-3 ^{1/4}	BMN	14.40	0.120	1K
345	T-1 ^{3/4}	FSCMD	6.00	0.040	10K	1893	T-3 ^{1/4}	BMN	14.00	0.330	7.5K
346	T-1 ^{3/4}	GMD	18.00	0.040	10K	1895	G-4 ^{1/2}	BMN	14.00	0.270	2K
349	T-1 ^{3/4}	FSCMD	6.30	0.200	5K	2102	T-1 ^{3/4}	WT	18.00	0.040	10K
370	T-1 ^{3/4}	FSCMD	18.00	0.040	10K	2107	T-1 ^{3/4}	WT	10.00	0.040	5K
373	T-1 ^{3/4}	SMD	14.00	0.080	1.5K	2158	T-1 ^{3/4}	WT	3.00	0.015	10K
375	T-1 ^{3/4}	FSCMD	3.00	0.015	10K	2162	T-1 ^{3/4}	WT	14.00	0.100	10K
376	T-1 ^{3/4}	FSCMD	28.00	0.060	25K	2169	T-1 ^{3/4}	WT	2.50	0.350	20K
380	T-1 ^{3/4}	FSCMD	6.30	0.040	20K	2180	T-1 ^{3/4}	WT	6.30	0.040	20K
381	T-1 ^{3/4}	FSCMD	6.30	0.200	20K	2181	T-1 ^{3/4}	WT	6.30	0.200	20K
382	T-1 ^{3/4}	FSCMD	14.00	0.080	15K	2182	T-1 ^{3/4}	WT	14.00	0.080	40K
385	T-1 ^{3/4}	FSCMD	28.00	0.040	10K	2187	T-1 ^{3/4}	WT	28.00	0.040	7K
386	T-1 ^{3/4}	GMD	14.00	0.080	15K	2304	T-1 ^{3/4}	BP	3.00	0.300	1.5K
387	T-1 ^{3/4}	FSCMD	28.00	0.040	7K	2307	T-1 ^{3/4}	BP	6.30	0.200	5K
388	T-1 ^{3/4}	GMD	28.00	0.040	7K	2314	T-1 ^{3/4}	BP	28.00	0.050	1K
397	T-1 ^{3/4}	GMD	10.00	0.040	5K	2316	T-1 ^{3/4}	BP	18.00	0.040	10K
398	T-1 ^{3/4}	GMD	6.30	0.200	5K	2324	T-1 ^{3/4}	BP	28.00	0.040	4K
399	T-1 ^{3/4}	SMD	28.00	0.040	7K	2335	T-1 ^{3/4}	BP	14.00	0.080	15K
502	G-4 ^{1/2}	SMN	5.10	0.150	100	2337	T-1 ^{3/4}	BP	6.30	0.200	20K
555	T-3 ^{1/4}	W	6.30	0.250	3K	2342	T-1 ^{3/4}	BP	28.00	0.040	25K
656	T-3 ^{1/4}	W	28.00	0.060	2.5K	3149	T-1 ^{3/4}	BP	5.00	0.060	5K
680AS15	T-1	WT	5.00	0.060	60K	6803AS25	T-3 ⁴	WT	5.00	0.060	60K
682AS15	T-1	FSMD	5.00	0.060	60K	6833AS15	T-3 ⁴	WT	5.00	0.060	25K
683AS15	T-1	WT	5.00	0.060	25K	6838	T-1	WT	28.00	0.024	4K
685AS15	T-1	FSMD	5.00	0.060	25K	6839	T-1	FSMD	28.00	0.024	4K
715AS15	T-1	WT	5.00	0.115	40K	7001	T-1 ^{3/4}	BP	24.00	0.050	2K
715AS25	T-1	WT	5.00	0.115	40K	7003	T-1 ^{3/4}	BP	24.00	0.050	2K
718AS25	T-1	FSMD	5.00	0.115	40K	7153AS15	T-3 ⁴	WT	5.00	0.115	40K
755	T-3 ^{1/4}	BMN	6.30	0.150	20K	7265	T-1	BP	5.00	0.060	5K
756	T-3 ^{1/4}	BMN	14.00	0.080	15K	7327	T-1 ^{3/4}	BP	28.00	0.040	4K
757	T-3 ^{1/4}	BMN	28.00	0.080	7.5K	7328	T-1 ^{3/4}	BP	6.00	0.200	1K
1034	S-8	BIDC	14.00	0.590	5K	7330	T-1 ^{3/4}	BP	14.00	0.080	1.5K
1073	S-8	BSC	12.80	1.800	200	7344	T-1 ^{3/4}	BP	10.00	0.014	50K
1130	S-8	BDC	6.40	2.630	200	7349	T-1 ^{3/4}	BP	6.30	0.200	5K
1133	RP-11	BSC	6.20	3.910	200	7361	T-1 ^{3/4}	BP	5.00	0.060	25K
1141	S-8	BSC	12.80	1.440	1K	7362	T-1 ^{3/4}	BP	5.00	0.115	40K
1143	RP-11	BSC	12.50	1.980	400	7367	T-1 ^{3/4}	BP	10.00	0.040	5K
1184	RP-11	BDC	5.50	6.250	100	7370	T-1 ^{3/4}	BP	18.00	0.040	10K
1251	G-6	BSC	28.00	0.230	2K	7371	T-1 ^{3/4}	BP	12.00	0.040	10K
1445	G-3 ^{1/2}	BMN	14.40	0.130	2K	7373	T-1 ^{3/4}	BP	14.00	0.100	10K
1487	T-3 ^{1/4}	SMN	14.00	0.200	3K	7374	T-1 ^{3/4}	BP	28.00	0.040	10K
1488	T-3 ^{1/4}	BMN	14.00	0.150	200	7375	T-1 ^{3/4}	BP	3.00	0.015	10K
1490	T-3 ^{1/4}	BMN	3.20	0.160	3K	7376	T-1 ^{3/4}	BP	28.00	0.065	10K
1493	S-8	BDC	6.50	2.750	100	7377	T-1 ^{3/4}	BP	6.30	0.075	1K
1619	S-8	BSC	6.70	1.900	500	7380	T-1 ^{3/4}	BP	6.30	0.040	30K
1630	S-8	PFDC	6.50	2.750	100	7381	T-1 ^{3/4}	BP	6.30	0.200	20K
1691	S-8	BSC	28.00	0.610	1K	7382	T-1 ^{3/4}	BP	14.00	0.080	15K
1705	T-1 ^{3/4}	WT	14.00	0.080	1.5K	7387	T-1 ^{3/4}	BP	28.00	0.040	7K
1728	T-1 ^{3/4}	WT	1.35	0.060	3K	7410	T-1 ^{3/4}	BP	14.00	0.080	15K
1730	T-1 ^{3/4}	WT	6.00	0.040	20K	7839	T-1	BP	28.00	0.025	4K
1738	T-1 ^{3/4}	WT	2.70	0.060	6K	7876	T-1 ^{3/4}	BP	28.00	0.060	25K
1762	T-1 ^{3/4}	WT	28.00	0.040	4K	7931	T-1 ^{3/4}	BP	1.35	0.060	3K
1764	T-1 ^{3/4}	WT	28.00	0.040	4K	7945	T-1 ^{3/4}	BP	6.00	0.040	20K
1767	T-1 ^{3/4}	SMD	2.50	0.200	500	7968	T-1 ^{3/4}	BP	2.50	0.200	500
1768	T-1 ^{3/4}	SMD	6.00	0.200	1K	8099	T-1	BP	18.00	0.020	16K
1775	T-1 ^{3/4}	SMD	6.30	0.075	1K	8362	T-1 ^{3/4}	SMD	14.00	0.080	15K
1813	T-3 ^{1/4}	BMN	14.40	0.100	1K	8369	T-1 ^{3/4}	SMD	28.00	0.065	10K
1815	T-3 ^{1/4}	BMN	14.00	0.200	3K						
1816	T-3 ^{1/4}	BMN	13.00	0.330	1K						
1818	T-3 ^{1/4}	BMN	24.00	0.170	250						
1819	T-3 ^{1/4}	BMN	28.00	0.040	2.5K						
1820	T-3 ^{1/4}	BMN	28.00	0.100	1K						
1821	T-3 ^{1/4}	SMN	28.00	0.170	500						
1822	T-3 ^{1/4}	BMN	36.00	0.100	1K						
1828	T-3 ^{1/4}	BMN	37.50	0.050	3K						
1829	T-3 ^{1/4}	BMN	28.00	0.070	1K						
1835	T-3 ^{1/4}	BMN	55.00	0.050	5K						
1847	T-3 ^{1/4}	BMN	6.30	0.150	5K						
1850	T-3 ^{1/4}	BMN	5.00	0.090	1.5K						
1864	T-3 ^{1/4}	BMN	28.00	0.170	1.5K						

(continued on next page)

Standard Line-Voltage Lamps

Type	V	W	Bulb	Base
10C7DC	115-125	10	C-7	BDC
3S6	120, 125	3	S-6	SC
6S6	30, 48, 115, 120, 125, 130, 135, 145, 155	6	S-6	SC
6S6/R	115-125	6	S-6 (red)	SC
6S6/W	115-125	6	S-6 (white)	SC
6T4-1/2	120, 130	6	T-4 ^{1/2}	SC
7C7	115-125	7	C-7	SC
7C7/W	115-125	7	C-7 (white)	SC
10C7	115-125	10	C-7	SC
10S6	120	10	S-6	SC
10S6/10	220, 230, 250	10	S-6	SC
6S6DC	30, 120, 125, 145	6	S-6	BDC
10S6/10DC	230, 250	10	S-6	BDC
40S11 N	115-125	40	S-11	SI
120MB	120	3	T-2 ^{1/2}	BMN
120MB/6	120	6	T-2 ^{1/2}	BMN
120PSB	120	3	T-2	SL
120PS	120	3	T-2	WT
120PS/6	120	6	T-2 ^{1/2}	WT

Indicator Lamps

Each has a T-2 bulb and a slide base.

Type	V	A	Life
6PSB	6.00	0.140	20K
12PSB	12.00	0.170	12K
24PSB	24.00	0.073	10K
28PSB	28.00	0.040	5K
48PSB	48.00	0.050	10K
60PSB	60.00	0.050	7.5K
120PSB	120.00	0.025	7.5K

Neon Glow Lamps

Operating circuit voltage 105-125

Type	Breakdown Voltage			Base	W	External Resistance
	AC	DC	Bulb			
NE-2	65	90	T-2	WT	¹ / ₁₂	150k
NE-2A	65	90	T-2	WT	¹ / ₁₅	100k
NE-2D	65	90	T-2	FSCMD	¹ / ₁₂	100k
NE-2E	65	90	T-2	WT	¹ / ₁₂	100k
NE-2H	95	135	T-2	WT	¹ / ₄	30k
NE-2J	95	135	T-2	FSCMD	¹ / ₄	30k
NE-2V	65	90	T-2	WT	¹ / ₂	100k
NE-45	65	90	T-4 ^{1/2}	SC	¹ / ₄	None
NE-51	65	90	T-3 ^{1/4}	BMN	¹ / ₂₅	220k
NE-51H	95	135	T-3 ^{1/4}	BMN	¹ / ₇	47k
NE-84	95	135	T-2	SL	¹ / ₄	30k
NE-120PSB	95	95	T-2	SL	¹ / ₄	None

Table 7.21

Metal-Oxide Varistor (MOV) Transient Suppressors

Listed by voltage

Type No.	ECG/NTE†† no.	V acRMS	Maximum Applied Voltage V acPeak	Maximum Energy (Joules)	Maximum Peak Current (A)	Maximum Power (W)	Maximum Varistor Voltage (V)
V180ZA1	1V115	115	163	1.5	500	0.2	285
V180ZA10	2V115	115	163	10.0	2000	0.45	290
V130PA10A		130	184	10.0	4000	8.0	350
V130PA20A		130	184	20.0	4000	15.0	350
V130LA1	1V130	130	184	1.0	400	0.24	360
V130LA2	1V130	130	184	2.0	400	0.24	360
V130LA10A	2V130	130	184	10.0	2000	0.5	340
V130LA20A	524V13	130	184	20.0	4000	0.85	340
V150PA10A		150	212	10.0	4000	8.0	410
V150PA20A		150	212	20.0	4000	15.0	410
V150LA1	1V150	150	212	1.0	400	0.24	420
V150LA2	1V150	150	212	2.0	400	0.24	420
V150LA10A	524V15	150	212	10.0	2000	0.5	390
V150LA20A	524V15	150	212	20.0	4000	0.85	390
V250PA10A		250	354	10.0	4000	0.85	670
V250PA20A		250	354	20.0	4000	7.0	670
V250PA40A		250	354	40.0	4000	13.0	670
V250LA2	1V250	250	354	2.0	400	0.28	690
V250LA4	1V250	250	354	4.0	400	0.28	690
V250LA15A	2V250	250	354	15.0	2000	0.6	640
V250LA20A	2V250	250	354	20.0	2000	0.6	640
V250LA40A	524V25	250	354	40.0	4000	0.9	640

††ECG and NTE numbers for these parts are identical, except for the prefix. Add the "ECG" or "NTE" prefix to the numbers shown for the complete part number.

Table 7.22

Voltage-Variable Capacitance Diodes†

Listed numerically by device

Nominal Capacitance									
	<i>pF</i> ±10% @ <i>V_R</i> = 4.0 V <i>f</i> = 1.0 MHz	<i>Capacitance</i> <i>Ratio</i> 2-30 V <i>Min.</i>	<i>Q</i> @ 4.0 V 50 MHz <i>Min.</i>	<i>Case</i> <i>Style</i>		<i>pF</i> ±10% @ <i>V_R</i> = 4.0 V <i>f</i> = 1.0 MHz	<i>Capacitance</i> <i>Ratio</i> 2-30 V <i>Min.</i>	<i>Q</i> @ 4.0 V 50 MHz <i>Min.</i>	<i>Case</i> <i>Style</i>
<i>Device</i>					<i>Device</i>				
1N5441A	6.8	2.5	450	DO-7	1N5471A	39	2.9	450	DO-7
1N5442A	8.2	2.5	450		1N5472A	47	2.9	400	
1N5443A	10	2.6	400		1N5473A	56	2.9	300	
1N5444A	12	2.6	400		1N5474A	68	2.9	250	
1N5445A	15	2.6	450		1N5475A	82	2.9	225	
1N5446A	18	2.6	350	DO-7	1N5476A	100	2.9	200	TO-92
1N5447A	20	2.6	350		MV2101	6.8	2.5	450	
1N5448A	22	2.6	350		MV2102	8.2	2.5	450	
1N5449A	27	2.6	350		MV2103	10	2.0	400	
1N5450A	33	2.6	350		MV2104	12	2.5	400	
1N5451A	39	2.6	300	DO-7	MV2105	15	2.5	400	TO-92
1N5452A	47	2.6	250		MV2106	18	2.5	350	
1N5453A	56	2.6	200		MV2107	22	2.5	350	
1N5454A	68	2.7	175		MV2108	27	2.5	300	
1N5455A	82	2.7	175		MV2109	33	2.5	200	
1N5456A	100	2.7	175	DO-7	MV2110	39	2.5	150	TO-92
1N5461A	6.8	2.7	600		MV2111	47	2.5	150	
1N5462A	8.2	2.8	600		MV2112	56	2.6	150	
1N5463A	10	2.8	550		MV2113	68	2.6	150	
1N5464A	12	2.8	550		MV2114	82	2.6	100	
1N5465A	15	2.8	550	DO-7	MV2115	100	2.6	100	
1N5466A	18	2.8	500		†For package shape, size and pin-connection information, see manufacturers' data sheets.				
1N5467A	20	2.9	500						
1N5468A	22	2.9	500						
1N5469A	27	2.9	500						
1N5470A	33	2.9	500						

Table 7.23

Zener Diodes

Volts	Power (Watts)							
	0.25	0.4	0.5	1.0	1.5	5.0	10.0	50.0
1.8	1N4614							
2.0	1N4615							
2.2	1N4616							
2.4	1N4617	1N4370, A	1N4370,A 1N5221,B 1N5985,B 1N5222B					
2.5								
2.6	1N702,A							
2.7	1N4618	1N4371,A	1N4371,A 1N5223,B 1N5839, 1N5986 1N5224B					
2.8								
3.0	1N4619	1N4372,A	1N4372 1N5225,B 1N5987					
3.3	1N4620	1N746,A 1N764,A 1N5518	1N746,A 1N5226,B 1N5988	1N3821 1N4728,A	1N5913	1N5333,B		
3.6	1N4621	1N747,A 1N5519	1N747,A 1N5227,B 1N5989	1N3822 1N4729,A	1N5914	1N5334,B		
3.9	1N4622	1N748,A 1N5520	1N748A 1N5228,B 1N5844, 1N5990	1N3823 1N4730,A	1N5915	1N5335,B	1N3993A	1N4549,B 1N4557,B
4.1	1N704,A							
4.3	1N4623	1N749,A 1N5521	1N749,A, 1N5229,B 1N5845 1N5991	1N3824 1N4731,A	1N5916	1N5336,B	1N3994,A	1N4550,B 1N4558,B

(continued on next page)

Volts	Power (Watts)							
	0.25	0.4	0.5	1.0	1.5	5.0	10.0	50.0
4.7	1N4624	1N750A 1N5522	1N750A 1N5230,B 1N5846, 1N5992	1N3825 1N4732,A	1N5917	1N5337,B	1N3995,A 1N4559,B	1N4551,B
5.1	1N4625 1N4689	1N751,A 1N5523	1N751,A, 1N5231,B 1N5847 1N5993	1N3826 1N4733	1N5918	1N5338,B	1N3996,A	1N4552,B 1N4560
5.6	1N708A 1N4626	1N752,A 1N5524	1N752,A 1N5232,B 1N5848, 1N5994	1N3827 1N4734,A	1N5919	1N5339,B	1N3997,A	2N4553,B 1N4561,B
5.8 6.0	1N706A	1N762	1N5233B 1N5849			1N5340,B		
6.2	1N709, 1N4627 MZ605, MZ610 MZ620,MZ640 1N4565-84,A	1N753,A	1N753,A 1N821,3,5,7,9;A	1N3828,A 1N5234,B, 1N5995	1N5920 1N5850	1N5341,B 1N4735,A	1N3998,A	1N4554,B 1N4562,B
6.4 6.8	1N4099	1N754,A 1N957,B 1N5526	1N754,A, 1N757,B 1N5235,B 1N5851 1N5996	1N3016,B 1N3829 1N4736,A	1N3785 1N5921	1N5342,B	1N2970,B 1N3999,A	1N2804B 1N3305B 1N4555, 1N4563
7.5	1N4100	1N755,A 1N958,B 1N5527	1N755,A, 1N958,B 1N5236,B 1N5852 1N5997	1N3017,A,B 1N3830 1N4737,A	1N3786 1N5922	1N5343,B	1N2971,B 1N4000,A	1N2805,B 1N3306,B 1N4556, 1N4564
8.0 8.2	1N707A 1N712A 1N4101	1N756,A 1N959,B 1N5528	1N756,A 1N959,B 1N5237,B 1N5853 1N5998	1N3018,B 1N4738,A	1N3787 1N5923	1N5344,B	1N2972,B	1N2806,B 1N3307,B
8.4		1N3154-57,A	1N3154,A 1N3155-57					
8.5	1N4775-84,A		1N5238,B 1N5854					
8.7 8.8 9.0 9.1	1N4102	1N764 1N764A	1N935-9;A,B			1N5345,B		
10.0	1N4103	1N757,A 1N960,B 1N5529	1N757,A, 1N960,B 1N5239,B, 1N5855 1N5999	1N3019,B 1N4739,A	1N3788 1N5924	1N5346,B	1N2973,B	1N2807,B 1N3308,B
11.0	1N4104	1N758,A 1N961,B 1N5530,B	1N758,A, 1N961,B 1N5240,B, 1N5856 1N6000	1N3020,B 1N4740,A	1N3789 1N5925	1N5347,B	1N2974,B	1N2808,B 1N3309,A,B
11.7	1N715,A 1N4105	1N962,B 1N5531	1N962,B 1N5241,B 1N5857, 1N6001 1N941-4;A,B	1N3021,B 1N4741,A	1N3790 1N5926	1N5348,B	1N2975,B	1N2809,B 1N3310,B
12.0	1N716,A 1N4106	1N759,A 1N963,B 1N5532	1N759,A, 1N963,B 1N5242,B, 1N5858 1N6002	1N3022,B 1N4742,A	1N3791 1N5927	1N5349,B	1N2976,B	1N2810,B 1N3311,B
13.0	1N4107	1N964,B 1N5533	1N964,B 1N5243,B, 1N5859 1N6003	1N3023,B 1N4743,A	1N3792 1N5928	1N5350,B	1N2977,B	1N2811,B 1N3312,B
14.0	1N4108	1N5534	1N5244B 1N5860			1N5351,B	1N2978,B	1N2812,B 1N3313,B
15.0	1N4109	1N965,B 1N5535	1N965,B 1N5245,B, 1N5861 1N6004	1N3024,B 1N4744A	1N3793 1N5929	1N5352,B	1N2979,A,B	1N2813,A,B 1N3314,B
16.0	1N4110	1N966,B 1N5536	1N966,B, 1N5246,B 1N5862, 1N6005	1N3025,B 1N4745,A	1N3794 1N5930	1N5353,B	1N2980,B	1N2814,B 1N3315,B
17.0	1N4111	1N5537	1N5247,B 1N5863			1N5354,B	1N2981B	1N2815,B 1N3316,B
18.0	1N4112	1N967,B 1N5538	1N967,B 1N5248,B 1N5864, 1N6006	1N3026,B 1N4746,A	1N3795 1N5931	1N5355,B	1N2982,B	1N2816,B 1N3317,B
19.0	1N4113	1N5539	1N5249,B 1N5865			1N5356,B	1N2983,B	1N2817,B 1N3318,B
20.0	1N4114	1N968,B 1N5540	1N968,B 1N5250,B 1N5866, 1N6007	1N3027,B 1N4747,A	1N3796 1N5932,A,B	1N5357,B	1N2984,B	1N2818,B 1N3319,B
22.0	1N4115	1N969,B 1N5541	1N969,B 1N5241,B 1N5867, 1N6008	1N3028,B 1N4748,A	1N3797 1N5933	1N5358,B	1N2985,B	1N2819,B 1N3320,A,B

Volts	Power (Watts)							
	0.25	0.4	0.5	1.0	1.5	5.0	10.0	50.0
24.0	1N4116	1N5542 1N970B	1N970,B 1N5252,B, 1N5868 1N6009	1N3029,B 1N4749,A	1N3798 1N5934	1N5359,B	1N2986,B	1N2820,B 1N3321,B
25.0	1N4117	1N5543	1N5253,B 1N5869			1N5360,B	1N2987B	1N2821,B 1N3322,B
27.0	1N4118	1N971,B	1N971 1N5254,B, 1N5870 1N6010	1N3030,B 1N4750,A	1N3799 1N5935	1N5361,B	1N2988,B	1N2822B 1N3323,B
28.0	1N4119	1N5544	1N5255,B 1N5871			1N5362,B		
30.0	1N4120	1N972,B 1N5545	1N972,B 1N5256,B, 1N5872 1N6011	1N3031,B 1N4751,A	1N3800 1N5936	1N5363,B	1N2989,B	1N2823,B 1N3324,B
33.0	1N4121	1N973,B 1N5546	1N973,B 1N5257,B 1N5873, 1N6012	1N3032,B 1N4752,A	1N3801 1N5937	1N5364,B	1N2990,A,B	1N2824,B 1N3325,B
36.0	1N4122	1N974,B	1N974,B 1N5258,B 1N5874, 1N6013	1N3033,B 1N4753,A	1N3802 1N5938	1N5365,B	1N2991,B	1N2825,B 1N3326,B
39.0	1N4123	1N975,B	1N975,B, 1N5259,B 1N5875, 1N6014	1N3034,B 1N4754,A	1N3803 1N5939	1N5366,B	1N2992,B	1N2826,B 1N3327,B
43.0	1N4124	1N976,B	1N976,B 1N5260,B, 1N5876 1N6015	1N3035,B 1N4755,A	1N3804 1N5940	1N5367,B	1N2993,A,B	1N2827,B 1N3328,B
45.0							1N2994B	1N2828B 1N3329B
47.0	1N4125	1N977,B	1N977,B, 1N5261,B 1N5877, 1N6016	1N3036,B 1N4756,A	1N3805 1N5941	1N5368,B	1N2996,B	1N2829,B 1N3330,B 1N2830B 1N3331B
50.0								
51.0	1N4126	1N978,B	1N978,B, 1N5262,A,B 1N5878, 1N6017	1N3037,B 1N4757,A	1N3806 1N5942	1N5369,B	1N2997,B	1N2831,B 1N3332,B 1N3333
52.0							1N2998B	
56.0	1N4127	1N979,B	1N979 1N5263,B 1N6018	1N3038,B 1N4758,A	1N3807 1N5943	1N5370,B	1N2999,B	1N2822,B 1N3334,B
60.0	1N4128		1N5264,A,B			1N5371,B		
62.0	1N4129	1N980,B	1N980 1N5265,A,B, 1N6019	1N3039,B 1N4759,A	1N3808 1N5944	1N5372,B	1N3000,B	1N2833,B 1N3335,B
68.0	1N4130	1N981,B	1N981,B 1N5266,A,B, 1N6020	1N3040,A,B 1N4760,A	1N3809 1N5945	1N5373,B	1N3001,B	1N2834,B 1N3336,B
75.0	1N4131	1N982,B	1N982 1N5267,A,B, 1N6021	1N3041,B 1N4761,A	1N3810 1N5946	1N5374,B	1N3002,B	1N2835,B 1N3337,B
82.0	1N4132	1N983,B	1N983 1N5268,A,B, 1N6022	1N3042,B 1N4762,A	1N3811 1N5947	1N5375,B	1N3003,B	1N2836,B 1N3338,B
87.0	1N4133		1N5269,B			1N5376,B		
91.0	1N4134	1N984,B	1N984 1N5270,B, 1N6023	1N3043,B 1N4763,A	1N3812 1N5948	1N5377,B	1N3004,B	1N2837,B 1N3339,B
100.0	1N4135	1N985	1N985,B 1N5271,B, 1N6024	1N3044,A,B 1N4764,A	1N3813 1N5949	1N5378,B	1N3005,B	1N2838,B 1N3340,B
105.0							1N3006B	1N2839,B 1N3341,B
110.0		1N986	1N986 1N5272,B, 1N6025	1N3045,B 1M110ZS10	1N3814 1N5950	1N5379,B	1N3007A,B	1N2840,B 1N3342,B
120.0		1N987	1N987,B 1N5273,B, 1N6026	1N3046,B 1M120ZS10	1N3815 1N5951	1N5380,B	1N3008A,B	1N2841,B 1N3343,B
130.0		1N988	1N988,B 1N5274,B, 1N6027	1N3047,B 1M130ZS10	1N3816 1N5952	1N5381,B	1N3009,B	1N2842,B 1N3344,B
140.0			1N5275,B			1N5382B	1N3010B	1N3345B
150.0		1N989	1N989,B 1N5276,B, 1N6028	1N3048,B 1M150ZS10	1N3817 1N5953	1N5383,B	1N3011,B	1N2843,B 1N3346,B
160.0		1N990	1N990,B 1N5277,B, 1N6029	1N3048,B 1M160ZS10	1N3818 1N5954	1N5384,B	1N3012A,B	1N2844B 1N3347,B
170.0			1N5278,B	1M170ZS10		1N5385,B		
175.0							1N3013B	1N3348B
180.0			1N991,B, 1N5279,B 1N6030	1M180ZS10 1N3819	1N5955			1N3349,B
190.0			1N5280,B			1N5387,B		
200.0			1N992, 1N5281,B 1N6031	1N3051,B 1M200ZS10	1N3820 1N5956	1N5388B	1N3015,B	1N2846,B 1N3350,B

Table 7.24

Semiconductor Diode Specifications[†]

Listed numerically by device

Device	Type	Material	Peak Inverse Voltage, PIV (V)	Average Rectified Current Forward (Reverse) $I_O(A)/I_R(A)$	Peak Surge Current, I_{FSM} 1 s @ 25°C (A)	Average Forward Voltage, V_F (V)
1N34	Signal	Ge	60	8.5 m (15.0 μ)		1.0
1N34A	Signal	Ge	60	5.0 m (30.0 μ)		1.0
1N67A	Signal	Ge	100	4.0 m (5.0 μ)		1.0
1N191	Signal	Ge	90	15.0 m		1.0
1N270	Signal	Ge	80	0.2 (100 μ)		1.0
1N914	Fast Switch	Si	75	75.0 m (25.0 n)	0.5	1.0
1N1183	RFR	Si	50	40 (5 m)	800	1.1
1N1184	RFR	Si	100	40 (5 m)	800	1.1
1N2071	RFR	Si	600	0.75 (10.0 μ)		0.6
1N3666	Signal	Ge	80	0.2 (25.0 μ)		1.0
1N4001	RFR	Si	50	1.0 (0.03 m)		1.1
1N4002	RFR	Si	100	1.0 (0.03 m)		1.1
1N4003	RFR	Si	200	1.0 (0.03 m)		1.1
1N4004	RFR	Si	400	1.0 (0.03 m)		1.1
1N4005	RFR	Si	600	1.0 (0.03 m)		1.1
1N4006	RFR	Si	800	1.0 (0.03 m)		1.1
1N4007	RFR	Si	1000	1.0 (0.03 m)		1.1
1N4148	Signal	Si	75	10.0 m (25.0 n)		1.0
1N4149	Signal	Si	75	10.0 m (25.0 n)		1.0
1N4152	Fast Switch	Si	40	20.0 m (0.05 μ)		0.8
1N4445	Signal	Si	100	0.1 (50.0 n)		1.0
1N5400	RFR	Si	50	3.0 (500 μ)	200	
1N5401	RFR	Si	100	3.0 (500 μ)	200	
1N5402	RFR	Si	200	3.0 (500 μ)	200	
1N5403	RFR	Si	300	3.0 (500 μ)	200	
1N5404	RFR	Si	400	3.0 (500 μ)	200	
1N5405	RFR	Si	500	3.0 (500 μ)	200	
1N5406	RFR	Si	600	3.0 (500 μ)	200	
1N5408	RFR	Si	1000	3.0 (500 μ)	200	
1N5711	Schottky	Si	70	1 m (200 n)	15 m	0.41 @ 1 mA
1N5767	Signal	Si		0.1 (1.0 μ)		1.0
1N5817	Schottky	Si	20	1.0 (1 m)	25	0.75
1N5819	Schottky	Si	40	1.0 (1 m)	25	0.9
1N5821	Schottky	Si	30	3.0		
ECG5863	RFR	Si	600	6	150	0.9
1N6263	Schottky	Si	70	15 m	50 m	0.41 @ 1 mA
5082-2835	Schottky	Si	8	1 m (100 n)	10 m	0.34 @ 1 mA

Si = Silicon; Ge = Germanium; RFR = rectifier, fast recovery.

[†]For package shape, size and pin-connection information see manufacturers' data sheets. Many retail suppliers offer data sheets to buyers free of charge on request. Data books are available from many manufacturers and retailers.

Table 7.25

Suggested Small-Signal FETs

Device	Type	Max Diss (mW)	Max V_{DS} (V)	$V_{GS(off)}$ (V)	Min gfs (μS)	Input C (pF)	Max ID (mA) ¹	f_{max} (MHz)	Noise Figure (typ)	Case	Base	Applications
2N4416	N-JFET	300	30	-6	4500	4	-15	450	4 dB @ 400 MHz	TO-72	1	VHF/UHF amp, mix, osc
2N5484	N-JFET	310	25	-3	2500	5	30	200	4 dB @ 200 MHz	TO-92	2	VHF/UHF amp, mix, osc
2N5485	N-JFET	310	25	-4	3500	5	30	400	4 dB @ 400 MHz	TO-92	2	VHF/UHF amp, mix, osc
2N5486	N-JFET	360	25	-2	5500	5	15	400	4 dB @ 400 MHz	TO-92	2	VHF/UHF amp, mix, osc
3N200	N-dual-gate	330	20	-6	10,000	4-8.5	50	500	4.5 dB @ 400 MHz	TO-72	3	VHF/UHF amp, mix, osc
NTE222	MOSFET											
SK3065												
3N202	N-dual-gate	360	25	-5	8000	6	50	200	4.5 dB @ 200 MHz	TO-72	3	VHF amp, mixer
NTE454	MOSFET											
SK3991												
MPF102	N-JFET	310	25	-8	2000	4.5	20	200	4 dB @ 400 MHz	TO-92	2	HF/VHF amp, mix, osc
NTE451												
SK9164												
MPF106	N-JFET	310	25	-6	2500	5	30	400	4 dB @ 200 MHz	TO-92	2	HF/VHF/UHF amp, mix, osc
2N5484												
40673	N-dual-gate	330	20	-4	12,000	6	50	400	6 dB @ 200 MHz	TO-72	3	HF/VHF/UHF amp, mix, osc
NTE222	MOSFET											
SK3050												
U304	P-JFET	350	-30	+10	27		-50	—	—	TO-18	4	analog switch chopper
U310	N-JFET	500	30	-6	10,000	2.5	60	450	3.2 dB @ 450 MHz	TO-52	5	common-gate
		300	30									VHF/UHF amp,
U350	N-JFET	1W	25	-6	9000	5	60	100	7 dB @ 100 MHz	TO-99	6	matched JFET
	Quad											doubly bal mix
U431	N-JFET	300	25	-6	10,000	5	30	100	—	TO-99	7	matched JFET
	Dual											cascode amp and bal mix
2N5670	N-JFET	350	25	8	3000	7	20	400	2.5 dB @ 100 MHz	TO-92	2	VHF/UHF osc, mix,
												front-end amp
2N5668	N-JFET	350	25	4	1500	7	5	400	2.5 dB @ 100 MHz	TO-92	2	VHF/UHF osc, mix,
												front-end amp
2N5669	N-JFET	350	25	6	2000	7	10	400	2.5 dB @ 100 MHz	TO-92	2	VHF/UHF osc,
												mix, front-end amp
J308	N-JFET	350	25	6.5	8000	7.5	60	1000	1.5 dB @ 100 MHz	TO-92	2	VHF/UHF osc,
												mix, front-end amp
J309	N-JFET	350	25	4	10,000	7.5	30	1000	1.5 dB @ 100 MHz	TO-92	2	VHF/UHF osc,
												mix, front-end amp
J310	N-JFET	350	25	6.5	8000	7.5	60	1000	1.5 dB @ 100 MHz	TO-92	2	VHF/UHF osc,
												mix, front-end amp
NE32684A	HJ-FET	165	2.0	-0.8	45,000	—	30	20 GHz	0.5 dB @ 12 GHz	84A		Low-noise amp

Notes:

¹25°C.

For package shape, size and pin-connection information, see manufacturers' data sheets.

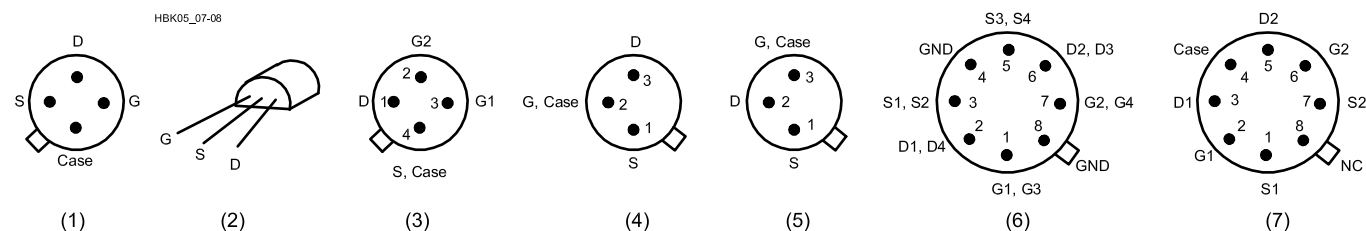


Table 7.26

Low-Noise Transistors

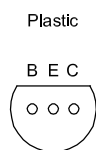
Device	NF (dB)	F (MHz)	f_T (GHz)	I_C (mA)	Gain (dB)	F (MHz)	$V_{(BR)CEO}$ (V)	I_C (mA)	P_T (mW)	Case
MRF904	1.5	450	4	15	16	450	15	30	200	TO-206AF
MRF571	1.5	1000	8	50	12	1000	10	70	1000	Macro-X
MRF2369	1.5	1000	6	40	12	1000	15	70	750	Macro-X
MPS911	1.7	500	7	30	16.5	500	12	40	625	TO-226AA
MRF581A	1.8	500	5	75	15.5	500	15	200	2500	Macro-X
BFR91	1.9	500	5	30	16	500	12	35	180	Macro-T
BFR96	2	500	4.5	50	14.5	500	15	100	500	Macro-T
MPS571	2	500	6	50	14	500	10	80	625	TO-226AA
MRF581	2	500	5	75	15.5	500	18	200	2500	Macro-X
MRF901	2	1000	4.5	15	12	1000	15	30	375	Macro-X
MRF941	2.1	2000	8	15	12.5	2000	10	15	400	Macro-X
MRF951	2.1	2000	7.5	30	12.5	2000	10	100	1000	Macro-X
BFR90	2.4	500	5	14	18	500	15	30	180	Macro-T
MPS901	2.4	900	4.5	15	12	900	15	30	300	TO-226AA
MRF1001A	2.5	300	3	90	13.5	300	20	200	3000	TO-205AD
2N5031	2.5	450	1.6	5	14	450	10	20	200	TO-206AF
MRF4239A	2.5	500	5	90	14	500	12	400	3000	TO-205AD
BFW92A	2.7	500	4.5	10	16	500	15	35	180	Macro-T
MRF521*	2.8	1000	4.2	-50	11	1000	-10	-70	750	Macro-X
2N5109	3	200	1.5	50	11	216	20	400	2500	TO-205AD
2N4957*	3	450	1.6	-2	12	450	-30	-30	200	TO-206AF
MM4049*	3	500	5	-20	11.5	500	-10	-30	200	TO-206AF
2N5943	3.4	200	1.5	50	11.4	200	30	400	3500	TO-205AD
MRF586	4	500	1.5	90	9	500	17	200	2500	TO-205AD
2N5179	4.5	200	1.4	10	15	200	12	50	200	TO-206AF
2N2857	4.5	450	1.6	8	12.5	450	15	40	200	TO-206AF
2N6304	4.5	450	1.8	10	15	450	15	50	200	TO-206AF
MPS536*	4.5	500	5	-20	4.5	500	-10	-30	625	TO-226AA
MRF536*	4.5	1000	6	-20	10	1000	-10	-30	300	Macro-X

*denotes a PNP device

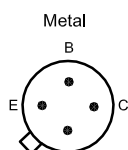
Complementary devices

NPN	PNP
2N2857	2N4957
MRF904	MM4049
MRF571	MRF521

For package shape, size and pin-connection information, see manufacturers' data sheets. Many retail suppliers and manufacturers offer data sheets on their Web sites.

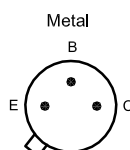


TO-226AA

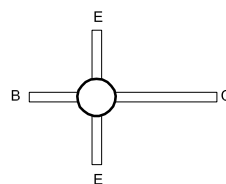


TO-206AF

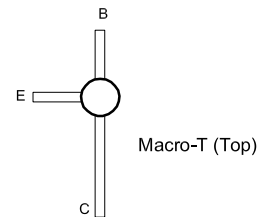
Bottom View, Base Pinouts



TO-205AD



Macro-X (Top)



Macro-T (Top)

HBK05_07-09

Table 7.27

Monolithic Amplifiers (50 Ω)
Mini-Circuits Labs MMICs

<i>Device</i>	<i>Freq Range (MHz)</i>	<i>Gain (dB) at 1000 MHz</i>	<i>Output Level 1 dB Comp (dBm)</i>	<i>NF (dB)</i>	<i>I_{max} (mA)</i>	<i>P_{max} (mW)</i>
ERA-1	dc - 8000	12.1	+12.0	4.3	75	330
ERA-2	dc - 6000	15.8	+13.0	4.0	75	330
ERA-3	dc - 3000	21.0	+12.5	3.5	75	330
ERA-4	dc - 4000	14.0	+17.3	4.2	120	650
ERA-5	dc - 4000	19.5	+18.4	4.3	120	650
ERA-6	dc - 4000	12.5	+17.9	4.5	12	650
GAL-1	dc - 8000	12.5	+12.2	4.5	55	225
GAL-2	dc - 8000	15.8	+12.9	4.6	55	225
GAL-3	dc - 8000	21.1	+12.5	3.5	55	225
GAL-4	dc - 8000	14.1	+17.5	4.0	85	475
GAL-5	dc - 8000	19.4	+18.0	3.5	85	475
GAL-6	dc - 8000	12.2	+18.2	4.5	85	475
GAL-21	dc - 8000	13.9	+12.6	4.0	55	225
GAL-33	dc - 8000	18.7	+13.4	3.9	55	265
GAL-51	dc - 8000	17.5	+18.0	3.5	85	475
HELA-10B	50 - 1000	12.0	+30.0	3.5	525	7150
HELA-10D	8 - 300	11.0	+30.0	3.5	525	7150
MAR-1	dc - 1000	15.5	+1.5	5.5	40	200
MAR-2	dc - 2000	12.0	+4.5	6.5	60	325
MAR-3	dc - 2000	12.0	+10.0	6.0	70	400
MAR-4	dc - 1000	8.0	+12.5	6.5	85	500
MAR-6	dc - 2000	16.0	+2.0	3.0	50	200
MAR-7	dc - 2000	12.5	+5.5	5.0	60	275
MAR-8	dc - 1000	22.5	+12.5	3.3	65	500
MAV-1	dc - 1000	15.0	+1.5	5.5	40	200
MAV-2	dc - 1500	11.0	+4.5	6.5	60	325
MAV-3	dc - 1500	11.0	+10.0	6.0	70	400
MAV-4	dc - 1000	7.5	+11.5	7.0	85	500
MAV-11	dc - 1000	10.5	+17.5	3.6	80	550
RAM-1	dc - 1000	15.5	+1.5	5.5	40	200
RAM-2	dc - 2000	11.8	+4.5	6.5	60	325
RAM-3	dc - 2000	12.0	+10.0	6.0	80	425
RAM-4	dc - 1000	8.0	+12.5	6.5	100	540
RAM-6	dc - 2000	16.0	+2.0	2.8	50	200
RAM-7	dc - 2000	12.5	+5.5	4.5	60	275
RAM-8	dc - 1000	23.0	+12.5	3.0	65	420
VAM-3	dc - 2000	11.0	+9.0	6.0	60	240
VAM-6	dc - 2000	15.0	+2.0	3.0	40	125
VAM-7	dc - 2000	12.0	+5.5	5.0	50	175
VNA-25	500 - 2500	18.0	+18.2	5.5	105	1000

Mini-circuits Labs Web site: www.minicircuits.com/.**Avago Technologies MMICs**

<i>Device</i>	<i>Freq Range (MHz)</i>	<i>Typical Gain (dB)</i>	<i>Output Level 1 dB Comp (dBm)</i>	<i>NF (dB)</i>	<i>I_{max} (mA)</i>	<i>P_{max} (mW)</i>
MGA-725M4	100 - 6000	17.6	+13.1	1.2	80	250
MGA-86576	1.5 - 8000	23.0	+6.3	2.0	16	—
MSA-02xx	dc - 2800	12.5	+4.5	6.5	60	325
MSA-03xx	dc - 2800	12.5	+10.0	6.0	80	425
MSA-04xx	dc - 4000	8.3	+11.5	7.0	85	500
MSA-05xx	dc - 2800	7.0	+19.0	6.5	135	1.5
MSA-06xx	dc - 800	19.5	+2.0	3.0	50	200
MSA-07xx	dc - 2500	13.0	+5.5	4.5	50	175
MSA-08xx	dc - 6000	32.5	+12.5	3.0	65	500
MSA-09xx	dc - 6000	7.2	+10.5	6.2	65	500
MSA-11xx	50-1300	12.0	+17.5	3.6	80	550

Avago Web site: www.avagotech.com.

(continued on next page)

Motorola Hybrid Amplifiers (50 Ω)

Device type	Freq Range (MHz)	Gain (dB) min/typ	Supply Voltage (V)	Output Level, 1 dB Comp (dBm)	NF at 250 MHz (dB)
MWA110	0.1 - 400	13/14	2.9	-2.5	4.0
MWA120	0.1 - 400	13/14	5	+8.2	5.5
MWA130	0.1 - 400	13/14	5.5	+18.0	7.0
MWA131	0.1 - 400	13/14	5.5	+20.0	5.0
MWA210	0.1 - 600	9/10	1.75	+1.5	6.0
MWA220	0.1 - 600	9/10	3.2	+10.5	6.5
MWA230	0.1 - 600	9/10	4.4	+18.5	7.5
MWA310	0.1 - 1000	7/8	1.6	+3.5	6.5
MWA320	0.1 - 1000	7/8	2.9	+11.5	6.7
MWA330	0.1 - 1000	na/6.2	4	+15.2	9.0

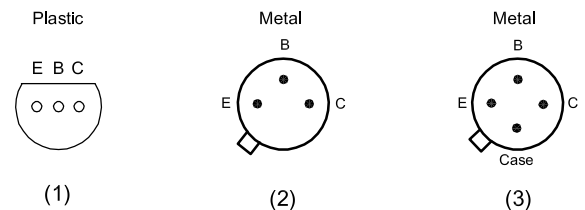
Note: Motorola no longer manufactures these modules but they may be available from distributors.

Table 7.28
General-Purpose Transistors

Listed numerically by device

Device	Type	V_{CE0} Maximum Collector Emitter Voltage (V)	V_{CBO} Maximum Collector Base Voltage (V)	V_{EBO} Maximum Emitter Base Voltage (V)	I_C Maximum Collector Current (mA)	P_O Maximum Device Dissipation (W)	Minimum DC $I_C = 0.1$ mA	Current Gain h_{FE} $I_C = 150$ mA	Current-Gain Bandwidth Product f_T (MHz)	Noise Figure NF Maximum (dB)	Base
2N918	NPN	15	30	3.0	50	0.2	20 (3 mA)	—	600	6.0	3
2N2102	NPN	65	120	7.0	1000	1.0	20	40	60	6.0	2
2N2218	NPN	30	60	5.0	800	0.8	20	40	250		2
2N2218A	NPN	40	75	6.0	800	0.8	20	40	250		2
2N2219	NPN	30	60	5.0	800	3.0	35	100	250		2
2N2219A	NPN	40	75	6.0	800	3.0	35	100	300	4.0	2
2N2222	NPN	30	60	5.0	800	1.2	35	100	250		2
2N2222A	NPN	40	75	6.0	800	1.2	35	100	200	4.0	2
2N2905	PNP	40	60	5.0	600	0.6	35	—	200		2
2N2905A	PNP	60	60	5.0	600	0.6	75	100	200		2
2N2907	PNP	40	60	5.0	600	0.4	35	—	200		2
2N2907A	PNP	60	60	5.0	600	0.4	75	100	200		2
2N3053	NPN	40	60	5.0	700	5.0	—	50	100		2
2N3053A	NPN	60	80	5.0	700	5.0	—	50	100		2
2N3563	NPN	15	30	2.0	50	0.6	20	—	800		1
2N3904	NPN	40	60	6.0	200	0.625	40	—	300	5.0	1
2N3906	PNP	40	40	5.0	200	0.625	60	—	250	4.0	1
2N4037	PNP	40	60	7.0	1000	5.0	—	50			2
2N4123	NPN	30	40	5.0	200	0.35	—	25 (50 mA)	250	6.0	1
2N4124	NPN	25	30	5.0	200	0.35	120 (2 mA)	60 (50 mA)	300	5.0	1
2N4125	PNP	30	30	4.0	200	0.625	50 (2 mA)	25 (50 mA)	200	5.0	1
2N4126	PNP	25	25	4.0	200	0.625	120 (2 mA)	60 (50 mA)	250	4.0	1
2N4401	NPN	40	60	6.0	600	0.625	20	100	250		1
2N4403	PNP	40	40	5.0	600	0.625	30	100	200		1
2N5320	NPN	75	100	7.0	2000	10.0	—	30 (1 A)			2
2N5415	PNP	200	200	4.0	1000	10.0	—	30 (50 mA)	15		2
MM4003	PNP	250	250	4.0	500	1.0	20 (10 mA)	—			2
MPSA55	PNP	60	60	4.0	500	0.625	—	50 (0.1 A)	50		1
MPS6531	NPN	40	60	5.0	600	0.625	60 (10 mA)	90 (0.1 A)			1
MPS6547	NPN	25	35	3.0	50	0.625	20 (2 mA)	—	600		1

Test conditions: $I_C = 20$ mA dc; $V_{CE} = 20$ V; $f = 100$ MHz



HBK05_07-10

Bottom View, Base Pinouts

Table 7.29**RF Power Amplifier Modules**

Listed by frequency

<i>Device</i>	<i>Supply (V)</i>	<i>Frequency Range (MHz)</i>	<i>Output Power (W)</i>	<i>Power Gain (dB)</i>	<i>Package[†]</i>	<i>Mfr/ Notes</i>
M57735	17	50-54	14	21	H3C	MI; SSB mobile
M57719N	17	142-163	14	18.4	H2	MI; FM mobile
S-AV17	16	144-148	60	21.7	5-53L	T, FM mobile
S-AV7	16	144-148	28	21.4	5-53H	T, FM mobile
MHW607-1	7.5	136-150	7	38.4	301K-02/3	MO; class C
BGY35	12.5	132-156	18	20.8	SOT132B	P
M67712	17	220-225	25	20	H3B	MI; SSB mobile
M57774	17	220-225	25	20	H2	MI; FM mobile
MHW720-1	12.5	400-440	20	21	700-04/1	MO; class C
MHW720-2	12.5	440-470	20	21	700-04/1	MO; class C
M57789	17	890-915	12	33.8	H3B	MI
MHW912	12.5	880-915	12	40.8	301R-01/1	MO; class AB
MHW820-3	12.5	870-950	18	17.1	301G-03/1	MO; class C

Manufacturer codes: MO = Motorola; MI = Mitsubishi; P = Philips; T = Toshiba.

[†]For package shape, size and pin-connection information, see manufacturers' data sheets. Many retail suppliers offer data sheets to buyers free of charge on request. Data books are available from many manufacturers and retailers.

Table 7.30
General Purpose Silicon Power Transistors

TO-220 Case, Pin 1=Base, Pin 2, Case = Collector; Pin 3 = Emitter TO-204 Case (TO-3), Pin 1=Base, Pin 2 = Emitter, Case = Collector;

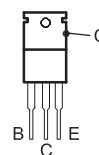
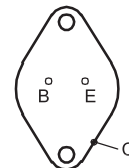
NPN	PNP	I_C Max (A)	V_{CEO} Max (V)	h_{FE} Min	F_T (MHz)	Power Dissipation (W)	NPN	PNP	I_C Max (A)	V_{CEO} Max (V)	h_{FE} Min	F_T (MHz)	Power Dissipation (W)
D44C8		4	60	100/220	50	30	2N3055A		15	60	20/70	0.8	115
	D45C8	4	60	40/120	50	30	2N3055		15	60	20/70	2.5	115
TIP29		1	40	15/75	3	30	MJ2955		15	60	20/70	2.5	115
	TIP30	1	40	15/75	3	30	2N6545		8	400	7/35	6	125
TIP29A		1	50	15/75	3	30	2N5039		20	75	20/100	—	140
	TIP30A	1	60	15/75	3	30	2N3771		30	40	15	0.2	150
TIP29B		1	80	15/75	3	30	2N3789		10	60	15	4	150
TIP29C		1	100	15/75	3	30	2N3715		10	60	30	4	150
	TIP30C	1	100	15/75	3	30	2N3791		10	60	30	4	150
TIP47		1	250	30/150	10	40	2N5875		10	60	20/100	4	150
TIP48		1	300	30/150	10	40	2N3790		10	80	15	4	150
TIP49		1	350	30/150	10	40	2N3716		10	80	30	4	150
TIP50		1	400	30/150	10	40	2N3792		10	80	30	4	150
TIP110 *		2	60	500	> 5	50	2N3773		16	140	15/60	4	150
	TIP115 *	2	60	500	> 5	50	2N6284		20	100	750/18K	—	160
TIP116		2	80	500	25	50	2N6287		20	100	750/18K	—	160
TIP31		3	40	25	3	40	2N5881		15	60	20/100	4	160
	TIP32	3	40	25	3	40	2N5880		15	80	20/100	4	160
TIP31A		3	60	25	3	40	2N6249		15	200	10/50	2.5	175
	TIP32A	3	60	25	3	40	2N6250		15	275	8/50	2.5	175
TIP31B		3	80	25	3	40	2N6546		15	300	6/30	6-28	175
	TIP32B	3	80	25	3	40	2N6251		15	350	6/50	2.5	175
TIP31C		3	100	25	3	40	2N5630		16	120	20/80	1	200
	TIP32C	3	100	25	3	40	2N5301		30	40	15/60	2	200
2N6124		4	45	25/100	2.5	40	2N5303		20	80	15/60	2	200
2N6122		4	60	25/100	2.5	40	2N5885		25	60	20/100	4	200
MJE1300		4	300	6/30	4	60	2N5302		30	60	15/60	2	200
TIP120 *		5	60	1000	> 5	65	2N4399		30	60	15/60	4	200
	TIP125 *	5	60	1000	> 10	65	2N5886		25	80	20/100	4	200
	TIP42	6	40	15/75	3	65	2N5884		25	80	20/100	4	200
TIP41A		6	60	15/75	3	65	MJ802		30	100	25/100	2	200
TIP41B		6	80	15/75	3	65	MJ4502		30	100	25/100	2	200
2N6290		7	50	30/150	4	40	MJ15003		20	140	25/150	2	250
	2N6109		50	30/150	4	40	MJI5004		20	140	25/150	2	250
2N6292		7	70	30/150	4	40	MJ15024		25	250	15/60	4	250
	2N6107	7	70	30/150	4	40							
MJE3055T		10	50	20/70	2	75							
	MJE2955T	10	60	20/70	2	75							
2N6486		15	40	20/150	5	75							
2N6488		15	80	20/150	5	75							
TIP140 *		10	60	500	> 5	125							
	TIP145 *	10	60	600	> 10	125							

— = Complimentary pairs

* = Darlington transistor

Useful URLs for finding transistor/IC data sheets:

1. General-purpose substitution URL: www.nteinc.com
2. Philips semiconductors: www.semiconductors.philips.com
3. Mitsubishi: www.mitsubishichips.com
4. Motorola: www.freescale.com
5. STMicroelectronics: www.st.com
6. Toshiba: www.semicon.toshiba.co.jp/eng

TO-220

Front View
TO-204

Bottom View

HBK05_07-11

HBK05_07-11

Table 7.31

RF Power Transistors

Device	Output Power (W)	Input Power (W)	Gain (dB)	Typ Supply Voltage (V)	Case	Mfr	Device	Output Power (W)	Input Power (W)	Gain (dB)	Typ Supply Voltage (V)	Case	Mfr
1.5 to 30 MHz, HF SSB/CW													
2SC2086	0.3		13	1.2	TO-92	MI	PT9733	50	10	7	28	145A-09/1	MO
BLV10	1		18	1.2	SOT123	PH	MRF344	60	15	6	28	221A-04/2	MO
BLV11	2		18	12	SOT123	PH	2SC2694	70		6.7	12.5	T-40	MI
MRF476	3	0.1	15	12.5-13.6	221A-04/1	MO	BLV75/12	75		6.5	12.5	SOT119	PH
BLW87	6		18	1.2	SOT123	PH	MRF316	80	8	10	28	316-01/1	MO
2SC2166	6		13.8	1.2	TO-220	MI	SD1477	100	25	6	12.5	M111	ST
BLW83	1.0		20	26	SOT123	PH	BLW78	100		6	28	SOT121	PH
MRF475	1.2	1.2	10	12.5-13.6	221A-04/1	MO	MRF317	100	12.5	9	28	316-01/1	MO
MRF433	12.5	0.125	20	12.5-13.6	211-07/1	MO	TP9386	150	15	10	28	316-01/1	MO
2SC3133	1.3		14	1.2	TO-220	MI	220 MHz						
MRF485	1.5	1.5	10	28	221 A-04/1	MO	MRF207	1	0.15	8.2	12.5	79-04/1	MO
2SC1969	1.6		1.2	1.2	TO-220	MI	2N5109	2.5		11	12	TO-205AD	MO
BLW50F	1.6		19.5	45	SOT123	PH	MRF227	3	0.13	13.5	12.5	79-05/5	MO
MRF406	20	1.25	12	12.5-13.6	221-07/1	MO	MRF208	1.0	1	10	12.5	145A-09/1	MO
SD1285	20	0.65	15	12.5	M113	ST	MRF226	1.3	1.6	9	12.5	145A-09/1	MO
MRF426	25	0.16	22	28	211-07/1	MO	2SC2133	30		8.2	28	T-40E	MI
MRF427	25	0.4	18	50	211-11/1	MO	2SC2134	60		7	28	T-40E	MI
MRF477	40	1.25	15	12.5-13.6	211-11/1	MO	2SC2609	100		6	28	T-40E	MI
MRF466	40	1.25	15	28	211-07/1	MO	UHF to 512 MHz						
BLW96	50		1.9	40	SOT121	PH	2N4427	0.4		10	12.5	TO-39	PH
2SC3241	75		12.3	12.5	T-45E	MI	2SC3019	0.5		14	12.5	T-43	MI
SD1405	75	3.8	13	12.5	M174	ST	MRF581	0.6	0.03	13	12.5	317-01/2	MO
2SC2097	75		12.3	13.5	T-40E	MI	2SC908	1		4	12.5	TO-39	MI
MRF464	80	2.53	10	28	211-11/1	MO	2N3866	1		10	28	TO-39	PH
MRF421	100	10	10	12.5-13.6	211-11/1	MO	2SC2131	1.4		6.7	13.5	TO-39	MI
SD1487	100	7.9	11	12.5	M174	ST	BLX65E	2		9	12.5	TO-39	PH
2SC2904	100		11.5	12.5	T-40E	MI	BLW89	2		12	28	SOT122	PH
SD1729	130	8.2	12	28	M174	ST	MRF586	2.5		16.5	1.5	79-04	MO
MRF422	150	15	10	28	211-11/1	MO	MRF630	3	0.33	9.5	12.5	79-05/5	MO
MRF428	150	7.5	13	50	211-11/1	MO	2SC3020	3	0.3	10	12.5	T-31 E	MI
SD1726	150	6	14	50	M174	ST	BLW80	4		8	12.5	SOT122	PH
PT9790	150	4.8	15	50	211-11/1	MO	BLW90	4		11	12.5	SOT122	PH
MRF448	250	15.7	12	50	211-11/1	MO	MRF652	5	0.5	10	12.5	244-04/1	MO
MRF430	600	60	10	50	368-02/1	MO	MRF587	5		16.5	15	244A-01/1	MO
50 MHz							2SC3021	7	1.2	7.6	12.5	T-31 E	MI
MRF475	4	0.4	10	12.5-13.6	221A-04/1	MO	BLW81	10		6	12.5	SOT122	PH
MRF497	40	4	10	12.5-13.6	221A-04/2	MO	MRF653	10	2	7	12.5	244-04/1	MO
SD1446	70	7	10	12.5	M113	ST	BLW91	10		9	28	SOT122	PH
MRF492	70	5.6	11	12.5-13.6	211-11/1	MO	MRF654	15	2.5	7.8	12.5	244-04/1	MO
SD1405	100	20	7	12.5	M174	ST	2SC3022	18	6	4.7	12.5	T-31 E	MI
VHF to 175 MHz							BLU20/12	20		6.5	12.5	SOT119	PH
2N4427	0.7		8	7.5	TO-39	PH	BLX94A	25		6	28	SOT48/2	PH
2N3866	1		10	28	TO-39	PH	2SC2695	28		4.9	13.5	T-31 E	MI
BFQ42	1.5		8.4	7.5	TO-39	PH	BLU30/12	30		6	12.5	SOT119	PH
2SC2056	1.6		9	7.2	T-41	MI	BLU45/12	45		4.8	12.5	SOT119	PH
2N3553	2.5	0.25	10	28	79-04/1	MO	2SC2905	45		4.8	12.5	T-40E	MI
BF043	3		9.4	7.5	TO-39	PH	MRF650	50	15.8	5	12.5	316-01/1	MO
SD1012	4	0.25	12	12.5	M135	ST	TP5051	50	6	9	24	333A-02/2	MO
2SC2627	5		13	12.5	T-40	MI	BLU60/12	60		4.4	12.5	SOT119	PH
2N5641	7	1	8.4	28	144B-05/1	MO	2SC3102	60	20	4.8	12.5	T-41 E	MI
MRF340	8	0.4	13	28	221A-04/2	MO	BLU60/28	60		7	28	SOT119	PH
BLW29	9		7.4	7.5	SOT120	PH	MRF658	65	25	4.15	12.5	316-01/1	MO
SD1143	10	1	10	12.5	M135	ST	MRF338	80	15	7.3	28	333-04/1	MO
2SC1729	1.4		10	13.5	T-31 E	MI	SD1464	100	28.2	5.5	28	M168	ST
SD1014-02	15	3.5	6.3	12.5	M135	ST	UHF to 960 MHz						
BLV11	15		8	13.5	SOT123	PH	MRF581	0.6	0.06	10	12.5	317-01/2	MO
2N5642	20	3	8.2	28	145A-09/1	MO	MRF8372	0.75	0.11	8	12.5	751-04/1	MO
MRF342	24	1.9	11	28	221A-04/2	MO	MRF557	1.5	0.23	8	12.5	317D-02/2	MO
BLW87	25		6	13.5	SOT123	PH	BLV99	2		9	24	SOT172	PH
2SC1946	28		6.7	13.5	T-31 E	MI	SD1420	2.1	0.27	9	24	M122	ST
MRF314	30	3	10	28	211-07/1	MO	MRF839	3	0.46	8	12.5	305A-01/1	MO
SD1018	40	14	4.5	12.5	M135	ST	MRF896	3	0.3	10	24	305-01/1	MO
2N5643	40	6.9	7.6	28	145A-09/1	MO	MRF891	5	0.63	9	24	319-06/2	MO
BLW40	40		10	12.5	SOT120	PH							
MRF315	45	5.7	9	28	211-07/1	MO							

(continued on next page)

<i>Device</i>	<i>Output Power (W)</i>	<i>Input Power (W)</i>	<i>Gain (dB)</i>	<i>Typ Supply Voltage (V)</i>	<i>Case</i>	<i>Mfr</i>
2SC2932	6		7.8	12.5	T-31 B	MI
SD1398	6	0.6	10	24	M142	ST
2SC2933	14	3	6.7	12.5	T-31 B	MI
SD1400-03	14	1.6	9.5	24	M118	ST
MRF873	15	3	7	12.5	319-06/2	MO
SD1495-03	30	6	7	24	M142	ST
SD1424	30	5.3	7.5	24	M156	ST
MRF897	30	3	10	24	395B-01/1	MO
MRF847	45	16	4.5	12.5	319-06/1	MO
BLV101A	50		8.5	26	SOT273	PH
SD1496-03	55	10	7.4	24	M142	ST
MRF898	60	12	7	24	333A-02/1	MO
MRF880	90	12.7	8.5	26	375A-01/1	MO
MRF899	150	24	8	26	375A-01/1	MO

Manufacturer codes:

MI = Mitsubishi; MO = Motorola; PH Philips;
ST = STMicroelectronics

There is a bewildering variety of package types, sizes and pin-out connections. (For example, for the 137 different transistors in this table there are 54 different packages.) See the data sheets on each manufacturer's Web pages for details.

Mitsubishi: www.mitsubishichips.com

Motorola: www.freescale.com

Philips semiconductors: www.semiconductors.philips.com

STMicroelectronics: www.st.com

Table 7.32

RF Power Transistors Recommended for New Designs

Device	Output Power (W)	Type	Gain (dB)	Typ Supply Voltage (V)	Case	Mfr	Device	Output Power (W)	Type	Gain (dB)	Typ Supply Voltage (V)	Case	Mfr
1.5 to 30 MHz, HF SSB/CW							VHF to 470 MHz						
MRF171A	30	MOS	20	28	211-07/2	MO	BLT50	1.2	BJT	10	7.5	SOT223	PH
BLF145	30	MOS	24	28	SOT123A	PH	SD2900	5	MOS	13.5	28	M113	ST
MRF148A	30	MOS	18	50	211-07/2	MO	SD1433	10	BJT	7	12.5	M122	ST
SD2918	30	MOS	18	50	M113	ST	SD2902	15	MOS	12.5	28	M113	ST
SD1405	75	BJT	13	12.5	M174	ST	SD2904	30	MOS	10	28	M113	ST
SD1733	75	BJT	14	50	M135	ST	SD2903	30	MOS	13	28	M229	ST
SD1487	100	BJT	11	12.5	M174	ST	SD1488	38	BJT	5.8	12.5	M111	ST
SD1407	125	BJT	15	28	M174	ST	SD1434	45	BJT	5	12.5	M111	ST
SD1729	130	BJT	12	28	M174	ST	MRF392	125	BJT	8	28	744A-01/1	MO
BLF147	150	MOS	17	28	SOT121B	PH	SD2921	150	MOS	12.5	50	M174	ST
BLF177	150	MOS	20	50	SOT121B	PH	VHF to 512 MHz						
BLF175	150	MOS	24	50	SOT123A	PH	BLF521	2	MOS	10	12.5	SOT172D	PH
SD1726	150	BJT	14	50	M174	ST	MRF158	2	MOS	17.5	28	305A-01/2	MO
SD1727	150	BJT	14	50	M164	ST	MRF160	4	MOS	17	28	249-06/3	MO
MRF150	150	MOS	17	50	211-07/2	MO	BLF542	5	MOS	13	28	SOT171A	PH
SD1411	200	BJT	16	40	M153	ST	VLF544	20	MOS	11	28	SOT171A	PH
SD1730	220	BJT	12	28	M174	ST	MRF166C	20	MOS	16	28	319-07/3	MO
SD1731	220	BJT	13	50	M174	ST	MRF166W	40	MOS	14	28	412-01/1	MO
SD1728	250	BJT	14.5	50	M177	ST	BLF546	80	MOS	11	28	SOT268A	PH
SD2923	300	MOS	16	50	M177	ST	MRF393	100	BJT	7.5	28	744A-01/1	MO
SD2933	300	MOS	18	50	M177	ST	MRF275L	100	MOS	8.8	28	333-04/2	MO
MRF154	600	MOS	17	50	368-03/2	MO	BLF548	150	MOS	10	28	SOT262A	PH
50 to 175 MHz							MRF275G	150	MOS	10	28	375-04/2	MO
BLF202	2	MOS	10	12.5	SOT409A	PH	UHF to 960 MHz						
BLF242	5	MOS	13	28	SOT123A	PH	BLT70	0.6	BJT	6	4.8	SOT223	PH
SD1274	30	BJT	10	13.6	M135	ST	BLT80	0.6	BJT	6	7.5	SOT223	PH
BLF245	30	MOS	13	28	SOT123	PH	BLT71/8	1.2	BJT	6	4.8	SOT223	PH
SD1275	40	BJT	9	13.6	M135	ST	BLT81	1.2	BJT	6	7.5	SOT223	PH
BLF246B	60	MOS	14	28	SOT161A	PH	BLF1043	10	MOS	16	26	SOT538A	PH
SD1477	100	BJT	6	12.5	M111	ST	BLF1046	45	MOS	14	26	SOT467C	PH
SD1480	100	BJT	9.2	28	M111	ST	BLF1047	70	MOS	14	26	SOT541A	PH
SD2921	150	MOS	12.5	50	M174	ST	BLF1048	90	MOS	14	26	SOT502A	PH
MRF141	150	MOS	13	28	211-11/2	MO	Notes:						
MRF151	150	MOS	13	50	211-11/2	MO	Manufacturer codes: MI = Mitsubishi; MO = Motorola;						
SD2931	150	MOS	14	50	M174	ST	PH = Philips; ST = STMicroelectronics						
BLF248	300	MOS	10	28	SOT262	PH	There is a bewildering variety of package types, sizes and pin-out connections. (For example, for the 71 different transistors in this table there are 35 different packages.) See the data sheets on each manufacturer's Web pages for details.						
SD2932	300	MOS	15	50	M244	ST	Mitsubishi: www.mitsubishichips.com						
VHF to 220 MHz							Motorola: www.freescale.com						
MRF134	5	MOS	10.6	28	211-07/2	MO	Philips semiconductors: www.semiconductors.philips.com						
MRF136	15	MOS	16	28	211-07/2	MO	STMicroelectronics: www.st.com						
MRF173	80	MOS	13	28	211-11/2	MO							
MRF174	125	MOS	11.8	28	211-11/2	MO							
BLF278	250	MOS	14	50	SOT261A1	PH							

Table 7.33
Power FETs

<i>Device</i>	<i>Type</i>	<i>VDSS min (V)</i>	<i>RDS(on) max (Ω)</i>	<i>ID max (A)</i>	<i>PD max (W)</i>	<i>Case†</i>	<i>Mfr</i>
BS250P	P-channel	45	14	0.23	0.7	E-line	Z
IRFZ30	N-channel	50	0.050	30	75	TO-220	IR
MTP50N05E	N-channel	50	0.028	25	150	TO-220AB	M
IRFZ42	N-channel	50	0.035	50	150	TO-220	IR
2N7000	N-channel	60	5	0.20	0.4	E-line	Z
VN10LP	N-channel	60	7.5	0.27	0.625	E-line	Z
VN10KM	N-channel	60	5	0.3	1	TO-237	S
ZVN2106B	N-channel	60	2	1.2	5	TO-39	Z
IRF511	N-channel	60	0.6	2.5	20	TO-220AB	M
MTP2955E	P-channel	60	0.3	6	25	TO-220AB	M
IRF531	N-channel	60	0.180	14	75	TO-220AB	M
MTP23P06	P-channel	60	0.12	11.5	125	TO-220AB	M
IRFZ44	N-channel	60	0.028	50	150	TO-220	IR
IRF531	N-channel	80	0.160	14	79	TO-220	IR
ZVP3310A	P-channel	100	20	0.14	0.625	E-line	Z
ZVN2110B	N-channel	100	4	0.85	5	TO-39	Z
ZVP3310B	P-channel	100	20	0.3	5	TO-39	Z
IRF510	N-channel	100	0.6	2	20	TO-220AB	M
IRF520	N-channel	100	0.27	5	40	TO-220AB	M
IRF150	N-channel	100	0.055	40	150	TO-204AE	M
IRFP150	N-channel	100	0.055	40	180	TO-247	IR
ZVP1320A	P-channel	200	80	0.02	0.625	E-line	Z
ZVN0120B	N-channel	200	16	0.42	5	TO-39	Z
ZVP1320B	P-channel	200	80	0.1	5	TO-39	Z
IRF620	N-channel	200	0.800	5	40	TO-220AB	M
MTP6P20E	P-channel	200	1	3	75	TO-220AB	M
IRF220	N-channel	200	0.400	8	75	TO-220AB	M
IRF640	N-channel	200	0.18	10	125	TO-220AB	M

Manufacturers: IR = International Rectifier; M = Motorola; S = Siliconix; Z = Zetex.

†For package shape, size and pin-connection information, see manufacturers' data sheets. Many retail suppliers offer data sheets to buyers free of charge on request. Data books are available from many manufacturers and retailers.

Table 7.34
Logic IC Families

Type	Propagation Delay for $C_L = 50$ pF Max Clock (ns)		Frequency (MHz)	Power Dissipation (CL = 0) @ 1 MHz (mW/gate)	Output Current @ 0.5 V max (mA)	Input Current (Max mA)	Threshold Voltage (V)	Supply Voltage (V)		
	Typ	Max						Min	Typ	Max
CMOS										
74AC	3	5.1	125	0.5	24	0	V+/2	2	5 or 3.3	6
74ACT	3	5.1	125	0.5	24	0	1.4	4.5	5	5.5
74HC	9	18	30	0.5	8	0	V+/2	2	5	6
74HCT	9	18	30	0.5	8	0	1.4	4.5	5	5.5
4000B/74C (10 V)	30	60	5	1.2	1.3	0	V+/2	3	5 - 15	18
4000B/74C (5V)	50	90	2	3.3	0.5	0	V+/2	3	5 - 15	18
TTL										
74AS	2	4.5	105	8	20	0.5	1.5	4.5	5	5.5
74F	3.5	5	100	5.4	20	0.6	1.6	4.75	5	5.25
74ALS	4	11	34	1.3	8	0.1	1.4	4.5	5	5.5
74LS	10	15	25	2	8	0.4	1.1	4.75	5	5.25
ECL										
ECL III	1.0	1.5	500	60	—	—	-1.3	-5.19	-5.2	-5.21
ECL 100K	0.75	1.0	350	40	—	—	-1.32	-4.2	-4.5	-5.2
ECL100KH	1.0	1.5	250	25	—	—	-1.29	-4.9	-5.2	-5.5
ECL 10K	2.0	2.9	125	25	—	—	-1.3	-5.19	-5.2	-5.21
GaAs										
10G	0.3	0.32	2700	125	—	—	-1.3	-3.3	-3.4	-3.5
10G	0.3	0.32	2700	125	—	—	-1.3	-5.1	-5.2	-5.5

Source: Horowitz (W1HFA) and Hill, *The Art of Electronics—2nd edition*, page 570. © Cambridge University Press 1980, 1989. Reprinted with the permission of Cambridge University Press.

Table 7.35

Three-Terminal Voltage Regulators

Listed numerically by device

Device	Description	Package	Voltage	Current (Amps)	Device	Description	Package	Voltage	Current (Amps)
317	Adj Pos	TO-205	+1.2 to +37	0.5	78TXX	Fixed Neg	TO-204	Note 1	3.0
317	Adj Pos	TO-204,TO-220	+1.2 to +37	1.5	79XX		TO-204,TO-220		1.0
317L	Low Current Adj Pos	TO-205,TO-92	+1.2 to +37	0.1	79LXX		TO-205,TO-92		0.1
317M	Med Current Adj Pos	TO-220	+1.2 to +37	0.5	79MXX		TO-220		0.5
338	Adj Pos	TO-3	+1.2 to +32	5.0	Note 1—XX indicates the regulated voltage; this value may be anywhere from 1.2 V to 35 V. A 7815 is a positive 15-V regulator, and a 7924 is a negative 24-V regulator.				
350	High Current Adj Pos	TO-204,TO-220	+1.2 to +33	3.0					
337	Adj Neg	TO-205	−1.2 to −37	0.5	The regulator package may be denoted by an additional suffix, according to the following:				
337	Adj Neg	TO-204,TO-220	−1.2 to −37	1.5					
337M	Med Current Adj Neg	TO-220	−1.2 to −37	0.5	Package	Suffix			
309	Fixed Pos	TO-205	+5	0.2	TO-204 (TO-3)	K			
309		TO-204	+5	1.0	TO-220	T			
323		TO-204,TO-220	+5	3.0	TO-205 (TO-39)	H, G			
140-XX		TO-204,TO-220	Note 1	1.0	TO-92	P, Z			
340-XX		TO-204,TO-220		1.0	For example, a 7812K is a positive 12-V regulator in a TO-204 package. An LM340T-5 is a positive 5-V regulator in a TO-220 package. In addition, different manufacturers use different prefixes. An LM7805 is equivalent to a mA7805 or MC7805.				
78XX		TO-204,TO-220		1.0					
78LXX		TO-205,TO-92		0.1					
78MXX		TO-220		0.5					

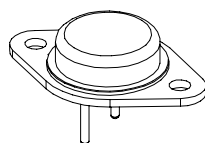
Note 1—XX indicates the regulated voltage; this value may be anywhere from 1.2 V to 35 V. A 7815 is a positive 15-V regulator, and a 7924 is a negative 24-V regulator.

The regulator package may be denoted by an additional suffix, according to the following:

Package	Suffix
TO-204 (TO-3)	K
TO-220	T
TO-205 (TO-39)	H, G
TO-92	P, Z

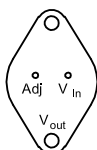
For example, a 7812K is a positive 12-V regulator in a TO-204 package. An LM340T-5 is a positive 5-V regulator in a TO-220 package. In addition, different manufacturers use different prefixes. An LM7805 is equivalent to a mA7805 or MC7805.

K Suffix
Metal TO - 204 Package

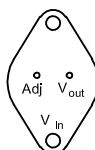


Pins 1 and 2 Electrically Isolated from Case. Case Is Third Electrical Connection.

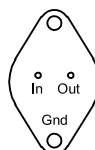
BOTTOM VIEW



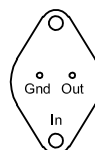
Case Is Output
317
350



Case Is Input
337

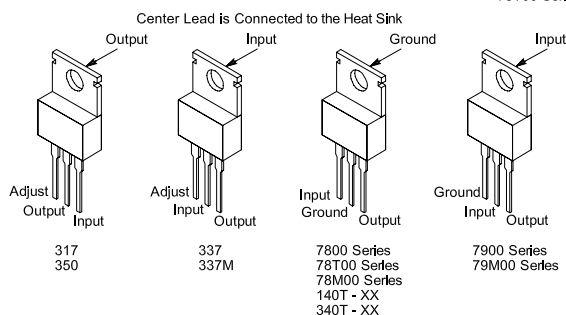


Case Is Ground
140 k - XX
340 k - XX
309
7800 Series
78T00 Series

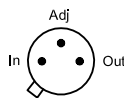
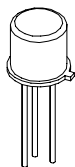


Case Is Input
7900 Series

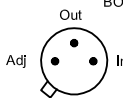
T Suffix
TO - 220 Package



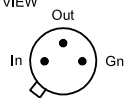
H, G Suffix
TO - 205 Package



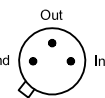
Case Is Output
317
317L



Case Is Input
337

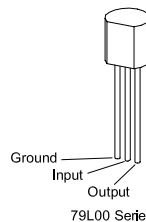
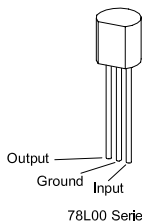
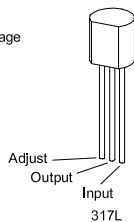


Case Is Ground
78L00 Series
78M00 Series



Case Is Input
79L00 Series
79M00 Series

P, Z Suffix
TO - 92 Package



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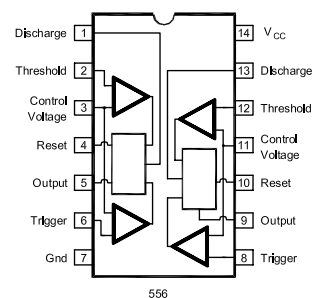
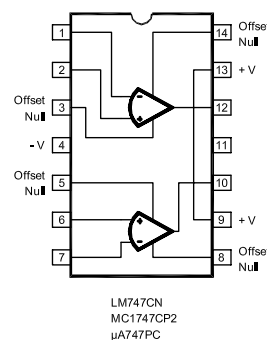
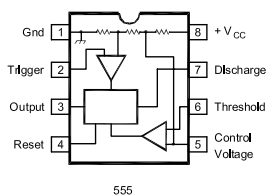
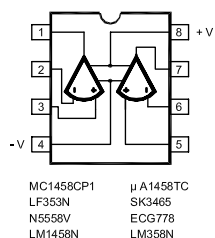
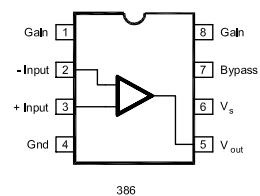
Table 7.36

Op Amp ICs

Listed by device number

Device	Type	Freq Comp	Max Supply* (V)	Min Input Resistance (M Ω)	Max Offset Voltage (mV)	Min dc Open-Loop Gain (dB)	Min Output Current (mA)	Min Small-Signal Bandwidth (MHz)	Min Slew Rate (V/ μ s)	Notes
101A	Bipolar	ext	44	1.5	3.0	79	15	1.0	0.5	General purpose
108	Bipolar	ext	40	30	2.0	100	5	1.0		
124	Bipolar	int	32		5.0	100	5	1.0		Quad op amp, low power
148	Bipolar	int	44	0.8	5.0	90	10	1.0	0.5	Quad 741
158	Bipolar	int	32		5.0	100	5	1.0		Dual op amp, low power
301	Bipolar	ext	36	0.5	7.5	88	5	1.0	10	Bandwidth extendable with external components
324	Bipolar	int	32		7.0	100	10	1.0		Quad op amp, single supply
347	BiFET	ext	36	106	5.0	100	30	4	13	Quad, high speed
351	BiFET	ext	36	106	5.0	100	20	4	13	
353	BiFET	ext	36	106	5.0	100	15	4	13	
355	BiFET	ext	44	106	10.0	100	25	2.5	5	
355B	BiFET	ext	44	106	5.0	100	25	2.5	5	
356A	BiFET	ext	36	106	2.0	100	25	4.5	12	
356B	BiFET	ext	44	106	5.0	100	25	5.0	12	
357	BiFET	ext	36	106	10.0	100	25	20.0	50	
357B	BiFET	ext	36	106	5.0	100	25	20.0	30	
358	Bipolar	int	32		7.0	100	10	1.0		Dual op amp, single supply
411	BiFET	ext	36	106	2.0	100	20	4.0	15	Low offset, low drift
709	Bipolar	ext	36	0.05	7.5	84	5	0.3	0.15	
741	Bipolar	int	36	0.3	6.0	88	5	0.4	0.2	
741S	Bipolar	int	36	0.3	6.0	86	5	1.0	3	Improved 741 for AF
1436	Bipolar	int	68	10	5.0	100	17	1.0	2.0	High-voltage
1437	Bipolar	ext	36	0.050	7.5	90		1.0	0.25	Matched, dual 1709
1439	Bipolar	ext	36	0.100	7.5	100		1.0	34	
1456	Bipolar	int	44	3.0	10.0	100	9.0	1.0	2.5	Dual 1741
1458	Bipolar	int	36	0.3	6.0	100	20.0	0.5	3.0	
1458S	Bipolar	int	36	0.3	6.0	86	5.0	0.5	3.0	Improved 1458 for AF
1709	Bipolar	ext	36	0.040	6.0	80	10.0	1.0		
1741	Bipolar	int	36	0.3	5.0	100	20.0	1.0	0.5	Dual 1741
1747	Bipolar	int	44	0.3	5.0	100	25.0	1.0	0.5	Dual 1741
1748	Bipolar	ext	44	0.3	6.0	100	25.0	1.0	0.8	Non-comp-ensated 1741
1776	Bipolar	int	36	50	5.0	110	5.0		0.35	Micro power, programmable
3140	BiFET	int	36	1.5 $\times$ 106	2.0	86	1	3.7	9	Stroable output
3403	Bipolar	int	36	0.3	10.0	80		1.0	0.6	Quad, low power
3405	Bipolar	ext	36		10.0	86	10	1.0	0.6	Dual op amp and dual comparator
3458	Bipolar	int	36	0.3	10.0	86	10	1.0	0.6	Dual, low power

Top Views



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Device	Type	Freq Comp	Max Supply* (V)	Min Input Resistance (M Ω)	Max Offset Voltage (mV)	Min dc Open-Loop Gain (dB)	Min Output Current (mA)	Min Small-Signal Bandwidth (MHz)	Min Slew Rate (V/ μ s)	Notes
3476	Bipolar	int	36	5.0	6.0	92	12		0.8	
3900	Bipolar	int	32	1.0		65	0.5	4.0	0.5	Quad, Norton single supply
4558	Bipolar	int	44	0.3	5.0	88	10	2.5	1.0	Dual, wideband
4741	Bipolar	int	44	0.3	5.0	94	20	1.0	0.5	Quad 1741
5534	Bipolar	int	44	0.030	5.0	100	38	10.0	13	Low noise, can swing 20V P-P across 600
5556	Bipolar	int	36	1.0	12.0	88	5.0	0.5	1	Equivalent to 1456
5558	Bipolar	int	36	0.15	10.0	84	4.0	0.5	0.3	Dual, equivalent to 1458
34001	BiFET	int	44	106	2.0	94		4.0	13	JFET input
AD745	BiFET	int	± 18	104	0.5	63	20	20	12.5	Ultra-low noise, high speed

LT1001 Precision op amp, low offset voltage (15 μ V max), low drift (0.6 μ V/ $^{\circ}$ C max), low noise (0.3 μ V p-p)

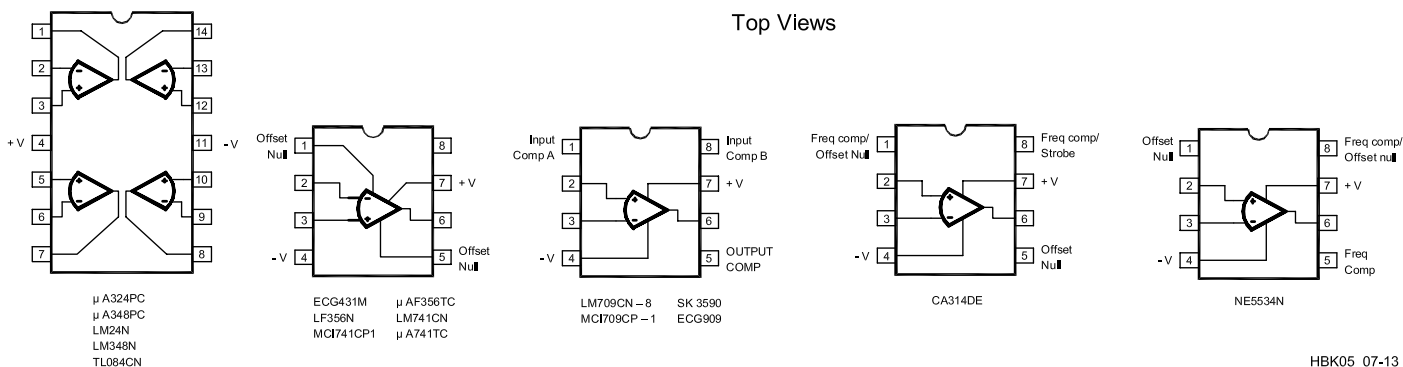
LT1007 Extremely low noise (0.06 μ V p-p), very high gain (20×10^6 into 2 k Ω load)

LT1360 High speed, very high slew rate (800 V/ μ s), 50 MHz gain bandwidth, ± 2.5 V to ± 15 V supply range

NE5514	Bipolar	int	± 16	100	1		10	3	0.6	
NE5532	Bipolar	int	± 20	0.03	4	47	10	10	9	Low noise
OP-27A	Bipolar	ext	44	1.5	0.025	115		5.0	1.7	Ultra-low noise, high speed
OP-37A	Bipolar	ext	44	1.5	0.025	115		45.0	11.0	
TL-071	BiFET	int	36	10^6	6.0	91		4.0	13.0	Low noise
TL-081	BiFET	int	36	10^6	6.0	88		4.0	8.0	
TL-082	BiFET	int	36	10^6	15.0	99		4.0	8.0	Low noise
TL-084	BiFET	int	36	10^6	15.0	88		4.0	8.0	Quad, high-performance AF
TLC27M2	CMOS	int	18	10^6	10	44		0.6	0.6	Low noise
TLC27M4	CMOS	int	18	10^6	10	44		0.6	0.6	Low noise

*From $-V$ to $+V$ terminals

Top Views



HBK05_07-13

Table 7.37
Triode Transmitting Tubes

The full 1988 Handbook table of power tube specifications and base diagrams can be viewed in pdf format on the [ARRL Web](http://www.arrl.org/notes/1921/pwrtubes.pdf) at www.arrl.org/notes/1921/pwrtubes.pdf.

Type	Power Diss. (W)	Plate (V)	Plate (mA)	Grid dc (mA)	Freq (MHz)	Ampl Factor	Fil (V)	Fil (A)	C_{in} (pF)	C_{gp} (pF)	C_{out} (pF)	Base Diagram	Service Class ¹	Plate (V)	Grid (V)	Plate (mA)	Grid dc (mA)	Input (W)	P-P (k Ω)	Output (W)
5675	5	165	30	8	3000	20	6.3	0.135	2.3	1.3	0.09	Fig 21	GG0	120	-8	25	4	¾	—	0.05
2C40	6.5	500	25	—	500	36	6.3	0.75	2.1	1.3	0.05	Fig 11	CT0	250	-5	20	0.3	¾	—	0.075
5893	8.0	400	40	13	1000	27	6.0	0.33	2.5	1.75	0.07	Fig 21	CT CP	350 300	-33 -45	35 30	13 12	2.4 2.0	—	6.5
2C43	12	500	40	—	1250	48	6.3	0.9	2.9	1.7	0.05	Fig 11	CT0	470	—	387	—	¾	—	9 ²
811-A	65	1000	175	50	60	160	6.3	4.0	5.9	5.6	0.7	3G	CT CP B/CG AB ₁	1500 1250 1250 1250	-70 -120 0 0	173 140 21/175 27/175	40 45 28 13	7.1 10.0 12 3.0	—	200 135 165 155
812-A	65	1500	175	35	60	29	6.3	4.0	5.4	5.5	0.77	3G	CT CP B ²	1500 1250 1500	-120 -115 -48	173 140 28/310	30 35 270 ⁴	6.5 7.6 5.0	—	190 130 340
3CX100A5 ⁶ 70	100 600	1000 1255 100 ⁵	100 60	50	2500	100	6.0	1.05	7.0	2.15	0.035	—	AGG CP	800 600	-20 -15	80 75	30 40	6 6	—	27 18
2C39	100	1000	60	40	500	100	6.3	1.1	6.5	1.95	0.03	—	G1C CT0 CP	600 900 600	-35 -40 -150	60 90 100 ⁵	40 30 50	5.0 ¾ ¾	—	20 40 ¾
AX9900, 5866	135	2500	200	40	150	25	6.3	5.4	5.8	5.5	0.1	Fig 3	CT CP B ²	2500 2000 2500	-200 -225 -90	200 127 80/330	40 40 350 ⁴	16 16 14 ³	—	390 204 560
572B T160L	160	2750	275	—	—	170	6.3	4.0	—	—	—	3G	CT B/GG ²	1650 2400	-70 -2.0	165 90/500	32 —	6 100	—	205 600
8873	200	2200	250	—	500	160	6.3	3.2	19.5	7.0	0.03	Fig 87	AB ₂	2000	—	22/500	98 ³	27 ³	—	505
8875	300	2200	250	—	500	160	6.3	3.2	19.5	7.0	0.03	—	AB ₂	2000	—	22/500	98 ³	27 ³	—	505
833A	350	3300	500	100	30	35	10	10	12.3	6.3	8.5	Fig 41	CT0 CT0 CP	2250 3000 2500	-125 -160 -300	445 335 335	85 70 75	23 20 30	—	780 800 635
450 ⁶	400 ⁶	4000 ⁶	500	100	20 ⁶	35	10	10	12.3	6.3	8.5	Fig 41	CP B ²	3000 3000	-240 -70	335 100/750	70 400 ⁴	26 20 ⁴	—	800 1650
8874	400	2200	350	—	500	160	6.3	3.2	19.5	7.0	0.03	—	AB ₂	2000	—	22/500	98 ³	27 ³	—	505
3-400Z	400	3000	400	—	110	200	5	14.5	7.4	4.1	0.07	Fig 3	B/GG	3000	0	100/333	120	32	—	655
3-500Z	500	4000	400	—	110	160	5	14.5	7.4	4.1	0.07	Fig 3	B/GG	3000	—	370	115	30	5	750
3-600Z	600	4000	425	—	110	165	5	15.0	7.8	4.6	0.08	Fig 3	B/GG B/GG	3000 3500	—	400 400	118 110	33 35	—	810 950
3CX800A7800	2250	600	600	60	350	200	13.5	1.5	26	—	6.1	Fig 87	AB ₂ GG ⁷	2200	-8.2	500	36	16	—	750
3-1000Z	1000	3000	800	—	110	200	7.5	21.3	17	6.9	0.12	Fig 3	B/GG	3000	0	180/670	300	65	—	1360
3CX1200A71200	5000	800	800	—	110	200	7.5	21.0	20	12	0.2	Fig 3	AB ₂ GG	3600	-10	700	230	85	—	1500
8877	1500	4000	1000	—	250	200	5.0	10	42	10	0.1	—	AB ₂	2500	-8.2	1000	—	57	—	1520

Table 7.38

Tetrode and Pentode Transmitting Tubes

www.arrl.org/notes/1921/pwrtubes.pdf.

Type	Max. Plate Diss.		Max. Screen Volts (V)	Max. Freq. (MHz)	Filament Volts	Amps		C _{IN} (pF)	C _{GP} (pF)	C _{OUT} (pF)	Base	Serv. Class ¹	Plate (V)	Screen (V)	Grid (V)	Plate (mA)	Screen (mA)	Grid (mA)	P _{IN} (W)	P-P (kΩ)	P _{OUT} (W)
	(W)	(V)				(A)	(pF)														
6146/	25	750	3	250	60	6.3	1.25	13	0.24	8.5	7CK	CT	500	170	-66	135	9	2.5	0.2	—	48
6146A												CT	700	160	-62	120	11	3.1	0.2	—	70
8032	25	750	3	250	60	12.6	0.585	13	0.24	8.5	7CK	CT ⁶	400	190	-54	150	10.4	2.2	3.0	—	35
6883												CP	400	150	-87	112	7.8	3.4	0.4	—	32
												CP	600	150	-87	112	7.8	3.4	0.4	—	52
6159B/	25	750	3	250	60	26.5	0.3	13	0.24	8.5	7CK	AB ₂ ⁸	600	190	-48	28/270	1.2/20	22	0.3	5	113
												AB ₂ ⁸	750	165	-46	22/240	0.3/20	2.6 ²	0.4	7.4	131
												AB ₁ ⁸	750	195	-50	23/220	1/26	100 ³	0	8	120
807, 807W	30	750	3.5	300	60	6.3	0.9	12	0.2	7	5AW	CT	750	250	-45	100	6	3.5	0.22	—	50
5933												CP	600	275	-90	100	6.5	4	0.4	—	42.5
												AB ₁	750	300	-35	15/70	3/8	75 ³	0	—	72
1625	30	750	3.5	300	60	12.6	0.45	12	0.2	7	5AZ	B ⁵	750	—	0	15/240	—	555 ³	5.3 ²	6.65	120
6146B	35	750	3	250	60	6.3	1.125	13	0.22	8.5	7CK	CT	750	200	-77	160	10	2.7	0.3	—	85
8298A												CP	600	175	-92	140	9.5	3.4	0.5	—	62
												AB ₁	750	200	-48	24/125	6.3	—	—	3.5	61
813	125	2500	20	800	30	10.0	5.0	16.3	0.25	14.0	5BA	CTO	1250	300	-75	180	35	12	1.7	—	170
												CTO	2250	400	-155	220	40	15	4	—	375
												AB ₁	2500	750	-95	25/145	27 ²	0	0	—	245
												AB ₂ ⁸	2000	750	-90	40/315	1.5/58	230 ³	0.1 ²	16	455
												AB ₂ ⁸	2500	750	-95	35/260	1.2/55	235 ³	0.35 ²	17	650
4CX250B	250	2000	12	400	175	6.0	2.9	18.5	0.04	4.7	—	CTO	2000	250	-90	250	25	27	2.8	—	410
												CP	1500	250	-100	200	25	17	2.1	—	250
												AB ₁ ⁸	2000	350	-50	500	30	100	0	8.26	650
4-400A	400 ⁴	4000	35	600	110	5.0	14.5	12.5	0.12	4.7	5BK	CT/CP	4000	300	-170	270	22.5	10	10	—	720
												GG	2500	0	0	80/270 ⁹	55 ⁹	100 ⁹	39 ⁹	4.0	435
												AB ₁	2500	750	-130	95/317	0/14	0	0	—	425
4CX400A	400	2500	8	400	500	6.3	3.2	24	0.08	7	See ¹¹	AB ₂ GD2200	325	300	-30	100/270	22	2	9	—	405
												AB ₂ GD2500	400	400	-35	100/400	18	1	13	—	610
4CX800A	800	2500	15	350	150	12.6	3.6	51	0.9	11	See ¹²	AB ₂ GD2200	350	350	-56	160/550	24	1	32	—	750
4-1000A	1000	6000	75	1000	—	7.5	21	27.2	0.24	7.6	—	CT	3000	500	-150	700	146	38	11	—	1430
8166												CP	3000	500	-200	600	145	36	12	—	1390
												AB ₂	4000	500	-60	300/1200	0/95	—	11	7	3000
												GG	3000	0	0	100/700 ⁹	105 ⁹	170 ⁹	130 ⁹	2.5	1475
4CX1000A	1000	3000	12	400	110	6.0	9.0	81.5	0.01	11.8	—	AB ₁ ⁸	2000	325	-55	500/2000	-4/60	—	—	2.5	2160
												AB ₁ ⁸	2500	325	-55	500/2000	-4/60	—	—	3.1	2920
												AB ₁ ⁸	3000	325	-55	500/1800	-4/60	—	—	3.85	3360
4CX1500B	1500	3000	12	400	110	6.0	10.0	81.5	0.02	11.8	—	AB ₁	2750	225	-34	300/755	-14/60	0.95	1.5	1.9	1100
4CX1600B	1600	3300	20	350	250	12.6	4.4	86	0.15	12	See ¹³	AB ₂ GD2400	350	350	-53	500/1100	20	2	28	—	1600
												AB ₂ GD2400	350	350	-70	200/870	48	2	83 ¹⁰	—	1500
												AB ₂ GD3200	240	240	-57	200/740	21	1	33	—	1600

¹Service Class Abbreviations:
 AB₂GD=AB₂ linear with 50-Ω passive grid circuit.
 B=Class-B push-pull
 CP=Class-C plate-modulated phone

CT=Class-C telegraph
 GG=Grounded-grid (grid and screen connected together)
²Maximum signal value
³Peak grid-grid volts

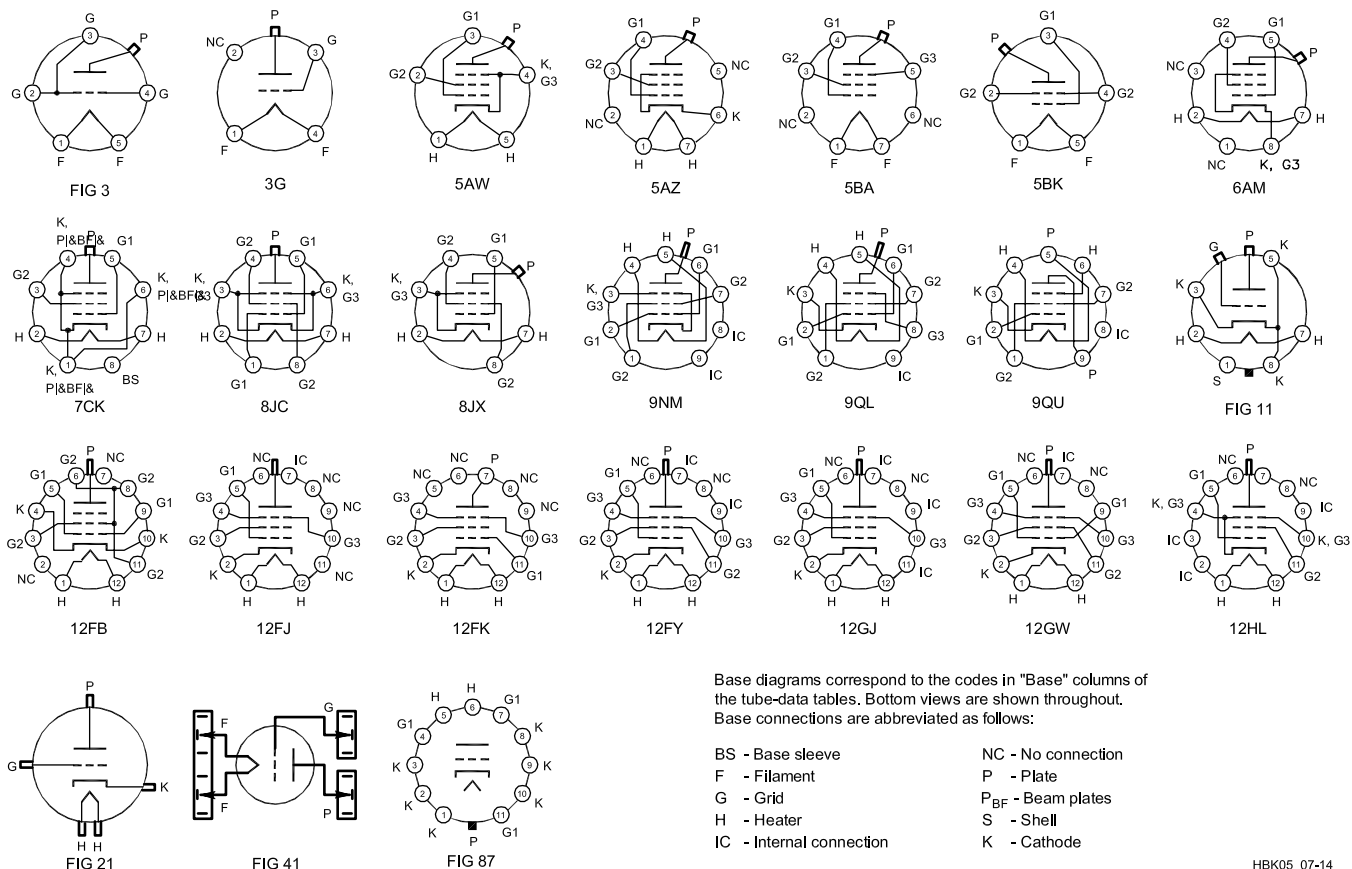
⁴Forced-air cooling required.
⁵Two tubes triode-connected, G2 to G1 through 20kΩ to G2.
⁶Typical operation at 175 MHz.
⁷±1.5 V.
⁸Values are for two tubes.

⁹Single tone.
¹⁰24-Ω cathode resistance.
¹¹Base same as 4CX250B.
 Socket is Russian SK2A.
¹²Socket is Russian SK1A.
¹³Socket is Russian SK3A.

Table 7.39
TV Deflection Tubes

Type	Plate Diss. (W)	Screen Diss. (W)	Transcond. μMho	Heater 6.3 V (A)	C_{IN} (pF)	C_{GP} (pF)	C_{OUT} (pF)	Base	Class of Service	Plate Volt. (V)	Screen Volt. (V)	Grid Volt. (V)	Plate Curr. (A)	Screen Curr. (A)	Grid Curr. (A)	Drive Power (W)	Output Power (W)
6DQ5	24	3.2	10.5k	2.5	23	0.5	11	8JC	C	400	200	-40	100	12	1.5	0.1	25
6DQ6B	18	3.6	7.3k	1.2	15	0.5	7	6AM	C	400	200	-40	100	12	1.5	0.1	25
6FH6	17	3.6	6k	1.2	33	0.4	8	6AM	C	400	200	-40	100	12	1.5	0.1	25
6GC6	17.5	4.5	6.6k	1.2	15	0.55	7	8JX	C	400	200	-40	100	12	1.5	0.1	25
6GJ5	17.5	3.5	7.1k	1.2	15	0.26	6.5	9NM	C	500	200	-75	180	15	5	0.43	63
								AB ₁	AB ₁	500	200	-43	85	4	—	—	35
6HF5	28	5.5	11.3k	2.25	24	0.56	10	12FB	C	500	140	-85	232	12.5	77	0.76	8
								AB ₁	AB ₁	500	140	-46	133	4.5	—	—	58
6JB6	17.5	3.5	7.1k	1.2	15	0.2	6	9QL	C	500	200	-75	180	13.3	5	0.43	63
								AB ₁	AB ₁	500	200	-42	85	4.2	—	—	35
6JE6	30	5	10.5k	2.5	24.3	—	14.5	9QL	C	450	150	-80	202	20	8	0.75	63
								AB ₁	AB ₁	450	150	-35	98	4.5	—	—	38
6JM6	17.5	3.5	7.3k	1.2	16	0.6	7	12FJ	C	500	200	-75	190	13.7	4	0.32	61
								AB ₁	AB ₁	500	200	-42	85	4.4	—	—	37
6JN6	17.5	3.5	7.3k	1.2	16	0.34	7	12FK	GC	800	0	-11	150	—	—	12.5	82
6JS6C	30	5.5	—	2.25	24	0.7	10	12FY	GC	800	0	-11	150	—	—	12.5	82
6KD6	33	5	14k	2.85	40	0.8	16	12GW	GC	800	0	-11	150	—	—	12.5	82
6LB6	30	5	13.4k	2.25	33	0.4	18	12GJ	GC	800	0	-11	150	—	—	12.5	82
6LG6	28	5	11.5k	2	25	0.8	13	12HL	GC	800	0	-11	150	—	—	12.5	82
6LQ6	30	5	9.6k	2.5	22	0.46	11	9QL	GC	800	0	-11	150	—	—	12.5	82
6MH6	38.5	7	14k	2.65	40	1.0	20	12GW	GC	800	0	-11	150	—	—	12.5	82

Table 7.40
EIA Vacuum-Tube Base Diagrams



HBK05_07-14

Alphabetical subscripts (D = diode, P = pentode, T = triode and HX = hexode) indicate structures in multistroke tubes. Subscript CT indicates filament or heater center tap. Generally, when pin 1 of a metal-envelope tube (except all triodes) is shown connected to the envelope, pin 1 of a glass-envelope counterpart (suffix G or GT) is connected to an internal shield.

Table 7.41**Properties of Common Thermoplastics**

Polyvinyl Chloride (PVC)		Polyethylene (PE)
<i>Advantages:</i>	• Can be compounded with plasticizers, filters, stabilizers, lubricants and impact modifiers to produce a wide range of physical properties • Can be pigmented to almost any color • Rigid PVC has good corrosion and stain resistance, thermal & electrical insulation, and weatherability	<i>Advantages: Low Density PE</i> • Good toughness • Excellent chemical resistance • Excellent coefficient of friction • Near zero moisture absorption • Easy to process • Relatively low heat resistance
<i>Disadvantages:</i>	• Base resin can be attacked by aromatic solvents, ketones, aldehydes, naphthalenes, and some chloride, acetate, and acrylate esters • Should not be used above 140°	<i>Disadvantages:</i> • Susceptible to environmental and some chemical stress cracking • Wetting agents (such as detergents) accelerate stress cracking
<i>Applications:</i>	• Conduit and conduit boxes • Housings • Pipe • Wire and cable insulation • Relative permittivity 3.20 down to 2.84 with rising frequency and 100% pure (plumbing PVC is not pure, but has additives for various purposes)	<i>Advantages: High Density PE</i> • Same as above, plus increased rigidity and tensile strength <i>Advantages: Ultra-High Molecular Weight PE</i> • Outstanding abrasion resistance • Low coefficient of friction • High impact strength • Excellent chemical resistance • Material does not break in impact strength tests using standard notched specimens
Polystyrene		<i>Applications:</i>
<i>Advantages:</i>	• Low cost • Moderate strength • Electrical properties only slightly affected by temperature and humidity • Sparkling clarity • Impact strength is increased by blending with rubbers, such as polybutadiene	• Bearings • Components requiring maximum abrasion resistance, impact strength, and low coefficient of friction • Relative permittivity 2.26, stable over frequency
<i>Disadvantages:</i>	• Brittle • Low heat resistance	Phenolic
<i>Applications:</i>	• Capacitors • Light shields • Knobs • Relative permittivity 2.55, stable over frequency	<i>Advantages:</i> • Low cost • Superior heat resistance • High heat-deflection temperatures • Good electrical properties • Good flame resistance • Excellent moldability • Excellent dimensional stability • Good water and chemical resistance
Polyphenylene Sulfide (PPS)		<i>Applications:</i> • Commutators and housings for small motors • Heavy duty electrical components • Rotary-switch wafers • Insulating spacers • Relative permittivity 5.25 down to 3.57 with rising frequency and depending on formulation
<i>Advantages:</i>	• Excellent dimensional stability • Strong • High-temperature stability • Chemical resistant • Inherently completely flame retardant • Completely transparent to microwave radiation	Nylon
<i>Applications:</i>	• R3-R5 have various glass-fiber levels that are suitable for applications demanding high mechanical and impact strength as well as good dielectric properties • R8 and R10 are suitable for high arc-resistance applications • R9-901 is suitable for encapsulation of electronic devices • Relative permittivity 3.0	<i>Advantages:</i> • Excellent fatigue resistance • Low coefficient of friction • Toughness as a function of degree of crystallinity • Resists many fuels and chemicals • Good creep- and cold-flow resistance as compared to less rigid thermoplastics • Resists repeated impacts
Polypropylene		<i>Disadvantages:</i> • All nylons absorb moisture • Nylons that have not been compounded with a UV stabilizer are sensitive to UV light, and thus not suitable for extended outdoor use
<i>Advantages:</i>	• Low density • Good balance of thermal, chemical, and electrical properties • Moderate strength (increases significantly with glass-fiber reinforcement)	<i>Applications:</i> • Bearings • Housings and tubing • Rope • Wire coatings • Wire connectors • Wear plates • Relative permittivity 3.2 - 5, numerous formulations
<i>Disadvantages:</i>	• Electrical properties affected to varying degrees by temperature (as temperature goes up, dielectric strength increases and volume resistivity decreases) • Inherently unstable in presence of oxidative and UV radiation	
<i>Applications:</i>	• Automotive battery cases • Blower housing and fan blades • Insulators • Lamp housings • Support for current-carrying electrical components • Relative permittivity 2.25 - 2.56, but not rated at UHF	

Table 7.42

Coaxial Cable End Connectors

UHF Connectors

Military No.	Style	Cable RG- or Description
PL-259	Str (m)	8, 9, 11, 13, 63, 87, 149, 213, 214, 216, 225
UG-111	Str (m)	59, 62, 71, 140, 210
SO-239	Pnl (f)	Std, mica/phenolic insulation
UG-266	Blkhd (f)	Rear mount, pressurized, copolymer of styrene ins.

Adapters

PL-258	Str (f/f)	Polystyrene ins.
UG-224,363	Blkhd (f/f)	Polystyrene ins.
UG-646	Ang (f/m)	Polystyrene ins.
M-359A	Ang (m/f)	Polystyrene ins.
M-358	T (f/m/f)	Polystyrene ins.

Reducers

UG-175	55, 58, 141, 142 (except 55A)
UG-176	59, 62, 71, 140, 210

Family Characteristics:

All are nonweatherproof and have a nonconstant impedance. Frequency range: 0-500 MHz. Maximum voltage rating: 500 V (peak).

N Connectors

Military No.	Style	Cable RG-	Notes
UG-21	Str (m)	8, 9, 213, 214	50 Ω
UG-94A	Str (m)	11, 13, 149, 216	70 Ω
UG-536	Str (m)	58, 141, 142	50 Ω
UG-603	Str (m)	59, 62, 71, 140, 210	50 Ω
UG-23, B-E	Str (f)	8, 9, 87, 213, 214, 225	50 Ω
UG-602	Str (f)	59, 62, 71, 140, 210	—
UG-228B, D, E	Pnl (f)	8, 9, 87, 213, 214, 225	—
UG-1052	Pnl (f)	58, 141, 142	50 Ω
UG-593	Pnl (f)	59, 62, 71, 140, 210	50 Ω
UG-160A, B, D	Blkhd (f)	8, 9, 87, 213, 214, 225	50 Ω
UG-556	Blkhd (f)	58, 141, 142	50 Ω
UG-58, A	Pnl (f)		50 Ω
UG-997A	Ang (f)		50 Ω ^{11/16"}

Panel mount (f) with clearance above panel

M39012/04-	Blkhd (f)	Front mount hermetically sealed
UG-680	Blkhd (f)	Front mount pressurized

N Adapters

Military No.	Style	Notes
UG-29,A,B	Str (f/f)	50 Ω , TFE ins.
UG-57A,B	Str (m/m)	50 Ω , TFE ins.
UG-27A,B	Ang (f/m)	Mitre body
UG-212A	Ang (f/m)	Mitre body
UG-107A	T (f/m/f)	—
UG-28A	T (f/f/f)	—
UG-107B	T (f/m/f)	—

Family Characteristics:

N connectors with gaskets are weatherproof. RF leakage: -90 dB min @ 3 GHz. Temperature limits: TFE: -67° to 390°F (-55° to 199°C). Insertion loss 0.15 dB max @ 10 GHz. Copolymer of styrene: -67° to 185°F (-55° to 85°C). Frequency range: 0-11 GHz. Maximum voltage rating: 1500 V P-P. Dielectric withstanding voltage 2500 V RMS. SWR (MIL-C-39012 cable connectors) 1.3 max 0-11 GHz.

BNC Connectors

Military No.	Style	Cable RG-	Notes
UG-88C	Str (m)	55, 58, 141, 142, 223, 400	
Military No.	Style	Cable RG-	Notes
UG-959	Str (m)	8, 9	
UG-260,A	Str (m)	59, 62, 71, 140, 210	Rexolite ins.
UG-262	Pnl (f)	59, 62, 71, 140, 210	Rexolite ins.
UG-262A	Pnl (f)	59, 62, 71, 140, 210	nwx, Rexolite ins.
UG-291	Pnl (f)	55, 58, 141, 142, 223, 400	
UG-291A	Pnl (f)	55, 58, 141, 142, 223, 400	nwx
UG-624	Blkhd (f)	59, 62, 71, 140, 210	Front mount Rexolite ins.
UG-1094A	Blkhd		Standard
UG-625B	Receptacle		
UG-625			

BNC Adapters

Military No.	Style	Notes
UG-491,A	Str (m/m)	
UG-491B	Str (m/m)	Beryllium, outer contact
UG-914	Str (f/f)	
UG-306	Ang (f/m)	
UG-306A,B	Ang (f/m)	Beryllium outer contact
UG-414,A	Pnl (f/f)	# 3-56 tapped flange holes
UG-306	Ang (f/m)	
UG-306A,B	Ang (f/m)	Beryllium outer contact
UG-274	T (f/m/f)	
UG-274A,B	T (f/m/f)	Beryllium outer contact

Family Characteristics:

Z = 50 Ω . Frequency range: 0-4 GHz w/low reflection; usable to 11 GHz. Voltage rating: 500 V P-P. Dielectric withstanding voltage 500 V RMS. SWR: 1.3 max 0-4 GHz. RF leakage -55 dB min @ 3 GHz. Insertion loss: 0.2 dB max @ 3 GHz. Temperature limits: TFE: -67° to 390°F (-55° to 199°C); Rexolite insulators: -67° to 185°F (-55° to 85°C). "Nwx" = not weatherproof.

HN Connectors

Military No.	Style	Cable RG-	Notes
UG-59A	Str (m)	8, 9, 213, 214	
UG-1214	Str (f)	8, 9, 87, 213, 214, 225	Captivated contact
UG-60A	Str (f)	8, 9, 213, 214	Copolymer of styrene ins.
UG-1215	Pnl (f)	8, 9, 87, 213, 214, 225	Captivated contact
UG-560	Pnl (f)		
UG-496	Pnl (f)		
UG-1212C	Ang (f/m)		Beryllium outer contact

Family Characteristics:

Connector Styles: Str = straight; Pnl = panel; Ang = Angle; Blkhd = bulkhead. Z = 50 Ω . Frequency range = 0-4 GHz. Maximum voltage rating = 1500 V P-P. Dielectric withstanding voltage = 5000 V RMS SWR = 1.3. All HN series are weatherproof. Temperature limits: TFE: -67° to 390°F (-55° to 199°C); copolymer of styrene: -67° to 185°F (-55° to 85°C).

Cross-Family Adapters

Families	Description	Military No.
HN to BNC	HN-m/BNC-f	UG-309
N to BNC	N-m/BNC-f	UG-201,A
	N-f/BNC-m	UG-349,A
	N-m/BNC-m	UG-1034
N to UHF	N-m/UHF-f	UG-146
	N-f/UHF-m	UG-83,B
	N-m/UHF-m	UG-318
UHF to BNC	UHF-m/BNC-f	UG-273
	UHF-f/BNC-m	UG-255

References

Table 7.43

US Customary Units

Linear Units

12 inches (in) = 1 foot (ft)
 36 inches = 3 feet = 1 yard (yd)
 1 rod = 5½ yards = 16½ feet
 1 statute mile = 1760 yards = 5280 feet
 1 nautical mile = 6076.11549 feet

Area

1 ft² = 144 in²
 1 yd² = 9 ft² = 1296 in²
 1 rod² = 30¼ yd²
 1 acre = 4840 yd² = 43,560 ft²
 1 acre = 160 rod²
 1 mile² = 640 acres

Volume

1 ft³ = 1728 in³
 1 yd³ = 27 ft³

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 = 57¾ in³
 1 gallon (gal) = 4 qt = 231 in³
 1 barrel = 31½ gal

Dry Volume Measure

1 quart (qt) = 2 pints (pt) = 67.2 in³
 1 peck = 8 qt
 1 bushel = 4 pecks = 2150.42 in³

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

Conversion

Metric Unit = Metric Unit × 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)

mm²	645.16	inch²
cm²	6.4516	in²
cm²	929.03	ft²
m²	0.0929	ft²
cm²	8361.3	yd²
m²	0.83613	yd²
m²	4047	acre
km²	2.59	mi²

(Mass)

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

(Avoirdupois Weight)

(Volume)

mm³	16387.064	in³
cm³	16.387	in³
m³	0.028316	ft³
m³	0.764555	yd³
ml	16.387	in³
ml	29.57	fl oz
ml	473	pint
ml	946.333	quart
l	28.32	ft³
l	0.9463	quart
l	3.785	gallon
l	1.101	dry quart
l	8.809	peck
l	35.238	bushel

(Mass)

g	31.103	oz t
g	373.248	lb t

(Troy Weight)

(Mass)

g	3.387	dr ap
g	31.103	oz ap
g	373.248	lb ap

(Apothecaries' Weight)

Multiply →

Metric Unit = Conversion Factor × US Customary Unit

← Divide

Metric Unit ÷ Conversion Factor = US Customary Unit

Table 7.44**International System of Units (SI)—Metric Units**

<i>Prefix</i>	<i>Symbol</i>	<i>Multiplication Factor</i>	
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

$1 \text{ m}^2 = 1 \times 10^4 \text{ cm}^2 = 1 \times 10^6 \text{ mm}^2$

Volume

$1 \text{ m}^3 = 1 \times 10^6 \text{ cm}^3 = 1 \times 10^9 \text{ mm}^3$

1 liter (l) = 1000 $\text{cm}^3 = 1 \times 10^6 \text{ mm}^3$

Mass

1 kilogram (kg) = 1000 grams (g)

(Approximately the mass of 1 liter of water)

1 metric ton (or tonne) = 1000 kg

Table 7.45**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

Ah—ampere hour

ALC—automatic level control

AM—amplitude modulation

AMRAD—Amateur Radio Research and Development Corporation

AMSAT—Radio Amateur Satellite Corporation

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 (bits 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

BPL—Broadband over Power Line

BT—battery

BW—bandwidth

Bytes—Bytes

C

c—centi (prefix for 10^{-2})
 C—coulomb (quantity of electric charge); capacitor
 CAC—Contest Advisory Committee
 CATV—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
 CD—civil defense
 cm—centimeter
 CMOS—complementary-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—double 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 Alliance
 EIRP—effective isotropic radiated power
 ELF—extremely low frequency
 ELT—emergency locator transmitter
 EMC—electromagnetic compatibility
 EME—earth-moon-earth (moonbounce)
 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^{-15}); 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
 GB—gigabytes
 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
 ITU-T—ITU Telecommunication Standardization Bureau

J-K

j—operator for complex notation, as for reactive component of an impedance (+*j* inductive; −*j* capacitive)
 J—joule ($\text{kg m}^2/\text{s}^2$) (energy or work unit); jack
 JFET—junction field-effect transistor
 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
 kB—kilobytes
 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
 k Ω —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
 MB—megabytes
 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 (MPH)—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
 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 ($1/16$ 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
 PD—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
 PLC—Power Line Carrier
 PLL—phase-locked loop
 PM—phase modulation
 PMOS—P-channel (metal-oxide
 semiconductor)
 PNP—positive negative positive
 (transistor)
 pot—potentiometer
 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 Emer-
 gency 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-capaci-
 tance
 RM—rule making (number assigned to
 petition)
 r/min (RPM)—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—ARRL 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

T

T—tera (prefix for 10^{12}); transformer
 TA—ARRL Technical Advisor
 TC—Technical Coordinator
 TCC—Transcontinental Corps (NTS)
 TCP/IP—Transmission Control Proto-
 col/ 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 ($\text{kg m}^2\text{s}^{-3}$), 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 Radiocommunication Conference
WVDC—working voltage, direct current

X
X—reactance
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

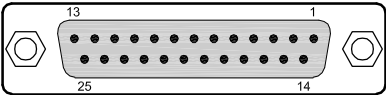
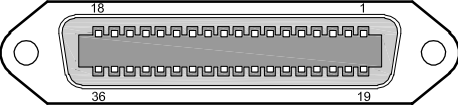
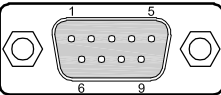
Numbers/Symbols

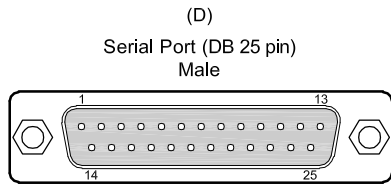
5BDXCC—Five-Band DXCC
5BWAC—Five-Band WAC
5BWAS—Five-Band WAS
6BWAC—Six-Band WAC
°—degree (plane angle)
°C—degree Celsius (temperature)

°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})
 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 $2\pi\text{F}$
 Ω —(omega) resistance in ohms; solid angle

Table 7.46
Computer Connector Pinouts

(A) Parallel Port (DB 25 pin) Female				(B) Parallel Port (Centronics 36 pin) Female				(C) Serial Port (DB 9 pin) Male	
									
Pin	Signal	Pin	Signal	Pin	Signal	Pin	Signal	Pin	Signal
1	Strobe	10	Acknowledge	1	Strobe	13	Select	1	DCD (Data Carrier Detect)
2	Data 0	11	Busy	2	Data 0	14	Auto Feed	2	RxD (Receive Data)
3	Data 1	12	Paper Empty	3	Data 1	15	N/C (not connected)	3	TxD (Transmit Data)
4	Data 2	13	Select	4	Data 2	16	Signal GND	4	DTR (Data Terminal Ready)
5	Data 3	14	Auto Feed	5	Data 3	17	Frame GND	5	GND (Signal Ground)
6	Data 4	15	Error	6	Data 4	18	+5 V Out	6	DSR (Data Set Ready)
7	Data 5	16	Initialize	7	Data 5	19-30	GND	7	RTS (Request To Send)
8	Data 6	17	Select In	8	Data 6	31	Reset	8	CTS (Clear To Send)
9	Data 7	18-25	GND	9	Data 7	32	Error	9	RI (Ring Indicator)
				10	Acknowledge	33	External GND		
				11	Busy	34	N/C		
				12	Paper Empty	35	N/C		
						36	Select In		

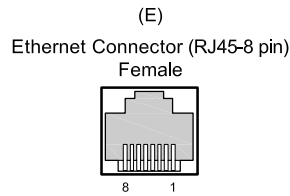


Pin Signal

- 1 N/C (not connected)
- 2 TxD (Transmit Data)
- 3 RxD (Receive Data)
- 4 RTS (Request To Send)
- 5 CTS (Clear To Send)
- 6 DSR (Data Set Ready)
- 7 GND (Signal Ground)
- 8 DCD (Data Carrier Detect)
- 9-19 N/C

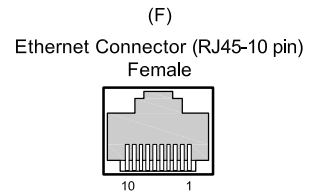
Pin Signal

- 20 DTR (Data Terminal Ready)
- 21 N/C
- 22 RI (Ring Indicator)
- 23 N/C
- 24 N/C
- 25 N/C



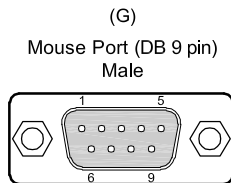
Pin Signal

- 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



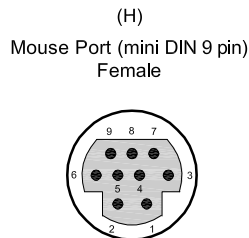
Pin Signal

- 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)



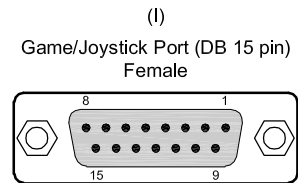
Pin Signal

- 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



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



Pin Signal

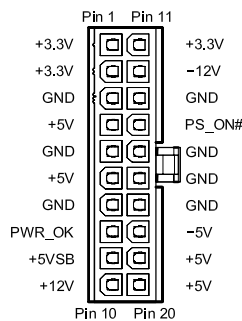
- 1 +5 V
- 2 Button (A-1)
- 3 Position (A-X)
- 4 GND
- 5 GND
- 6 Position (A-Y)
- 7 Button (A-2)
- 8 +5 V
- 9 +5 V

Pin Signal

- 10 Button (B-1)
- 11 Position (B-X)
- 12 GND
- 13 Position (B-Y)
- 14 Button (B-2)
- 15 +5 V

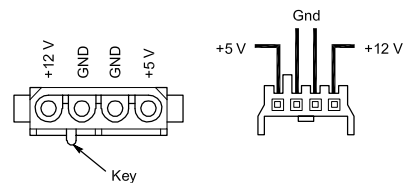
(K)

PC-ATX Type Power Connector
Viewed from Connector End



(L)

Disk Drive, CD and Other Device
Power Connector
Viewed from Connector End



Note: All figures not drawn to same scale.

HBK0030

Table 7.47

Voltage-Power Conversion Table

Based on a 50-ohm system

Voltage			Power	
RMS	Peak-to-Peak	dBmV	Watts	dBm
0.01 μ V	0.0283 μ V	-100	2×10^{-18}	-147.0
0.02 μ V	0.0566 μ V	-93.98	8×10^{-18}	-141.0
0.04 μ V	0.113 μ V	-87.96	32×10^{-18}	-134.9
0.08 μ V	0.226 μ V	-81.94	128×10^{-18}	-128.9
0.1 μ V	0.283 μ V	-80.0	200×10^{-18}	-127.0
0.2 μ V	0.566 μ V	-73.98	800×10^{-18}	-121.0
0.4 μ V	1.131 μ V	-67.96	3.2×10^{-15}	-114.9
0.8 μ V	2.236 μ V	-61.94	12.8×10^{-15}	-108.9
1.0 μ V	2.828 μ V	-60.0	20.0×10^{-15}	-107.0
2.0 μ V	5.657 μ V	-53.98	80.0×10^{-15}	-101.0
4.0 μ V	11.31 μ V	-47.96	320.0×10^{-15}	-94.95
8.0 μ V	22.63 μ V	-41.94	1.28×10^{-12}	-88.93
10.0 μ V	28.28 μ V	-40.00	2.0×10^{-12}	-86.99
20.0 μ V	56.57 μ V	-33.98	8.0×10^{-12}	-80.97
40.0 μ V	113.1 μ V	-27.96	32.0×10^{-12}	-74.95
80.0 μ V	226.3 μ V	-21.94	128.0×10^{-12}	-68.93
100.0 μ V	282.8 μ V	-20.0	200.0×10^{-12}	-66.99
200.0 μ V	565.7 μ V	-13.98	800.0×10^{-12}	-60.97
400.0 μ V	1.131 mV	-7.959	3.2×10^{-9}	-54.95
800.0 μ V	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 μ W	-28.93
10.0 mV	28.28 mV	20.00	1 2.0 μ W	-26.99
20.0 mV	56.57 mV	26.02	8.0 μ W	-20.97
40.0 mV	113.1 mV	32.04	32.0 μ W	-14.95
80.0 mV	226.3 mV	38.06	128.0 μ W	-8.93
100.0 mV	282.8 mV	40.0	200.0 μ W	-6.99
200.0 mV	565.7 mV	46.02	800.0 μ W	-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	1,000.0 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

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

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

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

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

Table 7.48
Large Machine-Wound Coil Specifications

<i>Coil Dia, Inches</i>	<i>Turns Per Inch</i>	<i>Inductance in μH</i>
1 $\frac{1}{4}$	4	2.75
	6	6.3
	8	11.2
	10	17.5
	16	42.5
1 $\frac{1}{2}$	4	3.9
	6	8.8
	8	15.6
	10	24.5
	16	63
1 $\frac{3}{4}$	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 $\frac{1}{2}$	4	10.2
	6	23
	8	41
	10	64
3	4	14
	6	31.5
	8	56
	10	89

Table 7.50
Small Machine-Wound Coil Specifications

<i>Coil Dia, Inches</i>	<i>Turns Per Inch</i>	<i>Inductance in μH</i>
1 $\frac{1}{2}$ (A)	4	0.18
	6	0.40
	8	0.72
	10	1.12
	16	2.8
	32	12
5 $\frac{5}{8}$ (A)	4	0.28
	6	0.62
	8	1.1
	10	1.7
	16	4.4
	32	18
3 $\frac{3}{4}$ (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

Table 7.49
Inductance Factor for Large Machine-Wound Coils

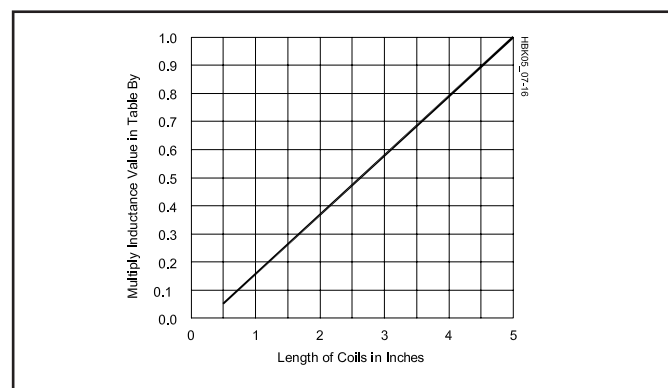


Table 7.51
Inductance Factor for Small Machine-Wound Coils

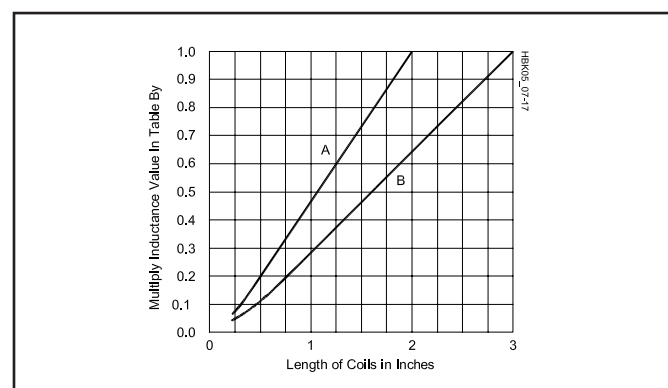
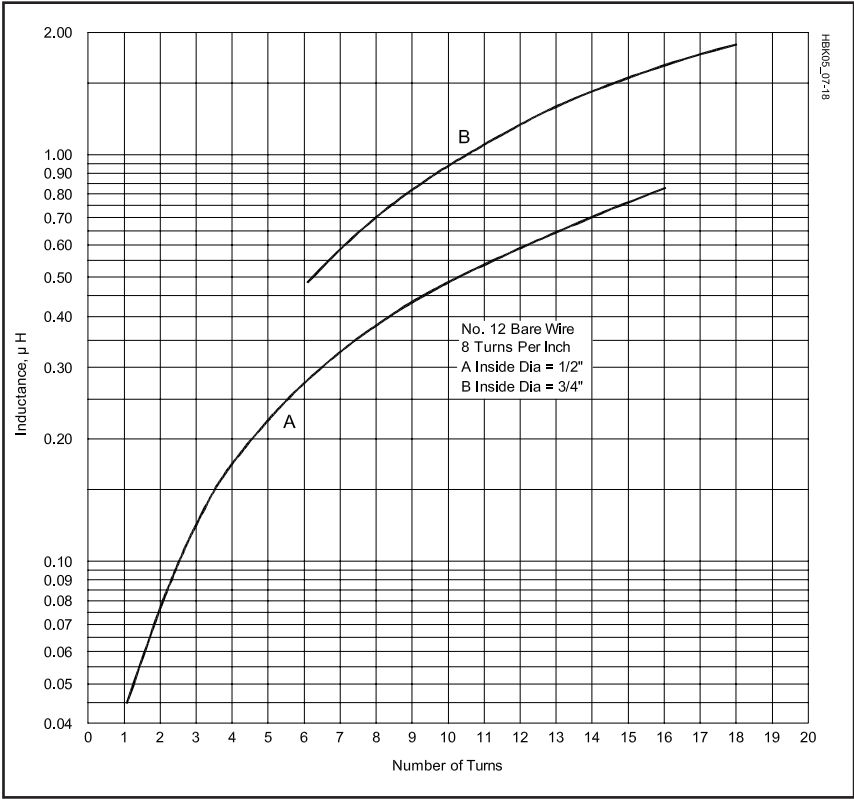


Table 7.52
Measured Inductance for #12 Wire Windings



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

Table 7.53
Relationship Between Noise Figure and Noise Temperature

Note: Reference temperature is 290 kelvin

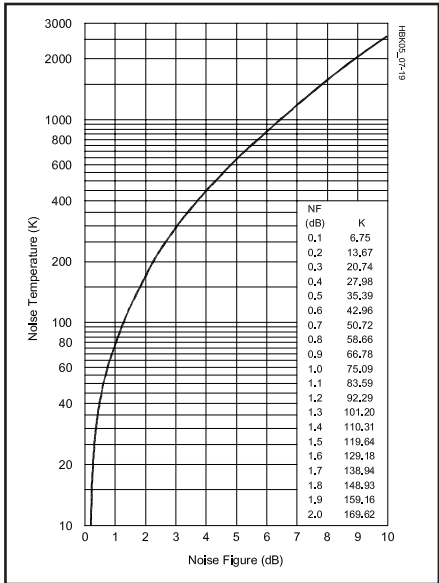


Table 7.54
Antenna Wire Strength

American Wire Gauge	Recommended Tension ¹ (pounds)		Weight (pounds per 1000 feet)	
	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

¹Approximately 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.

Table 7.55
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	—

Table 7.56
Pi-Network Resistive Attenuators (50 Ω)

dB Atten.	R1 (Ohms)	R2 (Ohms)
1.0	870	5.77
2.0	436	11.6
3.0	292	17.6
4.0	221	23.8
5.0	178	30.4
6.0	150	37.4
7.0	131	44.8
8.0	116	52.8
9.0	105	61.6
10.0	96.2	71.2
11.0	89.2	81.7
12.0	83.5	93.2
13.0	78.8	106
14.0	74.9	120
15.0	71.6	136
16.0	68.8	154
17.0	66.4	173
18.0	64.4	195
19.0	62.6	220
20.0	61.1	248
21.0	59.8	278
22.0	58.6	313
23.0	57.6	352
24.0	56.7	395
25.0	56.0	443
30.0	53.2	790
35.0	51.8	1405
40.0	51.0	2500
45.0	50.5	4446
50.0	50.3	7906
55.0	50.2	14,058
60.0	50.1	25,000

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**.

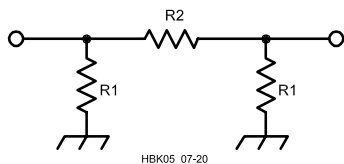


Table 7.57
T-Network Resistive Attenuators (50 Ω)

dB Atten.	R1 (Ohms)	R2 (Ohms)
1.0	2.88	433
2.0	5.73	215
3.0	8.55	142
4.0	11.3	105
5.0	14.0	82.2
6.0	16.6	66.9
7.0	19.1	55.8
8.0	21.5	47.3
9.0	23.8	40.6
10.0	26.0	35.1
11.0	28.0	30.6
12.0	30.0	26.8
13.0	31.7	23.5
14.0	33.3	20.8
15.0	35.0	18.4
16.0	36.3	16.2
17.0	37.6	14.4
18.0	38.8	12.8
19.0	40.0	11.4
20.0	41.0	10.0
21.0	41.8	9.0
22.0	42.6	8.0
23.0	43.4	7.1
24.0	44.0	6.3
25.0	44.7	5.6
30.0	47.0	3.2
35.0	48.2	1.8
40.0	49.0	1.0
45.0	49.4	0.56
50.0	49.7	0.32
55.0	49.8	0.18
60.0	49.9	0.10

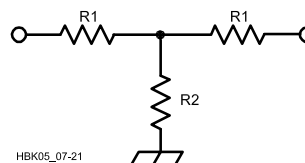


Table 7.58
Impedance of Various Two-Conductor Lines

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

Table 7.59**Attenuation per Foot for Lines**

Wire Size	Twists per Inch				
	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.

Table 7.60**Equivalent Values of Reflection Coefficient, Attenuation, SWR and Return Loss**

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

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

where $\rho = 0.01 \times (\text{reflection coefficient in \%})$

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

where RL = return loss (dB)

$$\rho = \sqrt{1 - (0.1^X)}$$

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

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

Return loss (dB) = $-8.68589 \ln(\rho)$

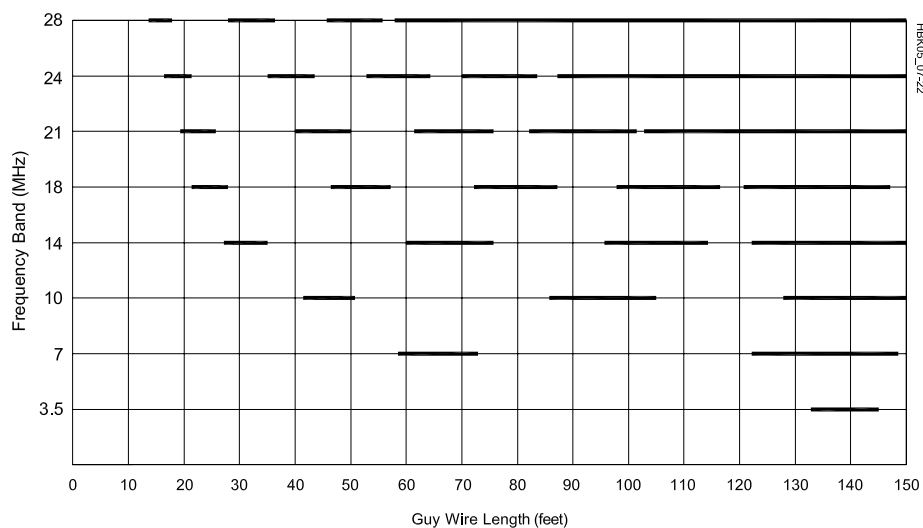
where ln is the natural log (log to the base e)

Attenuation (dB) = $-4.34295 \ln(1 - \rho^2)$

where ln is the natural log (log to the base e)

Table 7.61

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*)

Table 7.62

Morse Code Character Set¹

A	didah	• –	At [@]	didahdahdidahdit	• – • – •	AC
B	dahdididit	– •••	Period [.]	didahdidahdidah	• – • – • –	AAA
C	dahdidahdit	– • – •	Comma [,:]	dahdahdidahdah	– – •• – –	MIM
D	dahdidit	– ••	Question mark or request for repetition [?]:	didahdahdidit	•• – – ••	IMI
E	dit	•	Error:	dididididididit	••••••••	HH
F	dididahdit	•• – •	Hyphen or dash [–]:	dahdididididah	– •••• –	DU
G	dahdahdit	– – •	Double dash [=]	dahdidididah	– ••• –	BT
H	didididit	••••	Colon [,:]	dahdahdahdididit	– – – •••	OS
I	didit	••	Semicolon [;]:	dahdidahdidahdit	– • – • – •	KR
J	didahdahdah	• – – –	Left parenthesis [(]:	dahdidahdahdit	– • – – •	KN
K	dahdidah	– • –	Right parenthesis [)]:	dahdidahdahddidah	– • – – – •	KK
L	didahdidit	• – ••	Fraction bar [/]:	dahdididahdit	– •• – •	DN
M	dahdah	– –	Quotation marks ["]:	didahdididahdit	• – •• – •	AF
N	dahdit	– •	Dollar sign [\$]:	didididahdididah	••• – •• –	SX
O	dahdahdah	– – –	Apostrophe [']:	didahdahdahdahdit	• – – – – •	WG
P	didahdahdit	• – – •	Paragraph [¶]:	didahdidahdidit	•• – – ••	AL
Q	dahdahdidah	– • – •	Underline [_]:	dididahdahdidah	•• – – • –	IQ
R	didahdit	• – •	Starting signal:	dahdidahdidah	– •• – •	KA
S	dididit	•••	Wait:	didahdididit	•• – ••	AS
T	dah	–	End of message or cross [+]:	dahdidahdit	•• – ••	AR
U	dididah	•• –	Invitation to transmit [K]:	dahdidah	– • –	K
V	didididah	••• –	End of work:	didididahdidah	••• – • –	SK
W	didahdah	• – –	Understood:	didididahdit	••• – •	SN
X	dahdididah	– •• –				
Y	dahdidahdah	– • – –				
Z	dahdahdidit	– – ••				

1	didahdahdahdah	• – – – –	2. The following letters are used in certain European languages which use the Latin alphabet:	3. Special Esperanto characters:
2	dididahdahdah	•• – – –	Ä, Å	^ C dahdidahdidit – •• ••
3	didididahdah	••• – –	Ä, Å, Ä, Å	^ S didididahdit ••• – •
4	dididididah	•••• –	Ç, Ç	^ J didahdahdahdit • – – – •
5	dididididit	•••••	É, Ê, Ë	^ H dahdidahdahdit – • – – •
6	dahdidididit	– ••••	Ê	^ U dididahdah •• – –
7	dahdahdididit	– – •••	Ë	^ G dahdahdidahdit – – •• •
8	dahdahdahdidit	– – – ••	Ö, Ø, Ó	
9	dahdahdahdahdit	– – – – •	Ñ	
0	dahdahdahdahdah	– – – – –	Ü	
			Ž	
			Z	
			CH, Ş	

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

Table 7.63

Morse Abbreviated (“Cut”) Numbers

<i>Numeral</i>		<i>Long Number</i>		<i>Abbreviated Number</i>	<i>Equivalent Character</i>
1	didahdahdahdah	•-----	didah	•-	A
2	dididahdahdah	••-----	dididah	••-	U
3	didididahdah	•••-----	didididah	•••-	V
4	dididididah	••••-	dididididah	••••-	4
5	dididididit	•••••	dididididit	••••• or •	5 or E
6	dahdidididit	-----•	dahdidididit	-----•	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.

Table 7.64

The ASCII Coded Character Set

<i>Bit</i>		6	0	0	0	0	1	1	1	1
<i>Number</i>		5	0	0	1	1	0	0	1	1
	<i>Hex</i>	4	0	1	0	1	0	1	0	1
	<i>1st</i>	0	1	2	3	4	5	6	7	
3 2 1 0	<i>2nd</i>									
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	

Notes

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

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

Table 7.65**Voluntary HF Band Plans**

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.

<i>Frequencies</i>	<i>Modes/Activities</i>	<i>Frequencies</i>	<i>Modes/Activities</i>
1.800-2.000	CW	14.285	QRP SSB calling frequency
1.800-1.810	Digital Modes	14.286	AM calling frequency
1.810	CW QRP calling frequency		
1.843-2.000	SSB, SSTV and other wideband modes	18.100-18.105	RTTY/Data
1.910	SSB QRP	18.105-18.110	Automatically controlled data stations
1.995-2.000	Experimental	18.110	IBP/NCDXF beacons
1.999-2.000	Beacons		
		21.060	QRP CW calling frequency
3.500-3.510	CW DX window	21.070-21.110	RTTY/Data
3.560	QRP CW calling frequency	21.090-21.100	Automatically controlled data stations
3.570-3.600	RTTY/Data	21.150	IBP/NCDXF beacons
3.585-3.600	Automatically controlled data stations	21.340	SSTV
3.590	RTTY/Data DX	21.385	QRP SSB calling frequency
3.790-3.800	DX window		
3.845	SSTV	24.920-24.925	RTTY/Data
3.885	AM calling frequency	24.925-24.930	Automatically controlled data stations
3.985	QRP SSB calling frequency	24.930	IBP/NCDXF beacons
7.030	QRP CW calling frequency	28.060	QRP CW calling frequency
7.040	RTTY/Data DX	28.070-28.120	RTTY/Data
7.080-7.125	RTTY/Data	28.120-28.189	Automatically controlled data stations
7.100-7.105	Automatically controlled data stations	28.190-28.225	Beacons
7.171	SSTV	28.200	IBP/NCDXF beacons
7.285	QRP SSB calling frequency	28.385	QRP SSB calling frequency
7.290	AM calling frequency	28.680	SSTV
		29.000-29.200	AM
10.130-10.140	RTTY/Data	29.300-29.510	Satellite downlinks
10.140-10.150	Automatically controlled data stations	29.520-29.580	Repeater inputs
		29.600	FM simplex
14.060	QRP CW calling frequency	29.620-29.680	Repeater outputs
14.070-14.095	RTTY/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		

Notes

ARRL band plans for frequencies above 28.300 MHz are shown in *The ARRL Repeater Directory* and on www.arrl.org.

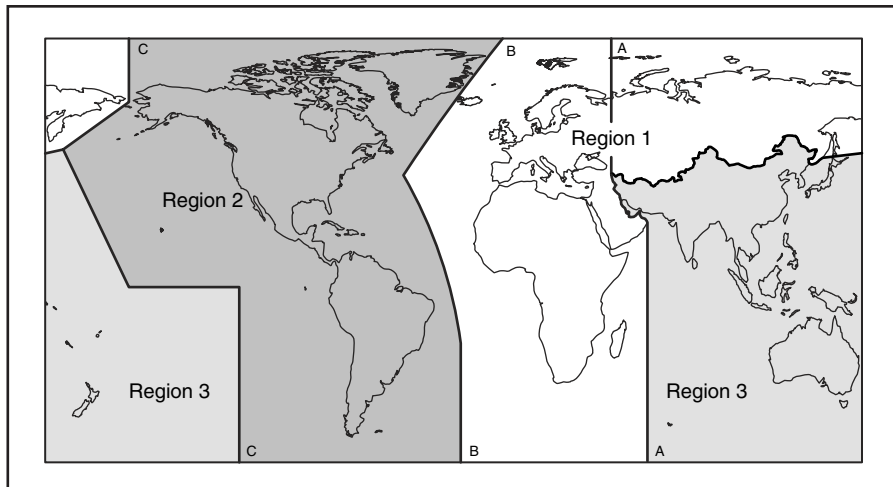
Table 7.66**VHF/UHF/EHF Calling Frequencies**

		1296	1294.500 National FM simplex frequency
			1296.100 CW/SSB
<i>Band (MHz)</i>	<i>Calling Frequency</i>		
50	50.125 SSB	2304	2304.4
	50.620 digital (packet)		2305.2 FM simplex frequency
	52.525 National FM simplex frequency		
144	144.010 EME	10000	10368.1 Narrow-band
	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		
		<i>Band (MHz)</i>	<i>Day</i>
		50	Sunday
		144	Monday
		222	Tuesday
		432	Wednesday
		902	Friday
		1296	Thursday
			<i>Local Time</i>
			6 PM
			7 PM
			8 PM
			9 PM
			9 PM
			10 PM

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.

Table 7.67
ITU Regions



The International Telecommunication Union divides the world into three regions.

Table 7.68
Allocation of International Call Signs

AAA-ALZ	United States of America	EKA-EKZ	Armenia	H4A-H4Z	Solomon Islands
AMA-AOZ	Spain	ELA-ELZ	Liberia	H6A-H7Z	Nicaragua
APA-ASZ	Pakistan	EMA-EOZ	Ukraine	H8A-H9Z	Panama
ATA-AWZ	India	EPA-EQZ	Iran	IAA-IZZ	Italy
AXA-AXZ	Australia	ERA-ERZ	Moldova	JAA-JSZ	Japan
AYA-AZZ	Argentina	ESA-ESZ	Estonia	JTA-JVZ	Mongolia
A2A-A2Z	Botswana	ETA-ETZ	Ethiopia	JWA-JXZ	Norway
A3A-A3Z	Tonga	EUA-EWZ	Belarus	JYA-JYZ	Jordan
A4A-A4Z	Oman	EXA-EXZ	Kyrgyzstan	JZA-JZZ	Indonesia
A5A-A5Z	Bhutan	EYA-EYZ	Tajikistan	J2A-J2Z	Djibouti
A6A-A6Z	United Arab Emirates	EZA-EZZ	Turkmenistan	J3A-J3Z	Grenada
A7A-A7Z	Qatar	E2A-E2Z	Thailand	J4A-J4Z	Greece
A8A-A8Z	Liberia	E3A-E3Z	Eritrea	J5A-J5Z	Guinea-Bissau
A9A-A9Z	Bahrain	†E4A-E4Z	Palestinian Authority	J6A-J6Z	Saint Lucia
BAA-BZZ	China (People's Republic of)	FAA-FZZ	France	J7A-J7Z	Dominica
CAA-CEZ	Chile	GAA-GZZ	United Kingdom of Great Britain and Northern Ireland	J8A-J8Z	St. Vincent and the Grenadines
CFA-CKZ	Canada	HAA-HAZ	Hungary	KAA-KZZ	United States of America
CLA-CMZ	Cuba	HBA-HBZ	Switzerland	LAA-LNZ	Norway
CNA-CNZ	Morocco	HCA-HDZ	Ecuador	LOA-LWZ	Argentina
COA-COZ	Cuba	HEA-HEZ	Switzerland	LXA-LXZ	Luxembourg
CPA-CPZ	Bolivia	HFA-HFZ	Poland	LYA-LYZ	Lithuania
CQA-CUZ	Portugal	HGA-HGZ	Hungary	LZA-LZZ	Bulgaria
CVA-CXZ	Uruguay	HHA-HHZ	Haiti	L2A-L9Z	Argentina
CYA-CZZ	Canada	HIA-HIZ	Dominican Republic	MAA-MZZ	United Kingdom of Great Britain and Northern Ireland
C2A-C2Z	Nauru	HJA-HKZ	Colombia	NAA-NZZ	United States of America
C3A-C3Z	Andorra	HLA-HLZ	Republic of Korea	OAA-OCZ	Peru
C4A-C4Z	Cyprus	HMA-HMZ	Democratic People's Republic of Korea	ODA-ODZ	Lebanon
C5A-C5Z	Gambia	HNA-HNZ	Republic of Korea	OEA-OEZ	Austria
C6A-C6Z	Bahamas	HOA-HPZ	Iraq	OFA-OJZ	Finland
* C7A-C7Z	World Meteorological Organization	HQA-HRZ	Panama	OKA-OLZ	Czech Republic
C8A-C9Z	Mozambique	HSA-HSZ	Honduras	OMA-OMZ	Slovak Republic
DAA-DRZ	Germany	HTA-HTZ	Thailand	ONA-OTZ	Belgium
DSA-DTZ	Republic of Korea	HUA-HUZ	Nicaragua	OUA-OZZ	Denmark
DUA-DZZ	Philippines	HVA-HVZ	El Salvador	PAA-PIZ	Netherlands
D2A-D3Z	Angola	HWA-HYZ	Vatican City State	PJA-PJZ	Netherlands Antilles
D4A-D4Z	Cape Verde	HZA-HZZ	France	PKA-POZ	Indonesia
D5A-D5Z	Liberia	H2A-H2Z	Saudi Arabia	PPA-PYZ	Brazil
D6A-D6Z	Comoros	H3A-H3Z	Cyprus	PZA-PZZ	Suriname
D7A-D9Z	Republic of Korea		Panama	P2A-P2Z	Papua New Guinea
EAA-EHZ	Spain				
EIA-EJZ	Ireland				

P3A-P3Z	Cyprus	XAA-XIZ	Mexico	5BA-5BZ	Cyprus
P4A-P4Z	Aruba	XJA-XOZ	Canada	5CA-5GZ	Morocco
P5A-P9Z	Democratic People's Republic of Korea	XPA-XPZ	Denmark	5HA-5IZ	Tanzania
RAA-RZZ	Russian Federation	XQA-XRZ	Chile	5JA-5KZ	Colombia
SAA-SMZ	Sweden	XSA-XSZ	China	5LA-5MZ	Liberia
SNA-SRZ	Poland	XTA-XTZ	Burkina Faso	5NA-5OZ	Nigeria
SSA-SSM	Egypt	XUA-XUZ	Cambodia	5PA-5QZ	Denmark
SSN-STZ	Sudan	XVA-XVZ	Viet Nam	5RA-5SZ	Madagascar
SUA-SUZ	Egypt	XWA-XWZ	Laos	5TA-5TZ	Mauritania
SVA-SZZ	Greece	XXA-XXZ	Portugal	5UA-5UZ	Niger
S2A-S3Z	Bangladesh	XYA-XZZ	Myanmar	5VA-5VZ	Togo
S5A-S5Z	Slovenia	YAA-YAZ	Afghanistan	5WA-5WZ	Western Samoa
S6A-S6Z	Singapore	YBA-YHZ	Indonesia	5XA-5XZ	Uganda
S7A-S7Z	Seychelles	YIA-YIZ	Iraq	5YA-5ZZ	Kenya
S8A-S8Z	South Africa	YJA-YJZ	Vanuatu	6AA-6BZ	Egypt
S9A-S9Z	Sao Tome and Principe	YKA-YKZ	Syria	6CA-6CZ	Syria
TAA-TCZ	Turkey	YLA-YLZ	Latvia	6DA-6JZ	Mexico
TDA-TDZ	Guatemala	YMA-YMZ	Turkey	6KA-6NZ	Republic of Korea
TEA-TEZ	Costa Rica	YNA-YNZ	Nicaragua	6OA-6OZ	Somalia
TFA-TFZ	Iceland	YOA-YRZ	Romania	6PA-6SZ	Pakistan
TGA-TGZ	Guatemala	YSA-YSZ	El Salvador	6TA-6UZ	Sudan
THA-THZ	France	YTA-YUZ	Serbia (Republic of)	6VA-6WZ	Senegal
TIA-TIZ	Costa Rica	YVA-YYZ	Venezuela	6XA-6XZ	Madagascar
TJA-TJZ	Cameroon	Y2A-Y9Z	Germany	6YA-6YZ	Jamaica
TKA-TKZ	France	ZAA-ZAZ	Albania	6ZA-6ZZ	Liberia
TLA-TLZ	Central Africa	ZBA-ZJZ	United Kingdom of Great Britain and Northern Ireland	7AA-7IZ	Indonesia
TMA-TMZ	France	ZKA-ZMZ	New Zealand	7JA-7NZ	Japan
TNA-TNZ	Congo (Republic of the)	ZNA-ZOZ	United Kingdom of Great Britain and Northern Ireland	7OA-7OZ	Yemen
TOA-TQZ	France	ZPA-ZPZ	Paraguay	7PA-7PZ	Lesotho
TRA-TRZ	Gabon	ZQA-ZQZ	United Kingdom of Great Britain and Northern Ireland	7QA-7QZ	Malawi
TSA-TSZ	Tunisia	ZRA-ZUZ	South Africa	7RA-7RZ	Algeria
TTA-TTZ	Chad	ZVA-ZZZ	Brazil	7SA-7SZ	Sweden
TUA-TUZ	Ivory Coast	Z2A-Z2Z	Zimbabwe	7TA-7YZ	Algeria
TVA-TXZ	France	Z3A-Z3Z	Macedonia (Former Yugoslav Republic)	7ZA-7ZZ	Saudi Arabia
TYA-TYZ	Benin	2AA-2ZZ	United Kingdom of Great Britain and Northern Ireland	8AA-8IZ	Indonesia
TZA-TZZ	Mali	3AA-3AZ	Monaco	8JA-8NZ	Japan
T2A-T2Z	Tuvalu	3BA-3BZ	Mauritius	8OA-8OZ	Botswana
T3A-T3Z	Kiribati	3CA-3CZ	Equatorial Guinea	8PA-8PZ	Barbados
T4A-T4Z	Cuba	3DA-3DM	Swaziland	8QA-8QZ	Maldives
T5A-T5Z	Somalia	3DN-3DZ	Fiji	8RA-8RZ	Guyana
T6A-T6Z	Afghanistan	3EA-3FZ	Panama	8SA-8SZ	Sweden
T7A-T7Z	San Marino	3GA-3GZ	Chile	8TA-8YZ	India
T8A-T8Z	Palau	3HA-3UZ	China	8ZA-8ZZ	Saudi Arabia
T9A-T9Z	Bosnia and Herzegovina	3VA-3VZ	Tunisia	9AA-9AZ	Croatia
UAA-UIZ	Russian Federation	3WA-3WZ	Viet Nam	9BA-9DZ	Iran
UJA-UMZ	Uzbekistan	3XA-3XZ	Guinea	9EA-9FZ	Ethiopia
UNA-UQZ	Kazakhstan	3YA-3YZ	Norway	9GA-9GZ	Ghana
URA-UZZ	Ukraine	3ZA-3ZZ	Poland	9HA-9HZ	Malta
VAA-VGZ	Canada	4AA-4CZ	Mexico	9IA-9JZ	Zambia
VHA-VNZ	Australia	4DA-4IZ	Philippines	9KA-9KZ	Kuwait
VOA-VOZ	Canada	4JA-4KZ	Azerbaijani Republic	9LA-9LZ	Sierra Leone
VPA-VQZ	United Kingdom of Great Britain and Northern Ireland	4LA-4LZ	Georgia	9MA-9MZ	Malaysia
VRA-VRZ	China (People's Republic of)—Hong Kong	4MA-4MZ	Venezuela	9NA-9NZ	Nepal
VSA-VSZ	United Kingdom of Great Britain and Northern Ireland	4OA-4OZ	Montenegro (Republic of)	9OA-9TZ	Democratic Republic of the Congo
VT A-VWZ	India	4PA-4SZ	Sri Lanka	9UA-9UZ	Burundi
VXA-VYZ	Canada	4TA-4TZ	Peru	9VA-9VZ	Singapore
VZA-VZZ	Australia	* 4UA-4UZ	United Nations	9WA-9WZ	Malaysia
V2A-V2Z	Antigua and Barbuda	4VA-4VZ	Haiti	9XA-9XZ	Rwanda
V3A-V3Z	Belize	* 4WA-4WZ	United Nations	9YZ-9ZZ	Trinidad and Tobago
V4A-V4Z	Saint Kitts and Nevis	4XA-4XZ	Israel		
V5A-V5Z	Namibia	* 4YA-4YZ	International Civil Aviation Organization		
V6A-V6Z	Micronesia	4ZA-4ZZ	Israel		
V7A-V7Z	Marshall Islands	5AA-5AZ	Libya		
V8A-V8Z	Brunei				
WAA-WZZ	United States of America				

Notes:

*Series allocated to an international organization

†In response to Resolution 99 (Minneapolis, 1998) of the Plenipotentiary Conference

Table 7.69**FCC-Allocated Prefixes for Areas Outside the Continental US**

<i>Prefix</i>	<i>Location</i>
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
AH0, KH0, NH0, WH0	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

Table 7.70**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 $\overline{SK}$, 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 ($\overline{SK}$).
 - b) Because you hear someone else calling him.
 - c) When he signs KN, 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 $\overline{KN}$ to indicate to impatient listeners the status of the QSO. $\overline{KN}$ 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.
-

Table 7.71

W1AW SCHEDULE

Pacific	Mtn	Central	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	Digital 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	Digital 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				

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 second Sunday in March to the first Sunday in November, UTC = Eastern Time + 4 hours. For the rest of the year, UTC = Eastern Time + 5 hours.

Morse code transmissions:

Frequencies are 1.8175, 3.5815, 7.0475, 14.0475, 18.0975, 21.0675, 28.0675 and 147.555 MHz.

Slow Code = practice sent at 5, 7½, 10, 13 and 15 WPM.

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

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 K6YR. See Contest Corral in *QST* or on the ARRL Web site for the schedule. 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. Fees: \$10 for a certificate, \$7.50 for endorsements.

Digital transmissions:

Frequencies are 3.5975, 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.

Voice transmissions:

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

Notes:

On Fridays, UTC, a DX bulletin replaces the regular bulletins. W1AW is open to visitors from 10 AM to noon and 1 PM to 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, digital at 15 minutes past the hour, and CW on the half hour.

Headquarters and W1AW are normally 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 and the following day.

Check *QST* or www.arrl.org/w1aw.html for more information.

Table 7.72**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.

<i>Situation</i>	<i>CW</i>	<i>Voice</i>
check for a clear frequency	QRL?	Is the frequency in use?
seek contact with any station	CQ	CQ
after call to specific named station or to indicate end of 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.

Table 7.73**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 ____.	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).
QRG	Will you tell me my exact frequency (or that of ____)? Your exact frequency (or that of ____) is ____ kHz.	QSB	Are my signals fading? Your signals are fading.
QRH	Does my frequency vary? Your frequency varies.	QSD	Is my keying defective? Your keying is defective.
QRI	How is the tone of my transmission? The tone of your transmission is ____ (1. Good; 2. Variable; 3. Bad).	QSG	Shall I send ____ messages at a time? Send ____ messages at a time.
QRJ	Are you receiving me badly? I cannot receive you. Your signals are too weak.	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.
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).	QSL	Can you acknowledge receipt? I am acknowledging receipt.
QRL	Are you busy? I am busy (or I am busy with ____). Please do not interfere.	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) ____].
QRM	Is my transmission being interfered with? Your transmission is being interfered with (1. Nil; 2. Slightly; 3. Moderately; 4. Severely; 5. Extremely.)	QSN	Did you hear me (or ____) on ____ kHz? I did hear you (or ____) on ____ kHz.
QRN	Are you troubled by static? I am troubled by static ____ (1-5 as under QRM).	QSO	Can you communicate with ____ direct or by relay? I can communicate with ____ direct (or by relay through ____).
QRO	Shall I increase power? Increase power.	QSP	Will you relay to ____? I will relay to ____
QRP	Shall I decrease power? Decrease power.	QST	General call preceding a message addressed to all amateurs and ARRL members. This is in effect "CQ ARRL."
QRQ	Shall I send faster? Send faster (____ WPM).	QSU	Shall I send or reply on this frequency (or on ____ kHz)? Send or reply on this frequency (or ____ kHz).
QRS	Shall I send more slowly? Send more slowly (____ WPM).	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).
QRT	Shall I stop sending? Stop sending.	QSW	Will you send on this frequency (or on ____ kHz)? I am going to send on this frequency (or on ____ kHz).
QRU	Have you anything for me? I have nothing for you.	QSX	Will you listen to ____ on ____ kHz? I am listening to ____ on ____ kHz.
QRV	Are you ready? I am ready.	QSY	Shall I change to transmission on another frequency? Change to transmission on another frequency (or on ____ kHz).
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).		

QSZ	Shall I send each word or group more than once? Send each word or group twice (or _____ times).	QNL	Your net frequency is Low.
QTA	Shall I cancel message number _____? Cancel message number _____	QNM*	You are QRMing the net. Stand by.
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.	QNN	Net control station is _____. What station has net control?
QTC	How many messages have you to send? I have _____ messages for you (or for _____).	QNO	Station is leaving the net.
QTH	What is your location? My location is _____	QNP	Unable to copy you. Unable to copy _____.
QTR	What is the correct time? The correct time is _____	QNQ*	Move frequency to _____ and wait for _____ to finish handling traffic. Then send him traffic for _____.
QTV	Shall I stand guard for you? Stand guard for me.	QNR*	Answer _____ and Receive traffic.
QTX	Will you keep your station open for further communication with me? Keep your station open for me.	QNS	Following Stations are in the net.* (follow with list.) Request list of stations in the net.
QUA	Have you news of _____? I have news of _____.	QNT	I request permission to leave the net for _____ minutes.
ARRL QN Signals		QNU*	The net has traffic for <i>you</i> . Stand by.
QNA*	Answer in prearranged order.	QNV*	Establish contact with _____ on this frequency. If successful, move to _____ and send him traffic for _____.
QNB	Act as relay between _____ and _____.	QNW	How do I route messages for _____?
QNC	All net stations copy. I have a message for all net stations.	QNX	You are excused from the net.*
QND*	Net is Directed (Controlled by net control station.)	QNY*	Shift to another frequency (or to _____ kHz) to clear traffic with _____.
QNE*	Entire net stand by.	QNZ	Zero beat your signal with mine.
QNF	Net is Free (not controlled).	*For use only by the Net Control Station.	
QNG	Take over as net control station	Notes on Use of QN Signals	
QNH	Your net frequency is High.	These QN signals are special ARRL signals for use in amateur CW nets <i>only</i> . 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. <i>Say it with words</i> . QN signals need not be followed by a question mark, even though the meaning may be interrogatory.	
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 _____.		

Table 7.74
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.

Table 7.75

CW Abbreviations

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

Table 7.76

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.

Table 7.77
ARRL Log

See inside front cover. Output in Watts. UTC recommended. RST. See back inside cover. This column may also be used for contest-exchange info received.

FIXED				VARIABLE									
DATE	FREQ.	MODE	POWER	TIME	STATION WORKED	REPORT SENT	RECD	TIME OFF	QTH	COMMENTS NAME	QSL Y/N	QSL S/R	
28 JUL	14.6.52	FM	10	0430	WA1CCR					Wellingford Eric	NEW CONVERTER WORKS!		
3 OCT	7.0	CW	150	2319	WAGVEF	001	322			CALIFORNIA QSO PARTY			
				22	N60J	002	157			SONO			
				24	KGNA	003	331			SD			
				31	N60P/M	004	117			CALAV			
9 OCT	28.6	SSB	1kW	0301	JA10CA	59	57			Tokyo Isao	Buro	✓	
	21	CW		1545	EA9GD	559	579			Melilla Jose	Box 348	✓	
				56	GO8DX	599	599			SOMALIA	I2YAE	✓	
5 NOV	3.810.2	SSB	150	0030	W9NA	59+	59+	0117		Wausau, WI. Reno			
9 NOV	21	CW	10	1642	G4BUE	339	449	1657		1 wgt+!			

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

Table 7.78
ARRL Operating Awards

Award

Worked All States (WAS)
Worked All Continents (WAC)
DX Century Club (DXCC)
VHF/UHF Century Club (VUCC)
A-1 Operator Club
Code Proficiency

Qualification

QSLs from all 50 US states
QSLs from all six continents
QSLs from at least 100 different countries
QSLs from many grid squares
Recommendation by two A-1 operators
One minute of perfect copy from W1AW qualifying run

Table 7.79
ARRL Membership QSL Card

10-K 37575
W-100-0
DXCC
WAS
WAZ
WAC

Confirming QSO with

Date	Time	Report	Mode	Freq.
UTC				
Rig	Power	Antenna		

N2ERN

• Union County • Grid FN20 •

Harris Ruben
74 Apple Tree Row
Berkeley Heights, NJ 07922

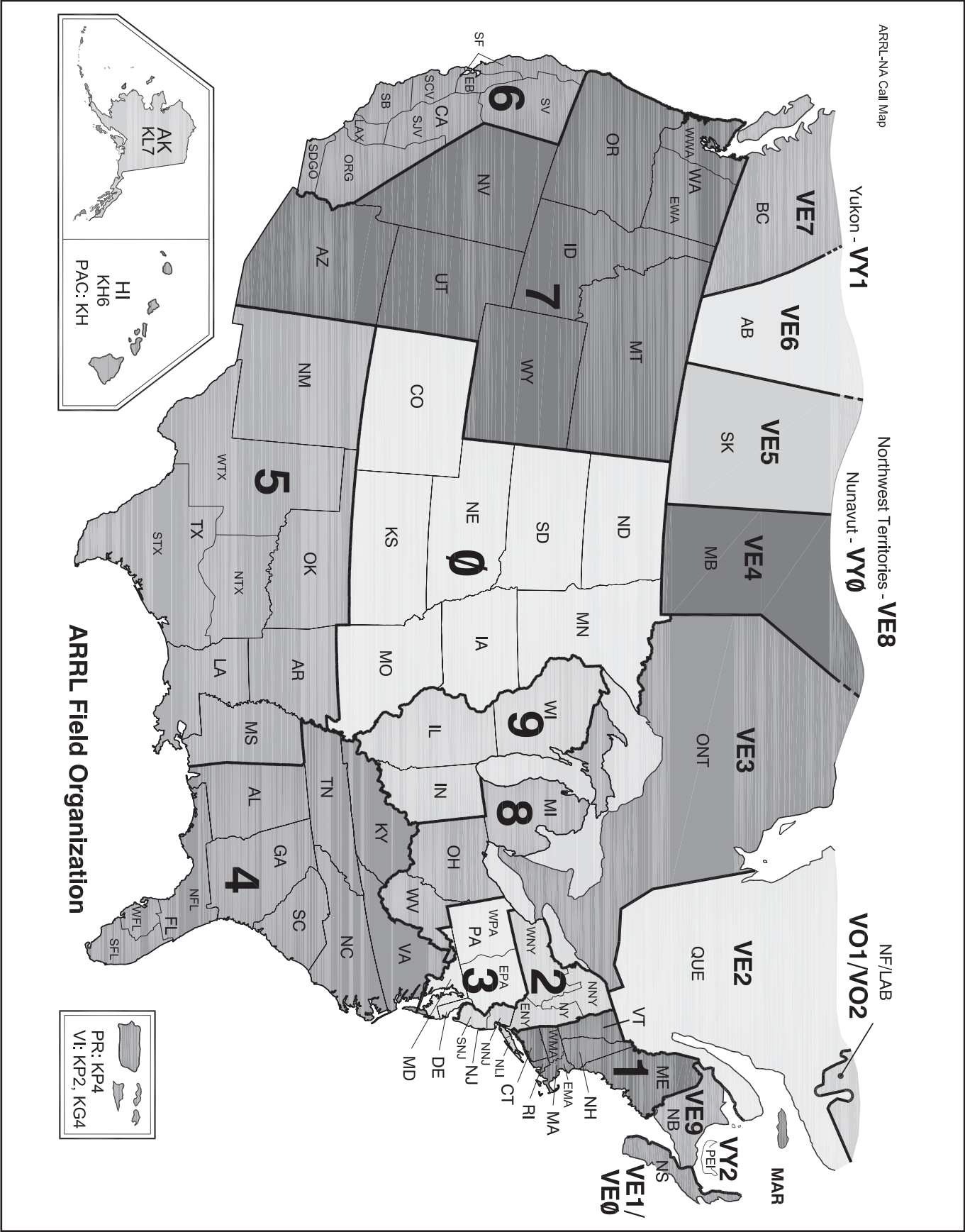
PSE QSL TNX

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.

Table 7.80
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

Table 7.81 US/Canada Map



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

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



Table 7.83**Amateur Message Form**

Every formal radiogram message originated and handled should contain the following component 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 CT 1830Z JULY 1

a b c d e f g h

II DONALD SMITH AA
160 EAST SIXTH AVE AA
NORTH RIVER CITY MO 00789 AA
733 4868 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 message. BT separates the address from the text the text from the signature. AR marks the 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 words 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 allow 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 his 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 fill 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 that 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 withinmiles. (If no number, authorization is unlimited.)

HXB—(Followed by number.) Cancel message if not delivered withinhours of filing time; service originating station.

HXC—Report date and time of delivery (TOD) to originating station.

HXD—Report to originating station the identify 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.

For further information on traffic handling, consult *The ARRL Operating Manual*, published by the ARRL.

THE AMERICAN RADIO RELAY LEAGUE RADIOGRAM VIA AMATEUR RADIO																													
Preamble ➔	NUMBER 133	PRECEDENCE R	HX HXG	STATION OF ORIGIN WØMME	CHECK ARL 7	PLACE OF ORIGIN MT. PLEASANT, IA	TIME FILED 1700	DATE SEP 1																					
Address ➔	TO MR AND MRS JEFF HOLTZCLAW RT 1 BOX 127 TONGANOXIE, KS 66086						THIS RADIO MESSAGE WAS RECEIVED AT AMATEUR STATION _____ PHONE _____ NAME _____ STREET ADDRESS _____ CITY AND STATE _____																						
Text ➔	TELEPHONE NUMBER 913 555 1212 <table style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 25%; border-bottom: 1px solid black; text-align: center;">ARL</td> <td style="width: 25%; border-bottom: 1px solid black; text-align: center;">FIFTY</td> <td style="width: 25%; border-bottom: 1px solid black; text-align: center;">ONE</td> <td style="width: 25%; border-bottom: 1px solid black; text-align: center;">OLD</td> <td style="width: 25%; border-bottom: 1px solid black; text-align: center;">THRESHERS</td> </tr> <tr> <td style="border-bottom: 1px solid black; text-align: center;">REUNION</td> <td style="border-bottom: 1px solid black; text-align: center;">LOVE</td> <td style="border-bottom: 1px solid black;"></td> <td style="border-bottom: 1px solid black;"></td> <td style="border-bottom: 1px solid black;"></td> </tr> <tr> <td style="border-bottom: 1px solid black;"></td> <td style="border-bottom: 1px solid black;"></td> <td style="border-bottom: 1px solid black;"></td> <td style="border-bottom: 1px solid black;"></td> <td style="border-bottom: 1px solid black;"></td> </tr> <tr> <td style="border-bottom: 1px solid black;"></td> <td style="border-bottom: 1px solid black;"></td> <td style="border-bottom: 1px solid black;"></td> <td style="border-bottom: 1px solid black;"></td> <td style="border-bottom: 1px solid black;"></td> </tr> </table>									ARL	FIFTY	ONE	OLD	THRESHERS	REUNION	LOVE													
ARL	FIFTY	ONE	OLD	THRESHERS																									
REUNION	LOVE																												
Signature ➔	<table style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 50%; padding: 5px;"> REC'D FROM WØSS </td> <td style="width: 50%; padding: 5px;"> DATE SEP 1 </td> </tr> <tr> <td colspan="2" style="text-align: center; padding: 5px;"> TIME </td> </tr> </table>									REC'D FROM WØSS	DATE SEP 1	TIME																	
REC'D FROM WØSS	DATE SEP 1																												
TIME																													
UNCLE CHUCKIE					<table style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 50%; padding: 5px;"> SENT TO WØFRC </td> <td style="width: 50%; padding: 5px;"> DATE SEP 2 </td> </tr> <tr> <td colspan="2" style="text-align: center; padding: 5px;"> TIME </td> </tr> </table>					SENT TO WØFRC	DATE SEP 2	TIME																	
SENT TO WØFRC	DATE SEP 2																												
TIME																													
THIS MESSAGE WAS HANDLED FREE OF CHARGE BY A LICENSED AMATEUR RADIO OPERATOR, WHOSE ADDRESS IS SHOWN IN THE BOX AT RIGHT ABOVE. AS SUCH MESSAGES ARE HANDLED SOLELY FOR THE PLEASURE OF OPERATING, NO COMPENSATION CAN BE ACCEPTED BY A "HAM" OPERATOR. A RETURN MESSAGE MAY BE FILED WITH THE "HAM" DELIVERING THIS MESSAGE TO YOU. FURTHER INFORMATION ON AMATEUR RADIO MAY BE OBTAINED FROM A.R.R.L. HEAD-QUARTERS, 225 MAIN STREET, NEWINGTON, CONN. 06111					THE AMERICAN RADIO RELAY LEAGUE, INC., IS THE NATIONAL MEMBERSHIP SOCIETY OF LICENSED RADIO AMATEURS AND THE PUBLISHER OF QST MAGAZINE. ONE OF ITS FUNCTIONS IS PROMOTION OF PUBLIC SERVICE COMMUNICATIONS AMONG AMATEUR OPERATORS. TO THAT END, THE LEAGUE HAS ORGANIZED THE NATIONAL TRAFFIC SYSTEM FOR DAILY NATION-WIDE MESSAGE HANDLING.																								

HXA—(Followed by number.) Collect landline delivery authorized by addressee within ____ miles. (If no number, authorization is unlimited.)

HXB—(Followed by number.) Cancel messages 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 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.

Table 7.86

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.
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.

Table 7.87**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.

Table 7.88**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."

Table 7.89**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.

