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, composition 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 µF, 220 µF, and 2200 µF are all standard capacitance values, available in all three tolerances. Standard resistor values include 3.9 Ω, 390 Ω, 39000 Ω and 3.9 MΩ in ±5% and ±10% tolerances. All standard resistance values, from less than 1 Ω to about 5 MΩ are based on this table.

Each value is greater than the next smaller value by a multiplier factor that depends on the1 tolerance. For ±5% devices, each value is approximately 1.1 times the next lower one. For ±10% devices, the multiplier is 1.21, and for ±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 ±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.

Table 7.1
Standard Values for Resistors and Capacitors

±5%	*±10%*	*±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

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 7.1A**. The first two bands represent the two significant digits of the component value, the third band represents the multiplier, and the fourth band (if there is one) represents the tolerance. Some units

Table 7.2
Resistor-Capacitor Color Codes

Color	*Significant Figure*	*Decimal Multiplier*	*Tolerance (%)*	*Voltage Rating**
Black	0	1	-	-
Brown	1	10	1*	100
Red	2	100	2*	200
Orange	3	1,000	3*	300
Yellow	4	10,000	4*	400
Green	5	100,000	5*	500
Blue	6	1,000,000	6*	600
Violet	7	10,000,000	7*	700
Gray	8	100,000,000	8*	800
White	9	1,000,000,000	9*	900
Gold	-	0.1	5	1000
Silver	-	0.01	10	2000
No color	-	-	20	500

*Applies to capacitors only

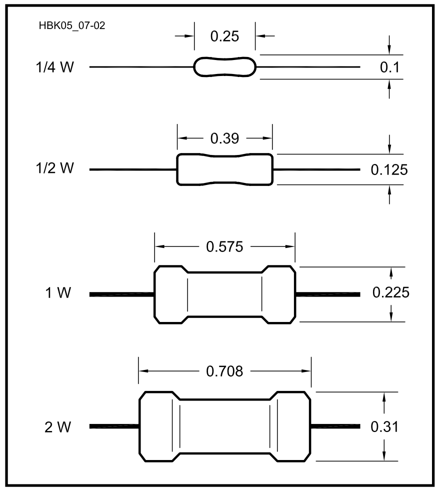


Fig 7.2—Typical carbon-composition resistor sizes.

are marked with a fifth band that represents the percentage of resistance change per 1000 hours of oper-ation: brown = 1%; red = 0.1%; orange = 0.01%; and yellow = 0.001%. Precision resistors (EIA Std RS-279,Fig 7.1B) and some mil-spec (MIL STD-1285A) resistors also use five color bands. On precision resistors, the first *three* bands are used for significant figures and the space between the fourth and fifth bands is wider than the others, to identify the tol-erance band. On the military resistors, the fifth band indicates reliability information, such as failure rate.

For example, if a resistor of the type shown in Fig 7.1A is marked with A = red; B = red; C = orange; D = no color, the significant figures are 2 and 2, the multi-plier is 1000, and the tolerance is ±20%. The device is a 22,000-Ω, ±20% unit.

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

Resistor Power Ratings

Carbon-composition and metal-film resistors are available in standard power ratings of $^{1}/_{10}$, $^{1}/_{8}$, $^{1}/_{4}$, $^{1}/_{2}$, 1 and 2 W. The $^{1}/_{10}$- and $^{1}/_{8}$-W sizes are relatively expen-sive and difficult to purchase in small quantities. They are used only where min-iaturization is essential. The $^{1}/_{4}$, $^{1}/_{2}$, 1, and 2-W composition resistor packages are drawn to scale in **Fig 7.2.** Metal-film re-sistors 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. Carbon-film and metal-film are the most commonly available resistors today, having largely replaced the less-stable carbon-composi-tion resistors.

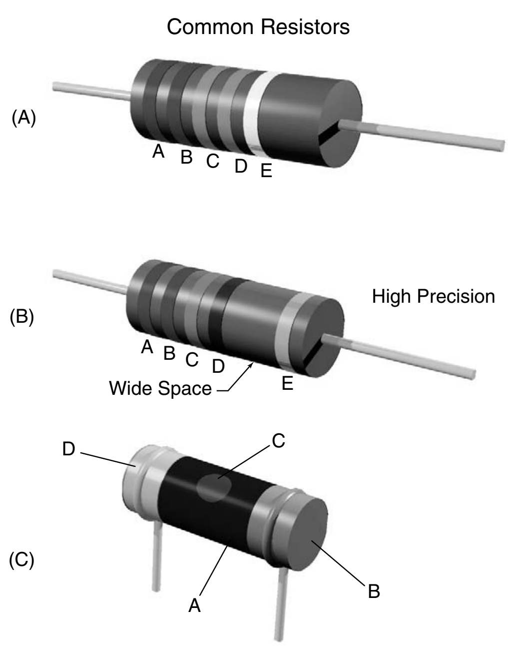


Fig 7.1—Color coding and body size for fixed resistors. The color code is given in Table 7.2. The colored areas have the following significance.

A—First significant figure of resistance in ohms.

B—Second significant figure.

C—Decimal multiplier.

D—Resistance in percent. If no color is shown the tolerance is ±20%.

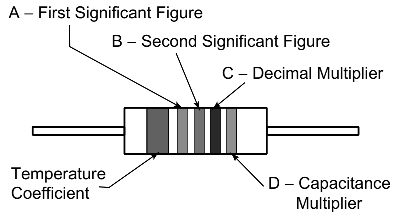
E—Relative percent change in value per 1000 hours of operation; Brown, 1%; Red 0.1%; Orange 0.01%; Yellow 0.001%.

Capacitor Markings

A variety of systems for capacitor mark-ings are in use. Some use color bands, some use combinations of numbers and letters. Capacitors may be marked with their value, tolerance, temperature char-acteristics, voltage ratings or some subset of these specifications. **Fig 7.3** shows sev-eral popular capacitor marking systems.

In addition to the value, ceramic disk capacitors may be marked with an alpha-numeric code signifying temperature characteristics**. Table 7.3** explains the EIA code for ceramic-disk capacitor tem-perature 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 capaci-tance of –56% or +22%.

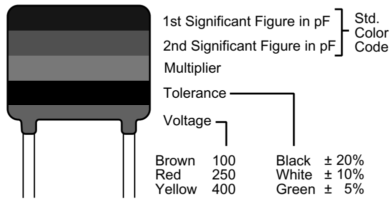
Capacitors with highly predictable tem-perature coefficients of capacitance are sometimes used in oscillators that must be frequency stable with temperature. If an application called for a temperature coef-ficient of –750 ppm/°C (N750), a capaci-tor marked U2J would be suitable. The older industry code for these ratings is being replaced with the EIA code shown



Color Code for Ceramic Capacitors

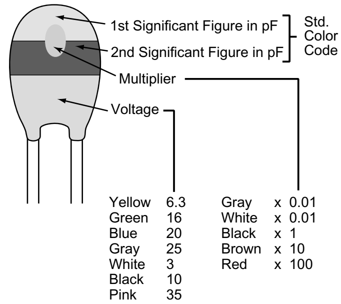
Color	Significant Figure	Decimal Multiplier	Capacitance Tolerance: More than 10 pF (in %)	Capacitance Tolerance: Less than 10 pF (in pF)	Temp. Coeff. ppm/ deg. C
Black	0	1	±20	2.0	0
Brown	1	10	± 1		– 30
Red	2	100	± 2		– 80
Orange	3	1000			–150
Yellow	4				–220
Green	5		± 5	0.5	–330
Blue	6				–470
Violet	7				–750
Gray	8	0.01		0.25	30
White	9	0.1	±10	1.0	500

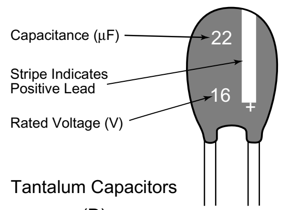
(A)



Polyester Capacitors

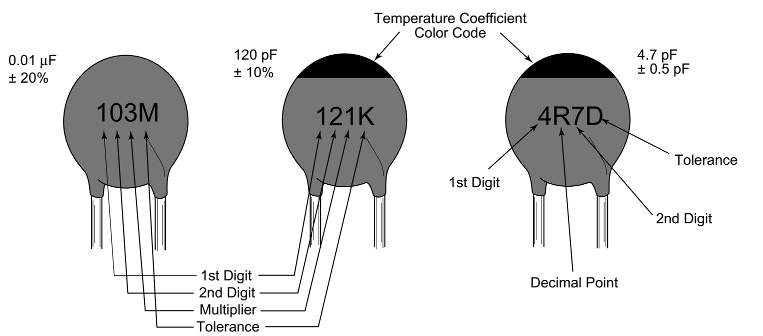
(B)





Tantalum Capacitors

(D)



Multiplier

Number	Multiply By
0	NONE
1	10
2	100
3	1000
4	10,000

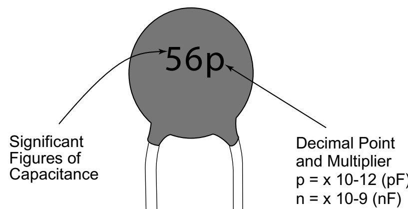
Tolerance

Letter	≤ 10 pF	≥ 10 pF
B	± 0.1 pF	–
C	± 0.25 pF	–
D	± 0.5 pF	–
E	–	± 25%
F	± 1 pF	± 1%
G	–	± 2%
H	–	± 2.5%
J	–	± 5%
K	–	± 10%
M	–	± 20%
P	–	– 0 +100%
S	–	– 20 +50%
W	–	– 0 +200%
X	–	– 20 +40%
Z	–	– 20 +80%

Color	Temperature Coefficient
Black	NP0
Brown	N030/N033
Red	N075/N080
Orange	N 150
Yellow	N 220
Green	N 330
Blue	N 470
Violet	N 750
Gray	
White	P 100
Red and Violet	P 100

Ceramic Capacitors

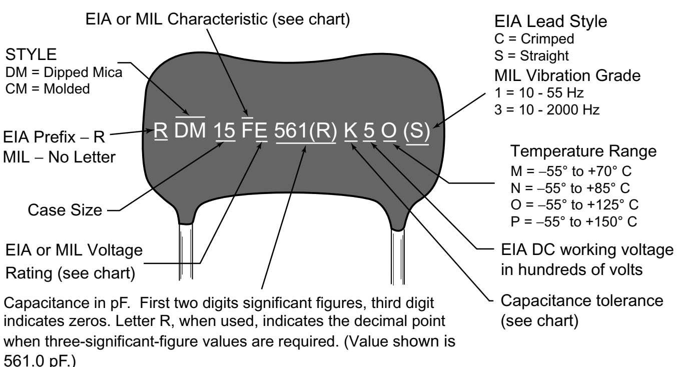
(E)



(pF)	Marking	(pF)	Marking
0.68	p68	15	15p
0.82	p62	18	18p
1.0	1p0	22	22p
1.2	1p2	27	27p
1.5	1p5	33	33p
1.8	1p8	39	39p
2.2	2p2	47	47p
2.7	2p7	56	56p
3.3	3p3	68	68p
3.9	3p9	82	82p
4.7	4p7	100	n10
5.6	5p6	120	n12
6.8	6p8	150	n15
8.2	8p2	180	n18
10	10p	220	n22
12	12p	270	n27

European Markings

(F)



EIA or MIL Designation for Mica Capacitors

(G)

Letter Designator	"Characteristic" Max Capacitance Drift	"Characteristic" Max Range of Temp Coeff (ppm / deg. C)	MIL Voltage Rating (V)	Capactitance Tolerance (Percent)
A	-	-	100	-
B	Not Specified	Not Specified	250	-
C	±(0.5% + 0.1 pF)	±200	300	-
D	±(0.3% + 0.1 pF)	±100	500	-
E	±(0.1% + 0.1 pF)	–20 to +100	600	-
F	±(0.05% + 0.1 pF)	0 to +70	1000	±1
G	-	-	1200	±2
H	-	-	1500	-
J	-	-	2000	±5
K	-	-	2500	±10
L	-	-	3000	-
M	-	-	4000	±20

MIL voltage ratings for other letter designators: N=5000 V, P=6000 V, Q=8000 V, R=10,000 V, S-12,000 V, T=15,000 V, U=20,000 V, V=25,000 V, W=30,000 V, X=35,000 V.

HBK05_07-003

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

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.

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 ±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

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°C	A ±1.0%
Y –30°C	4 +65°C	B ±1.5%
Z +10°C	5 +85°C	C ±2.2%
	6 +105°C	D ±3.3%
	7 +125°C	E ±4.7%
		F ±7.5%
		P ±10%
		R ±15%
		S ±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	±¼ pF
D	±½ pF
F	±1 pF or ±1%
G	±2 pF or ±2%
J	±5%
K	±10%
L	±15%
M	±20%
N	±30%
P or GMV*	–0%, +100%
W	–20%, +40%
Y	–20%, +50%
Z	–20%, +80%

*GMV = guaranteed minimum value.

Table 7.6
SMT Resistor Tolerance Codes

Letter	*Tolerance*
D	±0.5%
F	±1.0%
G	±2.0%
J	±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:

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

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

AL Values

Size	*Mix 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.

may be included (see Fig 7.3E for tolerance codes). Surface-mount capacitors can be very small; you may need a magnifying glass to read the markings.

INDUCTORS AND CORE MATERIALS

Inductors, both fixed and variable, are 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.

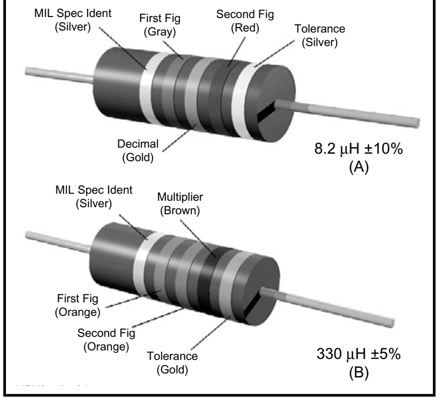


Fig 7.4—Color coding for tubular encapsulated RF chokes. At A, an example of the coding for an 8.2-µH choke is given. At B, the color bands for a 330-µH inductor are illustrated. The color code is given in Table 7.2.

Table 7.10
Powdered-Iron Toroidal Cores: Dimensions

Red E Cores—500 kHz to 30 MHz (μ = 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 (μ=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 (μ=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.

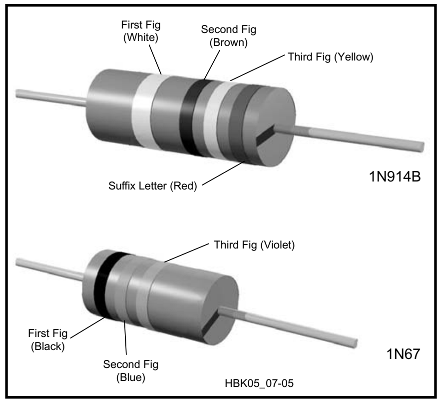


Fig 7.5—Color coding for semi-conductor diodes. At A, the cathode is identified by the double-width first band. At B, the bands are grouped toward the cathode. Two-figure designations are signified by a black first band. The color code is given in Table 7.2. The suffix-letter code is A—Brown, B—red,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

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 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 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

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

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

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} @25 MHz	32×10^{-6} @2.5 MHz	120×10^{-6} @1 MHz	4.5×10^{-6} @0.1 MHz	15×10^{-6} @0.1 MHz
Coercive force	Oer	2.40	1.60	0.30	0.22	0.16
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 green center tapped secondaries	Yellow (or if polarity not important)

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

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 packages (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

Table 7.16
Copper Wire Specifications

Bare and Enamel-Coated Wire

Wire Size (AWG)	Diam (Mils)	Area (CM[1])	Enamel Wire Coating Turns / Linear inch[2] Single	Heavy	Triple	Feet per Pound Bare	Ohms per 1000 ft 25° C	Current Carrying Capacity Continuous Duty[3] at 700 CM per Amp[4]	Open air	Conduit or bundles	Nearest British SWG No.
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	5267.36				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	167.09	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	107.00	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)

Size	Strands[5]	Turns per Linear inch[2] UL Style No. 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

Notes

[1]A circular mil (CM) is a unit of area equal to that of a one-mil-diameter circle (π/4 square mils). The CM area of a wire is the square of the mil diameter.

[2]Figures given are approximate only; insulation thickness varies with manufacturer.

[3]Maximum 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.

[4]700 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.

[5]Stranded wire construction is given as "count" × "strand size" (AWG).

Table 7.17
Color Code for Hookup Wire

Wire Color	*Type of Circuit*
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.

Table 7.18
Aluminum Alloy Characteristics

Common Alloy Numbers

Type	*Characteristic*
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 tempers
7075	Good formability, high strength

General Uses

Type	*Uses*
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

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

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 tens of thousands of IC devices. Some of the data from *IC Master* is also available on computer disk.

IC part numbers usually contain a few digits that identify the circuit die or 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. Harris (CD74HC4066, CD4066B and CD4066BE), National (MM74HC4066, CD4066BC and CD4066BM) and Panasonic (MN74HC4066 and MN4066B) all make similar devices (as do many other manufacturers) with slight differences. 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:

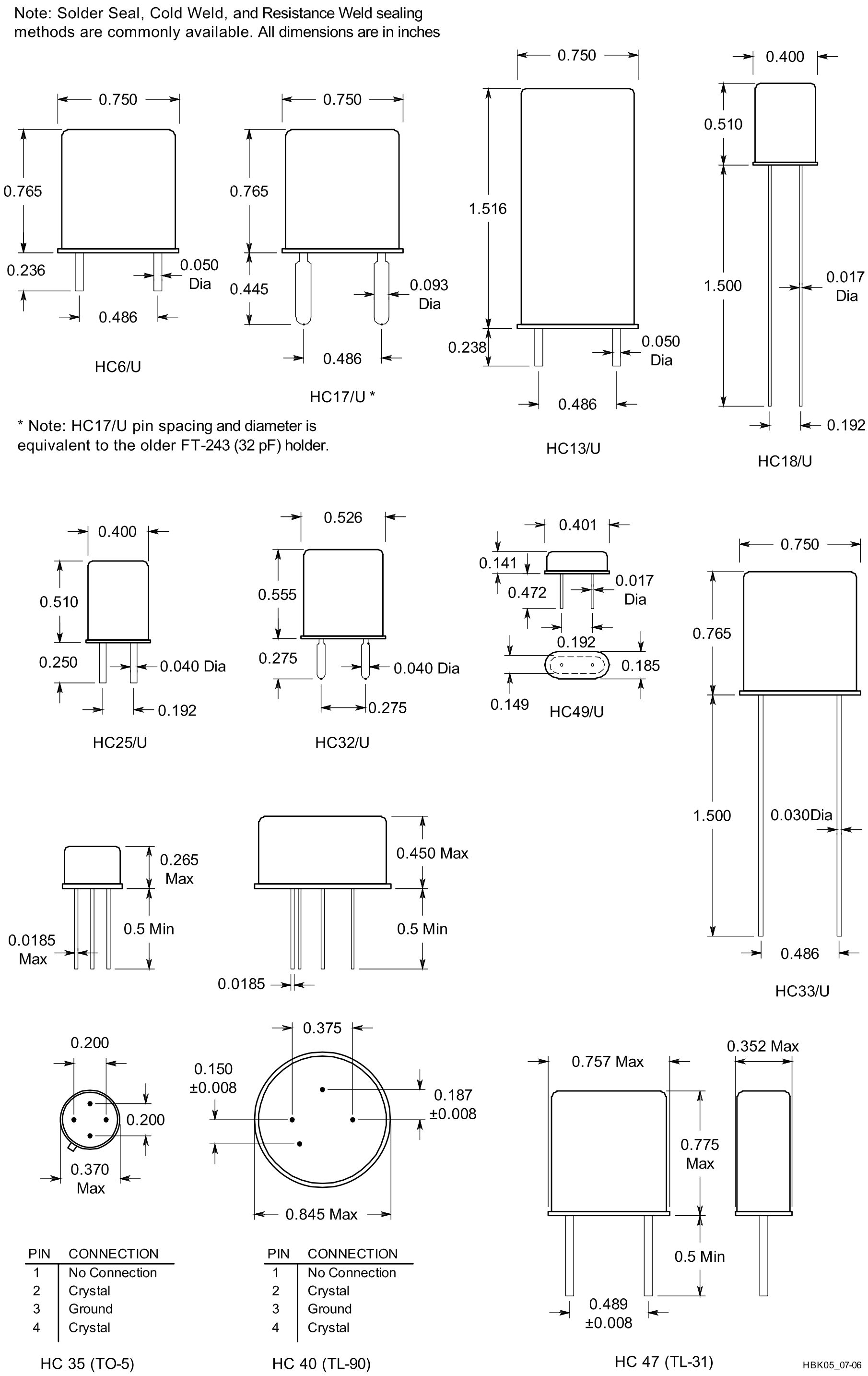
- Commercial: 0°C to 70°C
- Industrial: –25°C to 85°C
- Military: –55°C to 125°C

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.

An excellent source of information on many common ICs is *The ARRL Electronics Data Book*, which contains detailed data for digital ICs (CMOS and TTL), op amps and other analog ICs.

Table 7.19
Crystal Holders



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

OTHER SOURCES OF COMPONENT DATA

There are many sources you can consult for detailed component data. Many manufacturers publish data books for the components they make. Many distributors will include data sheets for parts you order if you ask for them. Parts catalogs themselves are often good sources of component data. The following list is representative of some of the data resources available from manufacturers and distributors.

Motorola Small-Signal Transistor Data
Motorola RF Device Data
Motorola Linear and Interface ICs
Signetics: General Purpose/Linear ICs
NTE Technical Manual and Cross Reference
TCE SK Replacement Technical Manual and Cross Reference
National Semiconductor:
Discrete Semiconductor Products Databook
CMOS Logic Databook
Linear Applications Handbook
Linear Application-Specific ICs Databook
Operational Amplifiers Databook

THE ARRL TECHNICAL INFORMATION SERVICE (TIS)

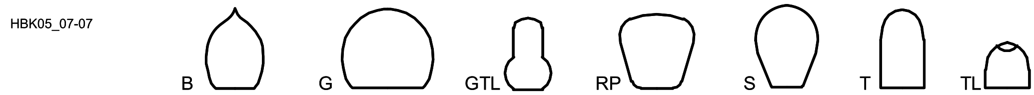
The ARRL answers questions of a technical nature for ARRL members and nonmembers alike through the Technical Information Service. Questions may be submitted via e-mail (**tis@arrl.org**); Fax (860-594-0259); or mail (TIS, ARRL, 225 Main St, Newington, CT 06111). The TIS also maintains a home page on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

TISfind — This search engine contains over 2000 providers of products, services and information of interest to radio amateurs. Before contacting TIS for the address of someone who can repair your radio, or sells antennas, or has old manuals or schematics, look in *TISfind*. Instructions and categories are on the *TISfind* page on ARRLWeb at: **www.arrl.org/tis/tisfind.html**.

SOURCING SUPPLIERS AND CONTACTS ON THE WEB

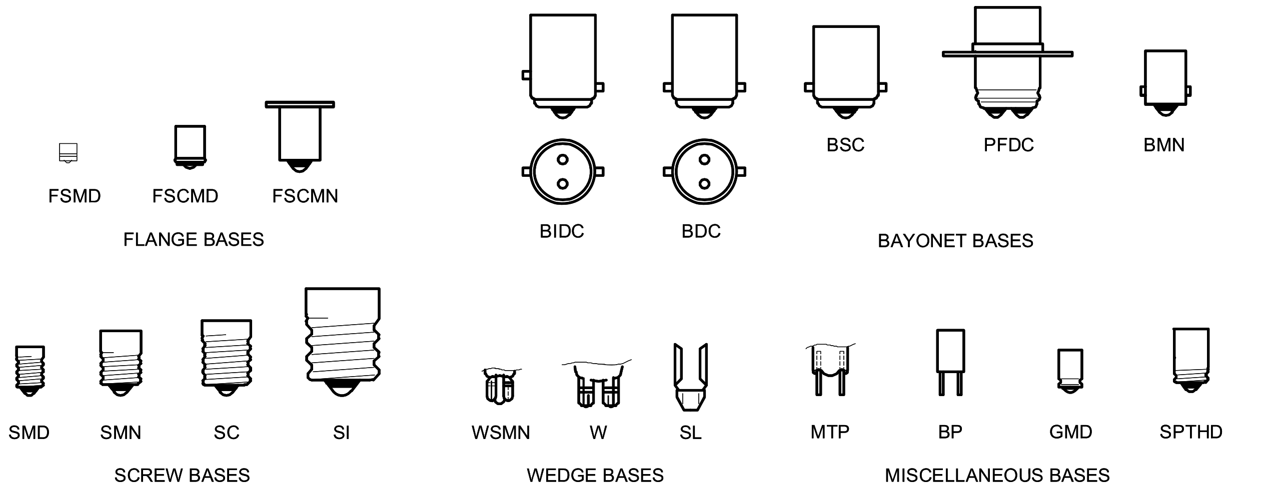
If you need to extend your search area beyond the TIS search engine described above, please refer to the Web section of the **Web, WiFi, Wireless and PC Technology** chapter in this *Handbook*. It contains information on using a search engine on the Web and tips that can help tailor your search.

Table 7.20
Miniature Lamp Guide



** 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	SPTHD	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*
PR2	B-3½	FSCMN	2.38	0.500	15
PR3	B-3½	FSCMN	3.57	0.500	15
PR4	B-3½	FSCMN	2.33	0.270	10
PR6	B-3½	FSCMN	2.47	0.300	30
PR7	B-3½	FSCMN	3.70	0.300	30
PR12	B-3½	FSCMN	5.95	0.500	15
PR13	B-3½	FSCMN	4.75	0.500	15
10	G-3½	MTP	2.50	0.500	3K
12	G-3½	MTP	6.30	0.150	5K
13	G-3½	SMN	3.70	0.300	15
14	G-3½	SMN	2.47	0.300	15
19	G-3½	MTP	14.4	0.100	1K
27	G-4½	SMN	4.90	0.300	30
37	T-1¾	WSMN	14.00	0.090	1.5K
40	T-3¼	SMN	6.30	0.150	3K
43	T-3¼	BMN	2.50	0.500	3K
44	T-3¼	BMN	6.30	0.250	3K
45	T-3¼	BMN	3.20	0.350	3K
46	T-3¼	SMN	6.30	0.250	3K
47	T-3¼	BMN	6.30	0.150	3K
48	T-3¼	SMN	2.00	0.060	1K
49	T-3¼	BMN	2.00	0.060	1K
50	G-3½	SMN	7.50	0.220	1K
51	G-3½	BMN	7.50	0.220	1K
52	G-3½	SMN	14.40	0.100	1K
53	G-3½	BMN	14.40	0.120	1K
55	G-4½	BMN	7.00	0.410	500
57	G-4½	BMN	14.00	0.240	500
63	G-6	BSC	7.00	0.630	1K
73	T-1¾	WSMN	14.00	0.080	15K
74	T-1¾	WSMN	14.00	0.100	500
82	G-6	BDC	6.50	1.020	500
85	T-1¾	WSMN	28.00	0.040	7K
86	T-1¾	WSMN	6.30	0.200	20K
88	S-8	BDC	6.80	1.910	300
93	S-8	BSC	12.80	1.040	700
112	TL-3	SMN	1.20	0.220	5
130	G-3½	BMN	6.30	0.150	5K
131	G-3½	SMN	1.30	0.100	50
158	T-3¼	W	14.00	0.240	500
159	T-3¼	W	6.30	0.150	5K
161	T-3¼	W	14.00	0.190	4K
168	T-3¼	W	14.00	0.350	1.5K
219	G-3½	BMN	6.30	0.250	5K
222	TL-3	SMN	2.25	0.250	0.5
239	T-3¼	BMN	6.30	0.360	5K
240	T-3¼	BMN	6.30	0.360	5K
259	T-3¼	W	6.30	0.250	5K
268	T-1¾	FSCMD	2.50	0.350	10K
305	S-8	BSC	28.00	0.510	300
307	S-8	BSC	28.00	0.670	300
308	S-8	BDC	28.00	0.670	300
313	T-3¼	BMN	28.00	0.170	500
323	T-1¼	SPTHD	3.00	0.190	350
327	T-1¾	FSCMD	28.00	0.040	4K
327AS15	T-1¾	FSCMD	28.00	0.040	4K
328	T-1¾	FSCMD	6.00	0.200	1K
330	T-1¾	FSCMD	14.00	0.080	1.5K
331	T-1¾	FSCMD	1.35	0.060	3K
334	T-1¾	GMD	28.00	0.040	4K
335	T-1¾	SMD	28.00	0.040	4K
336	T-1¾	GMD	14.00	0.080	1.5K

Type	Bulb	Base	V	A	Life
337	T-1¾	GMD	6.00	0.200	1K
338	T-1¾	FSCMD	2.70	0.060	6K
342	T-1¾	SMD	6.00	0.040	10K
344	T-1¾	FSCMD	10.00	0.014	50K
345	T-1¾	FSCMD	6.00	0.040	10K
346	T-1¾	GMD	18.00	0.040	10K
349	T-1¾	FSCMD	6.30	0.200	5K
370	T-1¾	FSCMD	18.00	0.040	10K
373	T-1¾	SMD	14.00	0.080	1.5K
375	T-1¾	FSCMD	3.00	0.015	10K
376	T-1¾	FSCMD	28.00	0.060	25K
380	T-1¾	FSCMD	6.30	0.040	20K
381	T-1¾	FSCMD	6.30	0.200	20K
382	T-1¾	FSCMD	14.00	0.080	15K
385	T-1¾	FSCMD	28.00	0.040	10K
386	T-1¾	GMD	14.00	0.080	15K
387	T-1¾	FSCMD	28.00	0.040	7K
388	T-1¾	GMD	28.00	0.040	7K
397	T-1¾	GMD	10.00	0.040	5K
398	T-1¾	GMD	6.30	0.200	5K
399	T-1¾	SMD	28.00	0.040	7K
502	G-4½	SMN	5.10	0.150	100
555	T-3¼	W	6.30	0.250	3K
656	T-3¼	W	28.00	0.060	2.5K
680AS15	T-1	WT	5.00	0.060	60K
682AS15	T-1	FSMD	5.00	0.060	60K
683AS15	T-1	WT	5.00	0.060	25K
685AS15	T-1	FSMD	5.00	0.060	25K
715AS15	T-1	WT	5.00	0.115	40K
715AS25	T-1	WT	5.00	0.115	40K
718AS25	T-1	FSMD	5.00	0.115	40K
755	T-3¼	BMN	6.30	0.150	20K
756	T-3¼	BMN	14.00	0.080	15K
757	T-3¼	BMN	28.00	0.080	7.5K
1034	S-8	BIDC	14.00	0.590	5K
1073	S-8	BSC	12.80	1.800	200
1130	S-8	BDC	6.40	2.630	200
1133	RP-11	BSC	6.20	3.910	200
1141	S-8	BSC	12.80	1.440	1K
1143	RP-11	BSC	12.50	1.980	400
1184	RP-11	BDC	5.50	6.250	100
1251	G-6	BSC	28.00	0.230	2K
1445	G-3½	BMN	14.40	0.130	2K
1487	T-3¼	SMN	14.00	0.200	3K
1488	T-3¼	BMN	14.00	0.150	200
1490	T-3¼	BMN	3.20	0.160	3K
1493	S-8	BDC	6.50	2.750	100
1619	S-8	BSC	6.70	1.900	500
1630	S-8	PFDC	6.50	2.750	100
1691	S-8	BSC	28.00	0.610	1K
1705	T-1¾	WT	14.00	0.080	1.5K
1728	T-1¾	WT	1.35	0.060	3K
1730	T-1¾	WT	6.00	0.040	20K
1738	T-1¾	WT	2.70	0.060	6K
1762	T-1¾	WT	28.00	0.040	4K
1764	T-1¾	WT	28.00	0.040	4K
1767	T-1¾	SMD	2.50	0.200	500
1768	T-1¾	SMD	6.00	0.200	1K
1775	T-1¾	SMD	6.30	0.075	1K
1813	T-3¼	BMN	14.40	0.100	1K
1815	T-3¼	BMN	14.00	0.200	3K
1816	T-3¼	BMN	13.00	0.330	1K
1818	T-3¼	BMN	24.00	0.170	250
1819	T-3¼	BMN	28.00	0.040	2.5K
1820	T-3¼	BMN	28.00	0.100	1K
1821	T-3¼	SMN	28.00	0.170	500
1822	T-3¼	BMN	36.00	0.100	1K
1828	T-3¼	BMN	37.50	0.050	3K
1829	T-3¼	BMN	28.00	0.070	1K
1835	T-3¼	BMN	55.00	0.050	5K
1847	T-3¼	BMN	6.30	0.150	5K
1850	T-3¼	BMN	5.00	0.090	1.5K
1864	T-3¼	BMN	28.00	0.170	1.5K
1866	T-3¼	BMN	6.30	0.250	5K
1869	T-1¾	WT	10.00	0.014	50K
1891	T-3¼	BMN	14.00	0.240	500
1892	T-3¼	BMN	14.40	0.120	1K
1893	T-3¼	BMN	14.00	0.330	7.5K
1895	G-4½	BMN	14.00	0.270	2K
2102	T-1¾	WT	18.00	0.040	10K
2107	T-1¾	WT	10.00	0.040	5K
2158	T-1¾	WT	3.00	0.015	10K
2162	T-1¾	WT	14.00	0.100	10K
2169	T-1¾	WT	2.50	0.350	20K
2180	T-1¾	WT	6.30	0.040	20K
2181	T-1¾	WT	6.30	0.200	20K
2182	T-1¾	WT	14.00	0.080	40K
2187	T-1¾	WT	28.00	0.040	7K
2304	T-1¾	BP	3.00	0.300	1.5K
2307	T-1¾	BP	6.30	0.200	5K
2314	T-1¾	BP	28.00	0.050	1K
2316	T-1¾	BP	18.00	0.040	10K
2324	T-1¾	BP	28.00	0.040	4K
2335	T-1¾	BP	14.00	0.080	15K
2337	T-1¾	BP	6.30	0.200	20K
2342	T-1¾	BP	28.00	0.040	25K
3149	T-1¾	BP	5.00	0.060	5K
6803AS25	T-¾	WT	5.00	0.060	60K
6833AS15	T-¾	WT	5.00	0.060	25K
6838	T-1	WT	28.00	0.024	4K
6839	T-1	FSMD	28.00	0.024	4K
7001	T-1¾	BP	24.00	0.050	2K
7003	T-1¾	BP	24.00	0.050	2K
7153AS15	T-¾	WT	5.00	0.115	40K
7265	T-1	BP	5.00	0.060	5K
7327	T-1¾	BP	28.00	0.040	4K
7328	T-1¾	BP	6.00	0.200	1K
7330	T-1¾	BP	14.00	0.080	1.5K
7344	T-1¾	BP	10.00	0.014	50K
7349	T-1¾	BP	6.30	0.200	5K
7361	T-1¾	BP	5.00	0.060	25K
7362	T-1¾	BP	5.00	0.115	40K
7367	T-1¾	BP	10.00	0.040	5K
7370	T-1¾	BP	18.00	0.040	10K
7371	T-1¾	BP	12.00	0.040	10K
7373	T-1¾	BP	14.00	0.100	10K
7374	T-1¾	BP	28.00	0.040	10K
7375	T-1¾	BP	3.00	0.015	10K
7376	T-1¾	BP	28.00	0.065	10K
7377	T-1¾	BP	6.30	0.075	1K
7380	T-1¾	BP	6.30	0.040	30K
7381	T-1¾	BP	6.30	0.200	20K
7382	T-1¾	BP	14.00	0.080	15K
7387	T-1¾	BP	28.00	0.040	7K
7410	T-1¾	BP	14.00	0.080	15K
7839	T-1	BP	28.00	0.025	4K
7876	T-1¾	BP	28.00	0.060	25K
7931	T-1¾	BP	1.35	0.060	3K
7945	T-1¾	BP	6.00	0.040	20K
7968	T-1¾	BP	2.50	0.200	500
8099	T-1	BP	18.00	0.020	16K
8362	T-1¾	SMD	14.00	0.080	15K
8369	T-1¾	SMD	28.00	0.065	10K

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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

	Breakdown Voltage					
Type	*AC*	*DC*	*Bulb*	*Base*	*W*	*External Resistance*
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 ac$_{RMS}$*	*Maximum Applied Voltage V ac$_{Peak}$*	*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

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

†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 7.23
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					
2.5			1N5222B					
2.6	1N702,A							
2.7	1N4618	1N4371,A	1N4371,A 1N5223,B 1N5839, 1N5986					
2.8			1N5224B					
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 IN5520	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)

	Power (Watts)							
Volts	*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	1N706A	1N762						
6.0			1N5233B 1N5849			1N5340,B		
6.2	1N709, 1N4627 MZ605, MZ610 MZ620,MZ640	1N753,A	1N753,A 1N821,3,5,7,9;A	1N3828,A 1N5234,B, 1N5850 1N5995	1N5920	1N5341,B 1N4735,A	1N3998,A	1N4554,B 1N4562,B
6.4	1N4565-84,A							
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	1N755A, 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	1N707A							
8.2	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	1N4102					1N5345,B		
8.8		1N764						
9.0		1N764A	1N935-9;A,B					
9.1	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
10.0	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
11.0	1N715,A 1N4105	1N962,B 1N5531	1N962,B 1N5241,B 1N5857, 1N6001	1N3021,B 1N4741,A	1N3790 1N5926	1N5348,B	1N2975,B	1N2809,B 1N3310,B
11.7	1N716,A 1N4106		1N941-4;A,B					
12.0		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

				Power (Watts)				
Volts	*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
50.0								1N2830B 1N3331B
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
52.0							1N2998B	1N3333
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	IN3012A,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

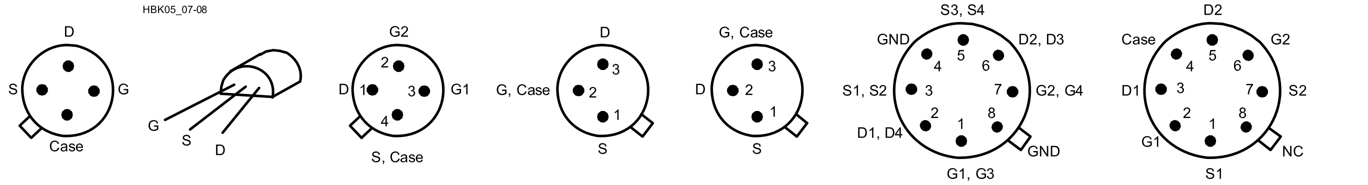
Si = Silicon; Ge = Germanium; RFR = rectifier, fast recovery.

†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)[3]	$V_{GS(off)}$ (V)[3]	Min gfs (µS)	Input C (pF)	Max ID (mA)[1]	f_{max} (MHz)	Noise Figure (typ)	Case	Base	Mfr[2]	Applications
2N4416	N-JFET	300	30	–6	4500	4	–15	450	4 dB @400 MHz	TO-72	1	S, M	VHF/UHF amp, mix, osc
2N5484	N-JFET	310	25	–3	2500	5	30	200	4 dB @200 MHz	TO-92	2	M	VHF/UHF amp, mix, osc
2N5485	N-JFET	310	25	–4	3500	5	30	400	4 dB @400 MHz	TO-92	2	S	VHF/UHF amp, mix, osc
2N5486	N-JFET	360	25	–2	5500	5	15	400	4 dB @400 MHz	TO-92	2	M	VHF/UHF amp, mix, osc
3N200 NTE222 SK3065	N-dual-gate MOSFET	330	20	–6	10,000	4-8.5	50	500	4.5 dB @400 MHz	TO-72	3	R	VHF/UHF amp, mix, osc
3N202 NTE454 SK3991	N-dual-gate MOSFET	360	25	–5	8000	6	50	200	4.5 dB @200 MHz	TO-72	3	S	VHF amp, mixer
MPF102 ECG451 SK9164	N-JFET	310	25	–8	2000	4.5	20	200	4 dB @400 MHz	TO-92	2	N, M	HF/VHF amp, mix, osc
MPF106 2N5484	N-JFET	310	25	–6	2500	5	30	400	4 dB @200 MHz	TO-92	2	N, M	HF/VHF/UHF amp, mix, osc
40673 NTE222 SK3050	N-dual-gate MOSFET	330	20	–4	12,000	6	50	400	6 dB @200 MHz	TO-72	3	R	HF/VHF/UHF amp, mix, osc
U304	P-JFET	350	–30	+10	27		–50	—	—	TO-18	4	S	analog switch chopper
U310	N-JFET	500 300	30 30	–6	10,000	2.5	60	450	3.2 dB @450 MHz	TO-52	5	S	common-gate VHF/UHF amp,
U350	N-JFET Quad	1W	25	–6	9000	5	60	100	7 dB @100 MHz	TO-99	6	S	matched JFET doubly bal mix
U431	N-JFET Dual	300	25	–6	10,000	5	30	100	—	TO-99	7	S	matched JFET cascode amp and bal mix
2N5670	N-JFET	350	25	8	3000	7	20	400	2.5 dB @100 MHz	TO-92	2	M	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	M	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	M	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	M	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	M	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	M	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		NE	Low-noise amp

Notes:
[1]25°C.
[2]M = Motorola; N = National Semiconductor; NE=NEC; R = RCA; S = Siliconix.
[3]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.



(1) (2) (3) (4) (5) (6) (7)

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 offer data sheets to buyers free of charge on request. Data books are available from many manufacturers and retailers.

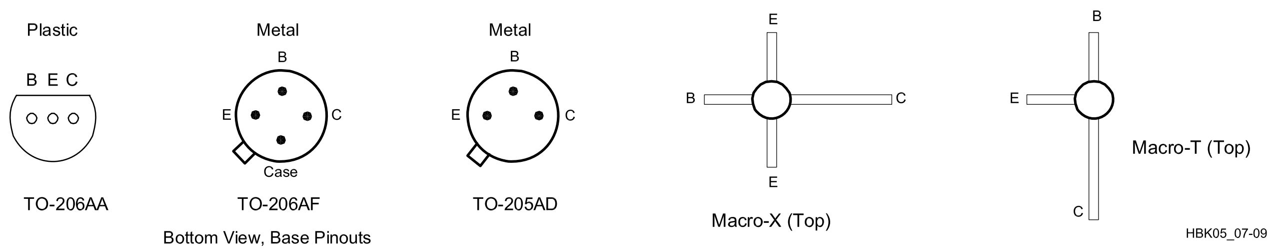


Table 7.27
Monolithic Amplifiers (50 Ω)
Mini-Circuits Labs MMICs

Device	*Freq Range (MHz)*	*Gain (dB) at 1000 MHz*	*Output Level 1 dB Comp (dBm)*	*NF (dB)*	I_{max} *(mA)*	P_{max} *(mW)*
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/**.

Agilent MMICs

Device	*Freq Range (MHz)*	*Typical Gain (dB)*	*Output Level 1 dB Comp (dBm)*	*NF (dB)*	I_{max} *(mA)*	P_{max} *(mW)*
INA-01170	dc - 500	32.5	+11.0	2.0	50	400
INA-02184	dc - 1500	26.0	+11.0	2.0	50	400
INA-32063	dc - 2400	16.8	+3.6	4.4	25	75
INA-51063	dc - 2400	25.0	+1.0	2.5	14	170
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-Olxx	dc - 1300	18.5	+1.5	5.5	40	200
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

Agilent Web site: **www.agilent.com/Products/English/index.html**.

(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

Motorola Web site: **merchant.hibbertco.com/servlet/MtrlDeactServlet**.

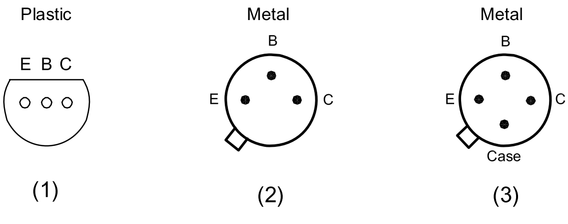
Table 7.28

General-Purpose Transistors

Listed numerically by device

Device	*Type*	*V_{CEO} 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 Current Gain h_{FE}*** *I_C = 0.1 mA*	*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 (I 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

Device	*Supply (V)*	*Frequency Range (MHz)*	*Output Power (W)*	*Power Gain (dB)*	*Package†*	*Mfr/ Notes*
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

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
	D45C8	4	60	40/120	50	30
TIP29		1	40	15/75	3	30
	TIP30	1	40	15/75	3	30
TIP29A		1	50	15/75	3	30
	TIP30A	1	60	15/75	3	30
TIP29B		1	80	15/75	3	30
TIP29C		1	100	15/75	3	30
	TIP30C	1	100	15/75	3	30
TIP47		1	250	30/150	10	40
TIP48		1	300	30/150	10	40
TIP49		1	350	30/150	10	40
TIP50		1	400	30/150	10	40
TIP110 *		2	60	500	> 5	50
	TIP115 *	2	60	500	> 5	50
TIP116		2	80	500	25	50
TIP31		3	40	25	3	40
	TIP32	3	40	25	3	40
TIP31A		3	60	25	3	40
	TIP32A	3	60	25	3	40
TIP31B		3	80	25	3	40
	TIP32B	3	80	25	3	40
TIP31C		3	100	25	3	40
	TIP32C	3	100	25	3	40
2N6124		4	45	25/100	2.5	40
2N6122		4	60	25/100	2.5	40
MJE1300		4	300	6/30	4	60
TIP120 *		5	60	1000	> 5	65
	TIP125 *	5	60	1000	> 10	65
	TIP42	6	40	15/75	3	65
TIP41A		6	60	15/75	3	65
TIP41B		6	80	15/75	3	65
2N6290		7	50	30/150	4	40
	2N6109		50	30/150	4	40
2N6292		7	70	30/150	4	40
	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

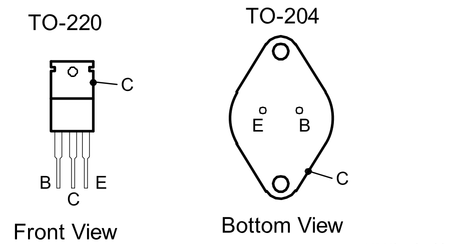
TO-204 Case (TO-3), Pin 1=Base, Pin 2 = Emitter, Case = Collector;

NPN	PNP	I_C Max (A)	V_{CEO} Max (V)	h_{FE} Min	F_T (MHz)	Power Dissipation (W)
2N3055A		15	60	20/70	0.8	115
2N3055		15	60	20/70	2.5	115
	MJ2955	15	60	20/70	2.5	115
2N6545		8	400	7/35	6	125
2N5039		20	75	20/100	—	140
2N3771		30	40	15	0.2	150
2N3789		10	60	15	4	150
2N3715		10	60	30	4	150
	2N3791	10	60	30	4	150
	2N5875	10	60	20/100	4	150
	2N3790	10	80	15	4	150
2N3716		10	80	30	4	150
	2N3792	10	80	30	4	150
2N3773		16	140	15/60	4	150
2N6284		20	100	750/18K	—	160
	2N6287	20	100	750/18K	—	160
2N5881		15	60	20/100	4	160
2N5880		15	80	20/100	4	160
2N6249		15	200	10/50	2.5	175
2N6250		15	275	8/50	2.5	175
2N6546		15	300	6/30	6-28	175
2N6251		15	350	6/50	2.5	175
2N5630		16	120	20/80	1	200
2N5301		30	40	15/60	2	200
2N5303		20	80	15/60	2	200
2N5885		25	60	20/100	4	200
2N5302		30	60	15/60	2	200
	2N4399	30	60	15/60	4	200
2N5886		25	80	20/100	4	200
	2N5884	25	80	20/100	4	200
MJ802		30	100	25/100	2	200
	MJ4502	30	100	25/100	2	200
MJ15003		20	140	25/150	2	250
	MJI5004	20	140	25/150	2	250
MJ15024		25	250	15/60	4	250

(shaded) = Complimentary pairs
* = Darlington transistor

Useful URLs for finding transistor/IC data sheets:

1. General-purpose URL: **members.nbci.com/cbradiomods/transistors/sigtransistors.html**.
2. General-purpose substitution URL: **www.nteinc.com/**.
3. Philips semiconductors: **www.semiconductors.philips.com/pack/discretes.html** and **www.semiconductors.philips.com/catalog**.
4. Mitsubishi: **www.mitsubishichips.com/data/datasheets/hf-optic/index.html**, then click "Si Modules."
5. Motorola: **design-net.com/redirect/books/index.html**. Look for archive section for older products.
6. STMicroelectronics (Thompson): **us.st.com/stonline/products/index.htm**.
7. Toshiba: **www.semicon.toshiba.co.jp/seek/us/td/16ktran/160021.htm**.



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
1.5 to 30 MHz, HF SSB/CW						
2SC2086	0.3		13	1.2	TO-92	MI
BLV10	1		18	1.2	SOT123	PH
BLV11	2		18	12	SOT123	PH
MRF476	3	0.1	15	12.5-13.6	221A-04/1	MO
BLW87	6		18	1.2	SOT123	PH
2SC2166	6		13.8	1.2	TO-220	MI
BLW83	1.0		20	26	SOT123	PH
MRF475	1.2	1.2	10	12.5-13.6	221A-04/1	MO
MRF433	12.5	0.125	20	12.5-13.6	211-07/1	MO
2SC3133	1.3		14	1.2	TO-220	MI
MRF485	1.5	1.5	10	28	221 A-04/1	MO
2SC1969	1.6		1.2	1.2	TO-220	MI
BLW50F	1.6		19.5	45	SOT123	PH
MRF406	20	1.25	12	12.5-13.6	221-07/1	MO
SD1285	20	0.65	15	12.5	M113	ST
MRF426	25	0.16	22	28	211-07/1	MO
MRF427	25	0.4	18	50	211-11/1	MO
MRF477	40	1.25	15	12.5-13.6	211-11/1	MO
MRF466	40	1.25	15	28	211-07/1	MO
BLW96	50		1.9	40	SOT121	PH
2SC3241	75		12.3	12.5	T-45E	MI
SDI405	75	3.8	13	12.5	M174	ST
2SC2097	75		12.3	13.5	T-40E	MI
MRF464	80	2.53	10	28	211-11/1	MO
MRF421	100	10	10	12.5-13.6	211-11/1	MO
SD1487	100	7.9	11	12.5	M174	ST
2SC2904	100		11.5	12.5	T-40E	MI
SD1729	130	8.2	12	28	M174	ST
MRF422	150	15	10	28	211-11/1	MO
MRF428	150	7.5	13	50	211-11/1	MO
SD1726	150	6	14	50	M174	ST
PT9790	150	4.8	15	50	211-11/1	MO
MRF448	250	15.7	12	50	211-11/1	MO
MRF430	600	60	10	50	368-02/1	MO
50 MHz						
MRF475	4	0.4	10	12.5-13.6	*221A-04/1*	MO
MRF497	40	4	10	12.5-13.6	221A-04/2	MO
SDI446	70	7	10	12.5	M113	ST
MRF492	70	5.6	11	12.5-13.6	211-11/1	MO
SD1405	100	20	7	12.5	M174	ST
VHF to 175 MHz						
2N4427	0.7		8	7.5	TO-39	PH
2N3866	1		10	28	TO-39	PH
BFQ42	1.5		8.4	7.5	TO-39	PH
2SC2056	1.6		9	7.2	T-41	MI
2N3553	2.5	0.25	10	28	79-04/1	MO
BF043	3		9.4	7.5	TO-39	PH
SD1012	4	0.25	12	12.5	M135	ST
2SC2627	5		13	12.5	T-40	MI
2N5641	7	1	8.4	28	144B-05/1	MO
MRF340	8	0.4	13	28	221A-04/2	MO
BLW29	9		7.4	7.5	SOT120	PH
SD1143	10	1	10	12.5	M135	ST
2SC1729	1.4		10	13.5	T-31 E	MI
SD1014-02	15	3.5	6.3	12.5	M135	ST
BLVII	15		8	13.5	SOT123	PH
2N5642	20	3	8.2	28	145A-09/1	MO
MRF342	24	1.9	11	28	221A-04/2	MO
BLW87	25		6	13.5	SOT123	PH
2SC1946	28		6.7	13.5	T-31 E	MI
MRF314	30	3	10	28	211-07/1	MO
SD1018	40	14	4.5	12.5	M135	ST
2N5643	40	6.9	7.6	28	145A-09/1	MO
BLW40	40		10	12.5	SOT120	PH
MRF315	45	5.7	9	28	211-07/1	MO
PT9733	50	10	7	28	145A-09/1	MO
MRF344	60	15	6	28	221A-04/2	MO
2SC2694	70		6.7	12.5	T-40	MI
BLV75/12	75		6.5	12.5	SOT119	PH
MRF316	80	8	10	28	316-01/1	MO
SD1477	100	25	6	12.5	M111	ST
BLW78	100		6	28	SOT121	PH
MRF317	100	12.5	9	28	316-01/1	MO
TP9386	150	15	10	28	316-01/1	MO
220 MHz						
MRF207	1	0.15	8.2	12.5	79-04/1	MO
2N5109	2.5		11	12	TO-205AD	MO
MRF227	3	0.13	13.5	12.5	79-05/5	MO
MRF208	1.0	1	10	12.5	145A-09/1	MO
MRF226	1.3	1.6	9	12.5	145A-09/1	MO
2SC2133	30		8.2	28	T-40E	MI
2SC2134	60		7	28	T-40E	MI
2SC2609	100		6	28	T-40E	MI
UHF to 512 MHz						
2N4427	0.4		10	12.5	TO-39	PH
2SC3019	0.5		14	12.5	T-43	MI
MRF581	0.6	0.03	13	12.5	317-01/2	MO
2SC908	1		4	12.5	TO-39	MI
2N3866	1		10	28	TO-39	PH
2SC2131	1.4		6.7	13.5	TO-39	MI
BLX65E	2		9	12.5	TO-39	PH
BLW89	2		12	28	SOT122	PH
MRF586	2.5		16.5	1.5	79-04	MO
MRF630	3	0.33	9.5	12.5	79-05/5	MO
2SC3020	3	0.3	10	12.5	T-31 E	MI
BLW80	4		8	12.5	SOT122	PH
BLW90	4		11	12.5	SOT122	PH
MRF652	5	0.5	10	12.5	244-04/1	MO
MRF587	5		16.5	15	244A-01/1	MO
2SC3021	7	1.2	7.6	12.5	T-31 E	MI
BLW81	10		6	12.5	SOT122	PH
MRF653	10	2	7	12.5	244-04/1	MO
BLW91	10		9	28	SOT122	PH
MRF654	15	2.5	7.8	12.5	244-04/1	MO
2SC3022	18	6	4.7	12.5	T-31 E	MI
BLU20/12	20		6.5	12.5	SOT119	PH
BLX94A	25		6	28	SOT48/2	PH
2SC2695	28		4.9	13.5	T-31 E	MI
BLU30/12	30		6	12.5	SOT119	PH
BLU45/12	45		4.8	12.5	SOT119	PH
2SC2905	45		4.8	12.5	T-40E	MI
MRF650	50	15.8	5	12.5	316-01/1	MO
TP5051	50	6	9	24	333A-02/2	MO
BLU60/12	60		4.4	12.5	SOT119	PH
2SC3102	60	20	4.8	12.5	T-41 E	MI
BLU60/28	60		7	28	SOT119	PH
MRF658	65	25	4.15	12.5	316-01/1	MO
MRF338	80	15	7.3	28	333-04/1	MO
SD1464	100	28.2	5.5	28	M168	ST
UHF to 960 MHz						
MRF581	0.6	0.06	10	12.5	317-01/2	MO
MRF8372	0.75	0.11	8	12.5	751-04/1	MO
MRF557	1.5	0.23	8	12.5	317D-02/2	MO
BLV99	2		9	24	SOT172	PH
SD1420	2.1	0.27	9	24	M122	ST
MRF839	3	0.46	8	12.5	305A-01/1	MO
MRF896	3	0.3	10	24	305-01/1	MO
MRF891	5	0.63	9	24	319-06/2	MO

(continued on next page)

Device	Output Power (W)	Input Power (W)	Gain (dB)	Typ Supply Voltage (V)	Case	Mfr
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/data/datasheets/hf-optic/index.html, then click "Si Modules." Scroll to section for "Si Discrete" and then choose frequency range and device.

Motorola: design-net.com/redirect/books/index.html. Type the part number in the search window at the upper left of the screen. If you receive a message that "No results were found for your search" the part you want is probably obsolete. Click on the text highlighted in red as "Motorola's SPS Literature Distribution Center Archive Site." In the Description box, type the part number you want, click the Search button and then click on the Document Number for the latest Revision level of that obsoleted part number.

Philips: www.semiconductors.philips.com/. Type the part number in the "search" box at the upper right corner of the screen. Click on the highlighted part number in the Description field and then click on Datasheet. Finally, view the PDF by clicking on the highlighted "Download" text or hold down the right-mouse button while clicking on "Download" to save the PDF to disk.

STMicroelectronics: us.st.com/stonline/discretes/index.shtml. Click on "Datasheets" at the top and then scroll down to the bottom of the listing to find "Radio Frequency, RF Power." Then specify the frequency range you want and either view the PDF directly or download the PDF by holding down the right-mouse button while clicking on the device's part number.

Table 7.32
RF Power Transistors Recommended for New Designs

Device	Output Power (W)	Type	Gain (dB)	Typ Supply Voltage (V)	Case	Mfr
1.5 to 30 MHz, HF SSB/CW						
MRF171A	30	MOS	20	28	211-07/2	MO
BLF145	30	MOS	24	28	SOT123A	PH
MRF148A	30	MOS	18	50	211-07/2	MO
SD2918	30	MOS	18	50	M113	ST
SD1405	75	BJT	13	12.5	M174	ST
SD1733	75	BJT	14	50	M135	ST
SD1487	100	BJT	11	12.5	M174	ST
SD1407	125	BJT	15	28	M174	ST
SD1729	130	BJT	12	28	M174	ST
BLF147	150	MOS	17	28	SOT121B	PH
BLF177	150	MOS	20	50	SOT121B	PH
BLF175	150	MOS	24	50	SOT123A	PH
SD1726	150	BJT	14	50	M174	ST
SD1727	150	BJT	14	50	M164	ST
MRF150	150	MOS	17	50	211-07/2	MO
SD1411	200	BJT	16	40	M153	ST
SD1730	220	BJT	12	28	M174	ST
SD1731	220	BJT	13	50	M174	ST
SD1728	250	BJT	14.5	50	M177	ST
SD2923	300	MOS	16	50	M177	ST
SD2933	300	MOS	18	50	M177	ST
MRF154	600	MOS	17	50	368-03/2	MO
50 to 175 MHz						
BLF202	2	MOS	10	12.5	SOT409A	PH
BLF242	5	MOS	13	28	SOT123A	PH
SD1274	30	BJT	10	13.6	M135	ST
BLF245	30	MOS	13	28	SOT123	PH
SD1275	40	BJT	9	13.6	M135	ST
BLF246B	60	MOS	14	28	SOT161A	PH
SD1477	100	BJT	6	12.5	M111	ST
SD1480	100	BJT	9.2	28	M111	ST
SD2921	150	MOS	12.5	50	M174	ST
MRF141	150	MOS	13	28	211-11/2	MO
MRF151	150	MOS	13	50	211-11/2	MO
SD2931	150	MOS	14	50	M174	ST
BLF248	300	MOS	10	28	SOT262	PH
SD2932	300	MOS	15	50	M244	ST
VHF to 220 MHz						
MRF134	5	MOS	10.6	28	211-07/2	MO
MRF136	15	MOS	16	28	211-07/2	MO
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
VHF to 470 MHz						
BLT50	1.2	BJT	10	7.5	SOT223	PH
SD2900	5	MOS	13.5	28	M113	ST
SD1433	10	BJT	7	12.5	M122	ST
SD2902	15	MOS	12.5	28	M113	ST
SD2904	30	MOS	10	28	M113	ST
SD2903	30	MOS	13	28	M229	ST
SD1488	38	BJT	5.8	12.5	M111	ST
SD1434	45	BJT	5	12.5	M111	ST
MRF392	125	BJT	8	28	744A-01/1	MO
SD2921	150	MOS	12.5	50	M174	ST
VHF to 512 MHz						
BLF521	2	MOS	10	12.5	SOT172D	PH
MRF158	2	MOS	17.5	28	305A-01/2	MO
MRF160	4	MOS	17	28	249-06/3	MO
BLF542	5	MOS	13	28	SOT171A	PH
VLF544	20	MOS	11	28	SOT171A	PH
MRF166C	20	MOS	16	28	319-07/3	MO
MRF166W	40	MOS	14	28	412-01/1	MO
BLF546	80	MOS	11	28	SOT268A	PH
MRF393	100	BJT	7.5	28	744A-01/1	MO
MRF275L	100	MOS	8.8	28	333-04/2	MO
BLF548	150	MOS	10	28	SOT262A	PH
MRF275G	150	MOS	10	28	375-04/2	MO
UHF to 960 MHz						
BLT70	0.6	BJT	6	4.8	SOT223	PH
BLT80	0.6	BJT	6	7.5	SOT223	PH
BLT71/8	1.2	BJT	6	4.8	SOT223	PH
BLT81	1.2	BJT	6	7.5	SOT223	PH
BLF1043	10	MOS	16	26	SOT538A	PH
BLF1046	45	MOS	14	26	SOT467C	PH
BLF1047	70	MOS	14	26	SOT541A	PH
BLF1048	90	MOS	14	26	SOT502A	PH

Notes:
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 71 different transistors in this table there are 35 different packages.) See the data sheets on each manufacturer's Web pages for details.

Mitsubishi: **www.mitsubishichips.com/data/datasheets/hf-optic/index.html**, then click on "Si Modules." Scroll to section for "Si Discrete" and then choose frequency range and device.

Motorola: **design-net.com/redirect/books/index.html**. Type the part number in the search window at the upper left of the screen. If you receive a message that "No results were found for your search" the part you want is probably obsolete. Click on the text highlighted in red as "Motorola's SPS Literature Distribution Center Archive Site." In the Description box, type the part number you want, click the Search button and then click on the Document Number for the latest Revision level of that obsoleted part number.

Philips: **www.semiconductors.philips.com/**. Type the part number in the "search" box at the upper right corner of the screen. Click on the highlighted part number in the Description field and then click on Datasheet. Finally, view the PDF by clicking on the highlighted "Download" text or hold down the right-mouse button while clicking on "Download" to save the PDF to disk.

STMicroelectronics: **us.st.com/stonline/discretes/index.shtml**. Click on "Datasheets" at the top and then scroll down to the bottom of the listing to find "Radio Frequency, RF Power." Then specify the frequency range you want and either view the PDF directly or download the PDF by holding down the right-mouse button while clicking on the device's part number.

Table 7.33
Power FETs

Device	*Type*	*VDSS min (V)*	*RDS(on) max (Ω)*	*ID max (A)*	*PD max (W)*	*Case*†	*Mfr*
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*** *(ns)* *Typ*	*Max*	*Max Clock 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)*** *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)*
317	Adj Pos	TO-205	+1.2 to +37	0.5
317	Adj Pos	TO-204,TO-220	+1.2 to +37	1.5
317L	Low Current Adj Pos	TO-205,TO-92	+1.2 to +37	0.1
317M	Med Current Adj Pos	TO-220	+1.2 to +37	0.5
338	Adj Pos	TO-3	+1.2 to +32	5.0
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
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
309		TO-205	+5	0.2
309		TO-204	+5	1.0
323		TO-204,TO-220	+5	3.0
140-XX	Fixed Pos	TO-204,TO-220	Note 1	1.0
340-XX		TO-204,TO-220		1.0
78XX		TO-204,TO-220		1.0
78LXX		TO-205,TO-92		0.1
78MXX		TO-220		0.5
78TXX		TO-204		3.0
79XX	Fixed Neg	TO-204,TO-220	Note 1	1.0
79LXX		TO-205,TO-92		0.1
79MXX		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.

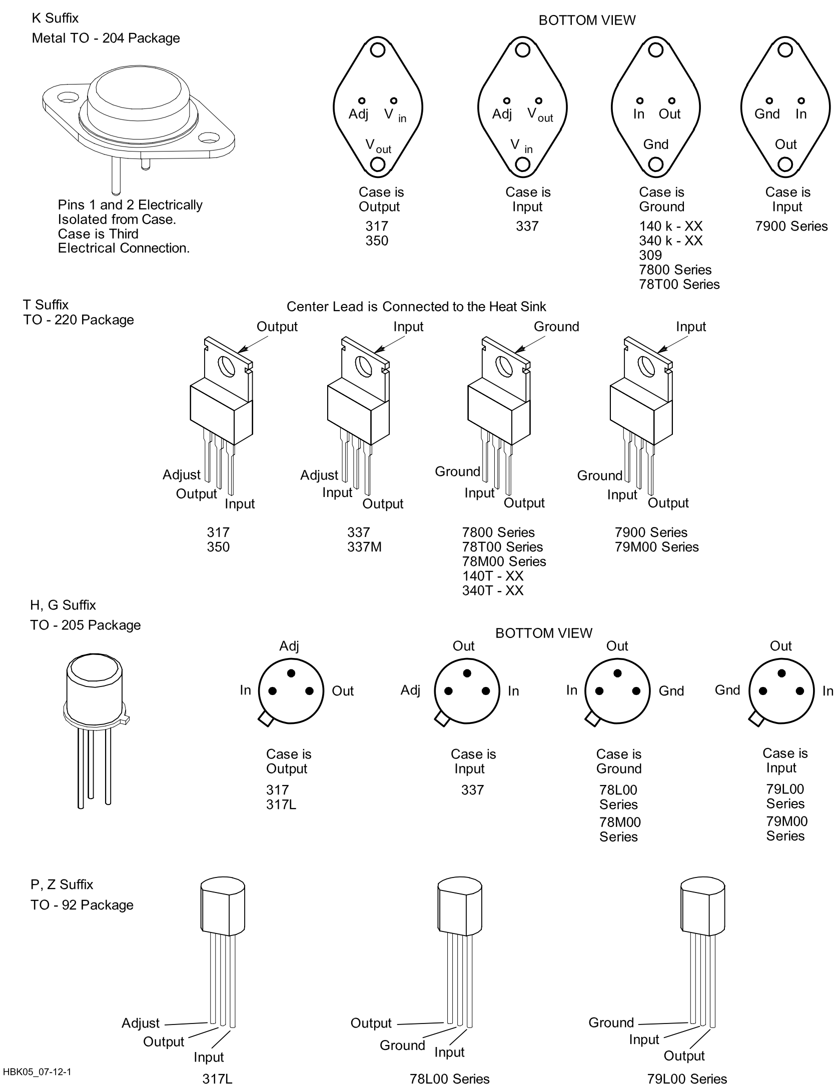
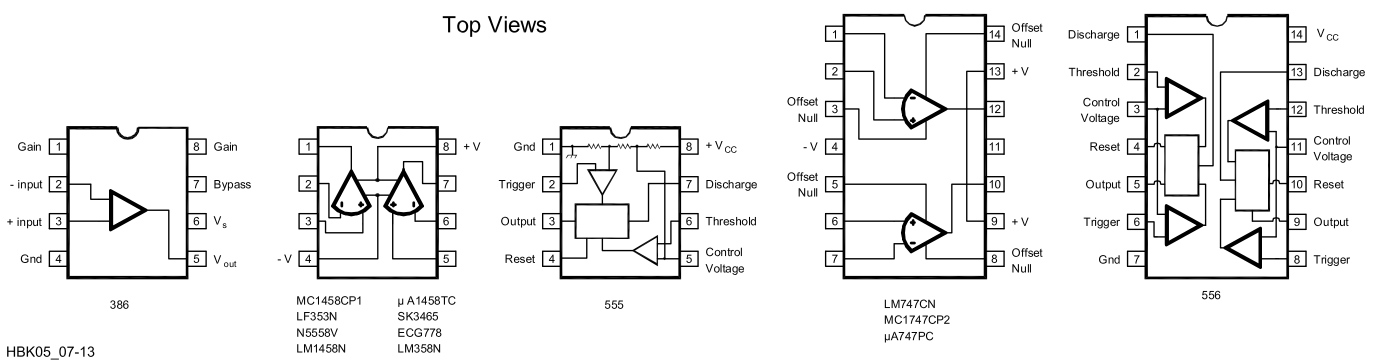


Table 7.36

Op Amp ICs

Listed by device number

Device	*Type*	*Freq Comp*	*Max Supply* (V)*	*Min Input Resistance (MΩ)*	*Max Offset Voltage (mV)*	*Min dc Open-Loop Gain (dB)*	*Min Output Current (mA)*	*Min Small-Signal Bandwidth (MHz)*	*Min Slew Rate (V/µs)*	*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	
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 × 106	2.0	86	1	3.7	9	Strobable 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



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Device	*Type*	*Freq Comp*	*Max Supply* (V)*	*Min Input Resistance (MΩ)*	*Max Offset Voltage (mV)*	*Min dc Open-Loop Gain (dB)*	*Min Output Current (mA)*	*Min Small-Signal Bandwidth (MHz)*	*Min Slew Rate (V/µs)*	*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 µV max), low drift (0.6 µV/°C max), low noise (0.3 µV p-p)
LT1007 Extremely low noise (0.06 µV p-p), very high gain (20 x 10^6 into 2 kΩ load)
LT1360 High speed, very high slew rate (800 V/µs), 50 MHz gain bandwidth, ±2.5 V to ±15 V supply range

Device	*Type*	*Freq Comp*	*Max Supply* (V)*	*Min Input Resistance (MΩ)*	*Max Offset Voltage (mV)*	*Min dc Open-Loop Gain (dB)*	*Min Output Current (mA)*	*Min Small-Signal Bandwidth (MHz)*	*Min Slew Rate (V/µs)*	*Notes*
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

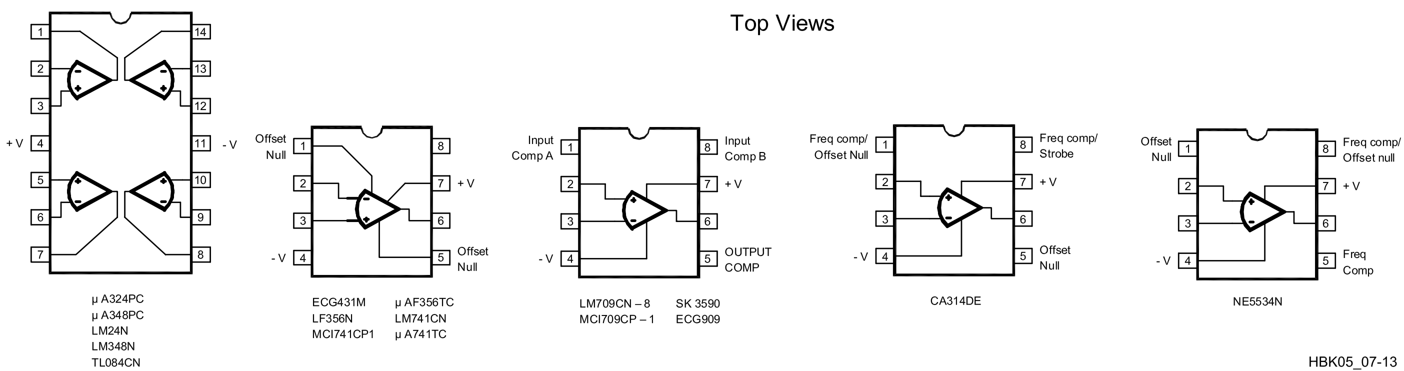


Table 7.37

Triode Transmitting Tubes

The full 1988 *Handbook* table of power tube specifications and base diagrams can be viewed in pdf format on the *ARRLWeb* 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 (kΩ)*	*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	350	–33	35	13	2.4	—	6.5
													CP	300	–45	30	12	2.0	—	6.5
2C43	12	500	40	—	1250	48	6.3	0.9	2.9	1.7	0.05	Fig 11	CTO	470	—	38[7]	—	¾	—	9[2]
811-A	65	1000	175	50	60	160	6.3	4.0	5.9	5.6	0.7	3G	CT	1500	–70	173	40	7.1	—	200
													CP	1250	–120	140	45	10.0	—	135
													B/CG	1250	0	21/175	28	12	—	165
													AB_1	1250	0	27/175	13	3.0	—	155
812-A	65	1500	175	35	60	29	6.3	4.0	5.4	5.5	0.77	3G	CT	1500	–120	173	30	6.5	—	190
													CP	1250	–115	140	35	7.6	—	130
													B[2]	1500	–48	28/310	270[4]	5.0	13.2	340
3CX100A5[6]	100	1000	125[5]	50	2500	100	6.0	1.05	7.0	2.15	0.035	—	AGG	800	–20	80	30	6	—	27
	70	600	100[5]										CP	600	–15	75	40	6	—	18
2C39	100	1000	60	40	500	100	6.3	1.1	6.5	1.95	0.03	—	G1C	600	–35	60	40	5.0	—	20
													CTO	900	–40	90	30	¾	—	40
													CP	600	–150	100[5]	50	¾	—	¾
AX9900, 5866	135	2500	200	40	150	25	6.3	5.4	5.8	5.5	0.1	Fig 3	CT	2500	–200	200	40	16	—	390
													CP	2000	–225	127	40	16	—	204
													B[2]	2500	–90	80/330	350[4]	14[3]	15.68	560
572B	160	2750	275	—	—	170	6.3	4.0	—	—	—	3G	CT	1650	–70	165	32	6	—	205
T160L													B/GG[2]	2400	–2.0	90/500	—	100	—	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	CTO	2250	–125	445	85	23	—	780
													CTO	3000	–160	335	70	20	—	800
													CP	2500	–300	335	75	30	—	635
	450[6]	4000[6]	500	100	20[6]	35	10	10	12.3	6.3	8.5	Fig 41	CP	3000	–240	335	70	26	—	800
													B[2]	3000	–70	100/750	400[4]	20[4]	9.5	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	3000	—	400	118	33	—	810
													B/GG	3500	—	400	110	35	—	950
3CX800A7	800	2250	600	60	350	200	13.5	1.5	26	—	6.1	Fig 87	AB_2GG[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
3CX1200A7	1200	5000	800	—	110	200	7.5	21.0	20	12	0.2	Fig 3	AB_2GG	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.

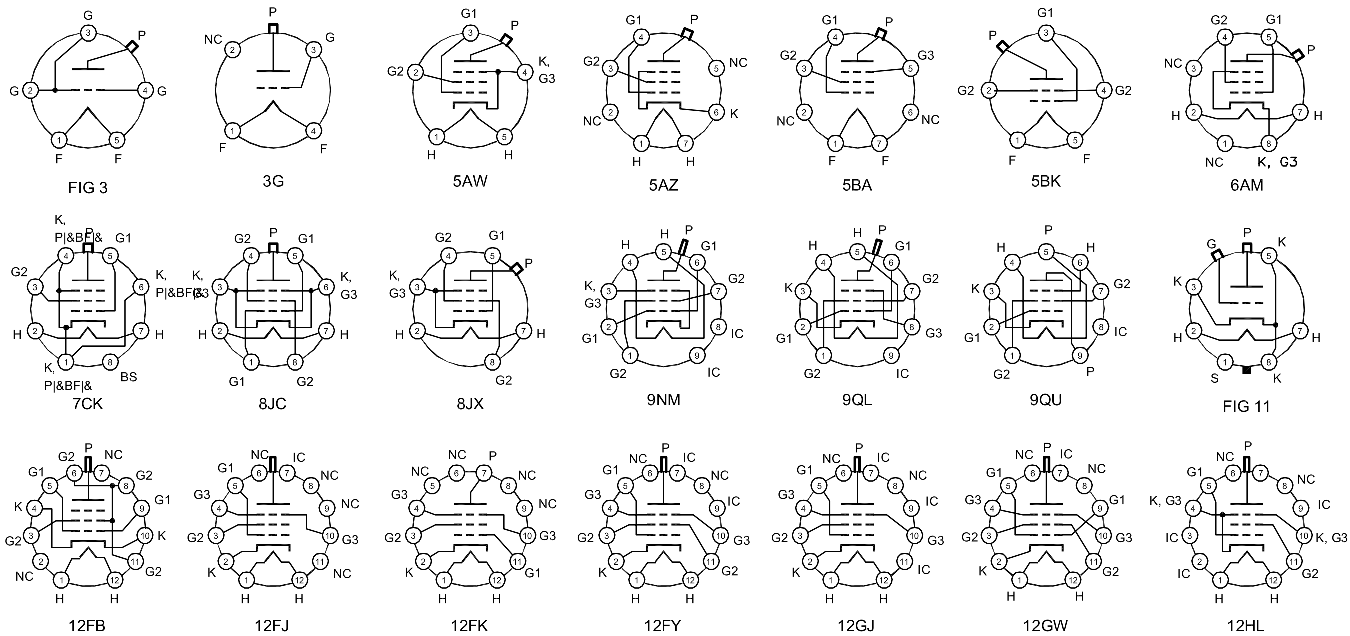
Type	Max. Plate Diss. (W)	Max. Plate Volts (V)	Max. Screen Diss. (W)	Max. Screen Volts (V)	Max. Freq. (MHz)	Filament Volts (V)	Amps (A)	C_{IN} (pF)	C_{GP} (pF)	C_{OUT} (pF)	Base	Serv. Class[1]	Plate (V)	Screen (V)	Grid (V)	Plate (mA)	Screen (mA)	Grid (mA)	P_{IN} (W)	P-P (kΩ)	P_{OUT} (W)
6146/	25	750	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	753	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
												AB1	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_2GD	2200	325	–30	100/270	22	2	9	—	405
												AB_2GD	2500	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_2GD	2200	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_2GD	2400	350	–53	500/1100	20	2	28	—	1600
												AB_2GD	2400	350	–70	200/870	48	2	83[10]	—	1500
												AB_2GD	3200	240	–57	200/740	21	1	33	—	1600

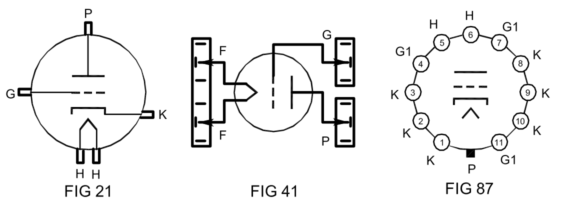
[1]Service Class Abbreviations:
AB_2GD=AB_2 linear with 50-Ω passive grid circuit.
B=Class-B push-pull
CP=Class-C plate-modulated phone
CT=Class-C telegraph
GG=Grounded-grid (grid and screen connected together)
[2]Maximum signal value
[3]Peak grid-grid volts
[4]Forced-air cooling required.
[5]Two tubes triode-connected, G2 to G1 through 20kΩ to G2.
[6]Typical operation at 175 MHz.
[7]±1.5 V.
[8]Values are for two tubes.
[9]Single tone.
[10]24-Ω cathode resistance.
[11]Base same as 4CX250B. Socket is Russian SK2A.
[12]Socket is Russian SK1A.
[13]Socket 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	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	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	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	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	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





Base diagrams correspond to the codes in "Base" columns of the tube-data tables. Bottom views are shown throughout. Base connections are abbreviated as follows:

BS - Base sleeve	NC - No connection
F - Filament	P - Plate
G - Grid	P_{BF} - Beam plates
H - Heater	S - Shell
IC - Internal connection	K - Cathode

HBK05_07-14

Alphabetical subscripts (D = diode, P = pentode, T = triode and HX = hexode) indicate structures in multistructure 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)

Advantages:
- 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

Disadvantages:
- Base resin can be attacked by aromatic solvents, ketones, aldehydes, naphthalenes, and some chloride, acetate, and acrylate esters
- Should not be used above 140°

Applications:
- Conduit
- Conduit boxes
- Housings
- Pipe
- Wire and cable insulation

Polystyrene

Advantages:
- 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

Disadvantages:
- Brittle
- Low heat resistance

Applications:
- Capacitors
- Light shields
- Knobs

Polyphenylene Sulfide (PPS)

Advantages:
- Excellent dimensional stability
- Strong
- High-temperature stability
- Chemical resistant
- Inherently completely flame retardant
- Completely transparent to microwave radiation

Applications:
- 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

Polypropylene

Advantages:
- Low density
- Good balance of thermal, chemical, and electrical properties
- Moderate strength (increases significantly with glass-fiber reinforcement)

Disadvantages:
- 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

Applications:
- Automotive battery cases
- Blower housings
- Fan blades
- Insulators
- Lamp housings
- Support for current-carrying electrical components
- TV yokes

Polyethylene (PE)

Advantages: Low Density PE
- Good toughness
- Excellent chemical resistance
- Excellent coefficient of friction
- Near zero moisture absorption
- Easy to process
- Relatively low heat resistance

Disadvantages:
- Susceptible to environmental and some chemical stress cracking
- Wetting agents (such as detergents) accelerate stress cracking

Advantages: High Density PE
- Same as above, plus increased rigidity and tensile strength

Advantages: Ultra-High Molecular Weight PE
- 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

Applications:
- Bearings
- Components requiring maximum abrasion resistance, impact strength, and low coefficient of friction

Phenolic

Advantages:
- 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

Applications:
- Commutators and housings for small motors
- Heavy duty electrical components
- Rotary-switch wafers
- Insulating spacers

Nylon

Advantages:
- Excellent fatigue resistance
- Low coefficient of friction
- Toughness as a function of degree of crystalinity
- Resists many fuels and chemicals
- Good creep- and cold-flow resistance as compared to less rigid thermoplastics
- Resists repeated impacts

Disadvantages:
- 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

Applications:
- Bearings
- Housings and tubing
- Rope
- Wire coatings
- Wire connectors
- Wear plates

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 Rexolite	Blkhd (f)	59, 62, 71, 140, 210	Front mount 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)	Berylium, outer contact
UG-914	Str (f/f)	
UG-306	Ang (f/m)	
UG-306A,B	Ang (f/m)	Berylium outer contact
UG-414,A	Pnl (f/f)	# 3-56 tapped flange holes
UG-306	Ang (f/m)	
UG-306A,B	Ang (f/m)	Berylium outer contact
UG-274	T (f/m/f)	
UG-274A,B	T (f/m/f)	Berylium 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-212C	Ang (f/m)		Berylium 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

International System of Units (SI)—Metric Units

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

Linear

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

Area

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

Volume

1 $m^3 = 1 \times 10^6$ $cm^3 = 1 \times 10^9$ mm^3
1 liter (l) = 1000 $cm^3 = 1 \times 10^6$ mm^3

Mass

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

Table 7.44
US Customary Units

Linear Units

12 inches (in) = 1 foot (ft)
36 inches = 3 feet = 1 yard (yd)
1 rod = 5 1/2 yards = 16 1/2 feet
1 statute mile = 1760 yards = 5280 feet
1 nautical mile = 6076.11549 feet

Area

1 ft^2 = 144 in^2
1 yd^2 = 9 ft^2 = 1296 in^2
1 rod^2 = 30 1/4 yd^2
1 acre = 4840 yd^2 = 43,560 ft^2
1 acre = 160 rod^2
1 $mile^2$ = 640 acres

Volume

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

Liquid Volume Measure

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

Dry Volume Measure

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

Avoirdupois Weight

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

Troy Weight

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

Apothecaries' Weight

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

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)		
mm^2	645.16	$inch^2$
cm^2	6.4516	in^2
cm^2	929.03	ft^2
m^2	0.0929	ft^2
cm^2	8361.3	yd^2
m^2	0.83613	yd^2
m^2	4047	acre
km^2	2.59	mi^2
(Mass)	**(Avoirdupois Weight)**	
grams	0.0648	grains
g	28.349	oz
g	453.59	lb
kg	0.45359	lb
tonne	0.907	short ton
tonne	1.016	long ton
(Volume)		
mm^3	16387.064	in^3
cm^3	16.387	in^3
m^3	0.028316	ft^3
m^3	0.764555	yd^3
ml	16.387	in^3
ml	29.57	fl oz
ml	473	pint
ml	946.333	quart
l	28.32	ft^3
l	0.9463	quart
l	3.785	gallon
l	1.101	dry quart
l	8.809	peck
l	35.238	bushel
(Mass)	**(Troy Weight)**	
g	31.103	oz t
g	373.248	lb t
(Mass)	**(Apothecaries' Weight)**	
g	3.387	dr ap
g	31.103	oz ap
g	373.248	lb ap

Multiply →

Metric Unit = Conversion Factor × US Customary Unit

← Divide

Metric Unit ÷ Conversion Factor = US Customary Unit

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 (bids in single-channel binary data transmission)
BER—bit error rate
BFO—beat-frequency oscillator
bit—binary digit
bit/s—bits per second
BM—Bulletin Manager
BPF—band-pass filter
BPL—Brass Pounders League
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
CATVI—cable television interference
CB—Citizens Band (radio)
CBBS—computer bulletin-board service
CBMS—computer-based message system
CCITT—International Telegraph and Telephone Consultative Committee
CCTV—closed-circuit television
CCW—coherent CW
ccw—counterclockwise
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^{-5}); frequency
F—farad (capacitance unit); fuse
fax—facsimile
FCC—Federal Communications Commission
FD—Field Day
FEMA—Federal Emergency Management Agency
FET—field-effect transistor
FFT—fast Fourier transform
FL—filter
FM—frequency modulation
FMTV—frequency-modulated television
FSK—frequency-shift keying
FSTV—fast-scan (real-time) television
ft—foot (unit of length)

G

g—gram (unit of mass)
G—giga (prefix for 10^9); conductance
GaAs—gallium arsenide
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 (kg m^2/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
kΩ—kilohm

L

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

M

m—meter (length); milli (prefix for 10^{-3})
M—mega (prefix for 10^6); meter (instrument)
mA—milliampere
mAh—milliampere hour
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 Emergency Service
RAM—random-access memory
RC—resistance-capacitance
R/C—radio control
RCC—Rag Chewer's Club
RDF—radio direction finding
RF—radio frequency
RFC—radio-frequency choke
RFI—radio-frequency interference
RHC—right-hand circular (polarization)
RIT—receiver incremental tuning
RLC—resistance-inductance-capacitance
RM—rule making (number assigned to petition)
r/min (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 Protocol/ Internet Protocol
tfc—traffic
TNC—terminal node controller (packet radio)
TR—transmit/receive
TS—Technical Specialist
TTL—transistor-transistor logic
TTY—teletypewriter
TU—terminal unit
TV—television
TVI—television interference
TX—transmitter, transmitting

U

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

V

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

W

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

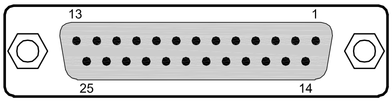
Numbers/Symbols

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
Κ—(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 πF
Ω—(omega) resistance in ohms; solid angle

Table 7.46
Computer Connector Pinouts

(A)

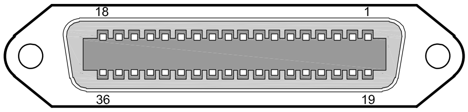
Parallel Port (DB 25 pin)
Female



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

(B)

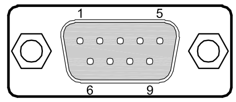
Parallel Port (Centronics 36 pin)
Female



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

(C)

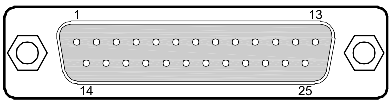
Serial Port (DB 9 pin)
Male



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

(D)

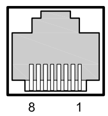
Serial Port (DB 25 pin)
Male



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

(E)

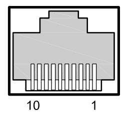
Ethernet Connector (RJ45-8 pin)
Female



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

(F)

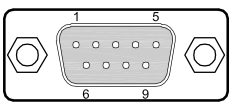
Ethernet Connector (RJ45-10 pin)
Female



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

(G)

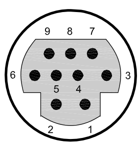
Mouse Port (DB 9 pin)
Male



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

(H)

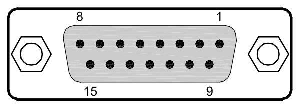
Mouse Port (mini DIN 9 pin)
Female



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

(I)

Game/Joystick Port (DB 15 pin)
Female



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

Note: All figures not drawn to same scale.

HBK05_07-15

Table 7.47

Voltage-Power Conversion Table

Based on a 50-ohm system

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

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

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

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

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

Table 7.48

Large Machine-Wound Coil Specifications

Coil Dia, Inches	*Turns Per Inch*	*Inductance in µH*
1¹/₄	4	2.75
	6	6.3
	8	11.2
	10	17.5
	16	42.5
1¹/₂	4	3.9
	6	8.8
	8	15.6
	10	24.5
	16	63
1³/₄	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
2¹/₂	4	10.2
	6	23
	8	41
	10	64
3	4	14
	6	31.5
	8	56
	10	89

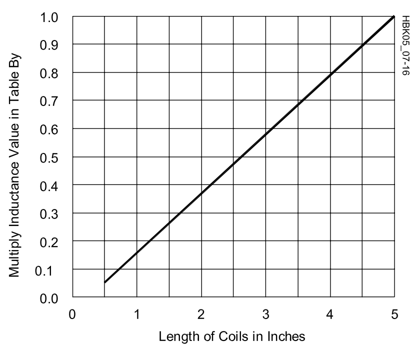
Table 7.50

Small Machine-Wound Coil Specifications

Coil Dia, Inches	*Turns Per Inch*	*Inductance in µH*
¹/₂ (A)	4	0.18
	6	0.40
	8	0.72
	10	1.12
	16	2.8
	32	12
⁵/₈ (A)	4	0.28
	6	0.62
	8	1.1
	10	1.7
	16	4.4
	32	18
³/₄ (B)	4	0.6
	6	1.35
	8	2.4
	10	3.8
	16	9.9
	32	40
1 (B)	4	1.0
	6	2.3
	8	4.2
	10	6.6
	16	16.9
	32	68

Table 7.49

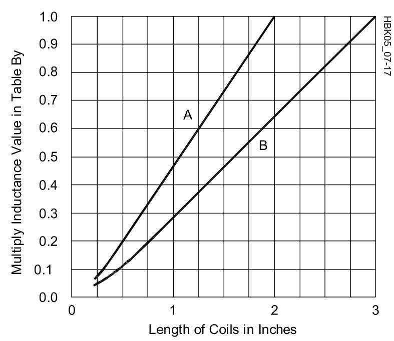
Inductance Factor for Large Machine-Wound Coils



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

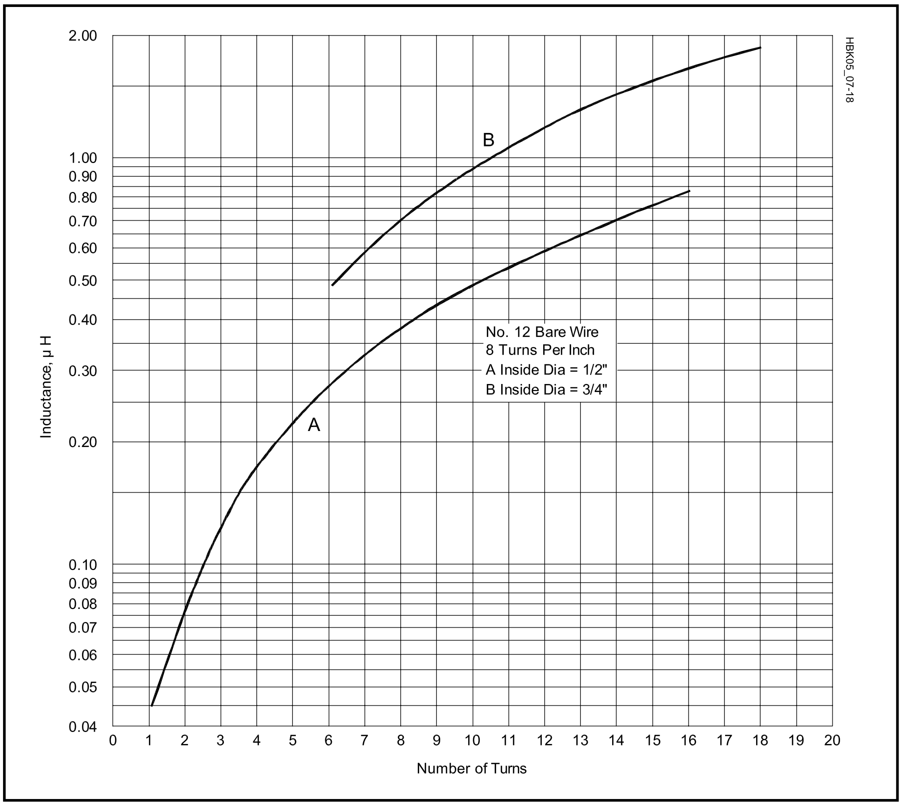
Table 7.51

Inductance Factor for Small Machine-Wound Coils



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

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

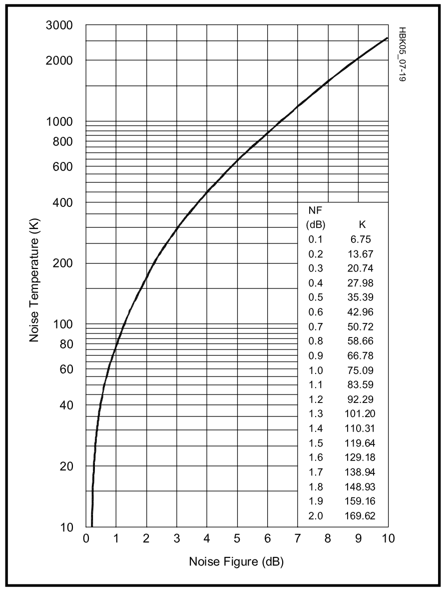


Table 7.54
Antenna Wire Strength

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

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

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.**

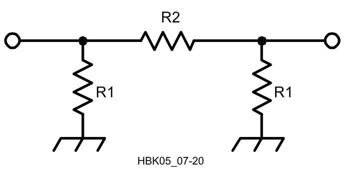


Table 7.57
T-Network Resistive Attenuators (50 Ω)

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

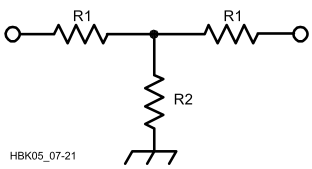


Table 7.58
Impedance of Various Two-Conductor Lines

	—— 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

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

Measured in decibels at 14.0 MHz.

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

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

Reflection Coefficient (%)	*Attenuation (dB)*	*Max SWR*	*Return Loss, dB*
1.000	0.000434	1.020	40.00
1.517	0.001000	1.031	36.38
2.000	0.001738	1.041	33.98
3.000	0.003910	1.062	30.46
4.000	0.006954	1.083	27.96
4.796	0.01000	1.101	26.38
5.000	0.01087	1.105	26.02
6.000	0.01566	1.128	24.44
7.000	0.02133	1.151	23.10
7.576	0.02500	1.164	22.41
8.000	0.02788	1.174	21.94
9.000	0.03532	1.198	20.92
10.000	0.04365	1.222	20.00
10.699	0.05000	1.240	19.41
11.000	0.05287	1.247	19.17
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
44.000	0.9345	2.571	7.13
45.351	1.0000	2.660	6.87
48.000	1.1374	2.846	6.38
50.000	1.2494	3.000	6.02
52.000	1.3692	3.167	5.68
54.042	1.5000	3.352	5.35
56.234	1.6509	3.570	5.00
58.000	1.7809	3.762	4.73
60.000	1.9382	4.000	4.44
60.749	2.0000	4.095	4.33
63.000	2.1961	4.405	4.01
66.156	2.5000	4.909	3.59
66.667	2.5528	5.000	3.52
70.627	3.0000	5.809	3.02
70.711	3.0103	5.829	3.01

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

where ρ = 0.01 × (reflection coefficient in %)

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

where RL = return loss (dB)

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

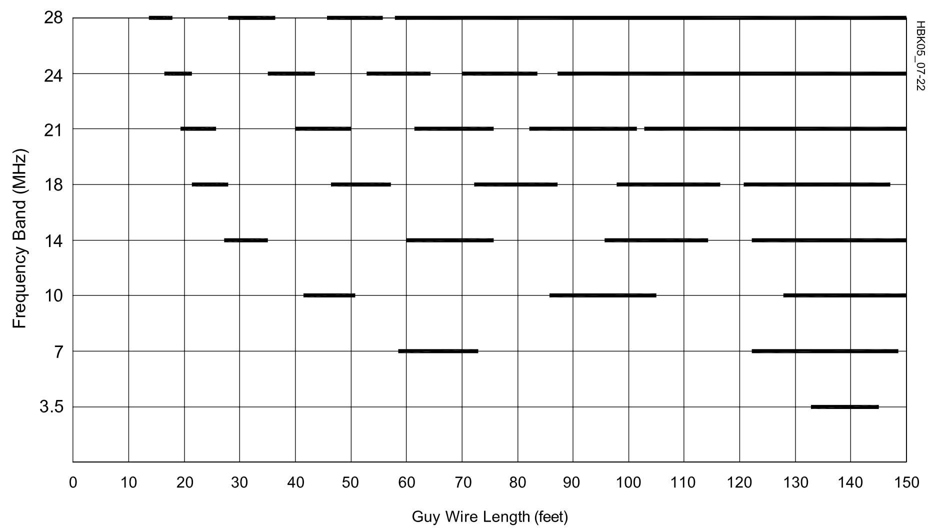
where X = A/10 and A = attenuation (dB)

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

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

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

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 Set[1]

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

Period [.]:	didahdidahdidah	• – • – • –	$\overline{AAA}$
Comma [,]:	dahdahdididahdah	– – •• – –	$\overline{MIM}$
Question mark or request for repetition [?]:	dididahdahdidit	•• – – ••	$\overline{IMI}$
Error:	didididididididit	••••••••	$\overline{HH}$
Hyphen or dash [–]:	dahdidididdidah	– •••• –	$\overline{DU}$
Double dash [=]	dahdidididah	– ••• –	$\overline{BT}$
Colon [:]:	dahdahdahdididit	– – – •••	$\overline{OS}$
Semicolon [;]:	dahdidahdidahdit	– • – • – •	$\overline{KR}$
Left parenthesis [(]:	dahdidahdahdit	– • – – •	$\overline{KN}$
Right parenthesis [)]:	dahdidahdahddidah	– • – – • –	$\overline{KK}$
Fraction bar [/]:	dahdididahdit	– •• – •	$\overline{DN}$
Quotation marks [“]:	didahdididahdit	• – • • – •	$\overline{AF}$
Dollar sign [$]:	didididahdididah	••• – • •–	$\overline{SX}$
Apostrophe [’]:	didahdahdahdahdit	• – – – – – •	$\overline{WG}$
Paragraph [¶]:	didahdidahdidit	• – • – ••	$\overline{AL}$
Underline [_]:	dididahdahdidah	•• – – • –	$\overline{IQ}$
Starting signal:	dahdidahdidah	– • – •–	$\overline{KA}$
Wait:	didahdididit	• – •••	$\overline{AS}$
End of message or cross [+]:	didahdidahdit	• – • – •	$\overline{AR}$
Invitation to transmit [K]:	dahdidah	– • –	K
End of work:	didididahdidah	••• – • –	$\overline{SK}$
Understood:	didididahdit	••• – •	$\overline{SN}$

Notes:

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

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

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

3. Special Esperanto characters:

Ĉ	dahdidahdidit	– • – ••
Ŝ	didididahdit	••• – •
Ĵ	didahdahdahdit	• – – –•
Ĥ	dahdidahdahdit	–• – –•
Û	dididahdah	•• – –
Ĝ	dahdahdidahdit	– –• –•

4. Signals used in other radio services:

Interrogatory	dididahdidah	•• – • –	$\overline{INT}$
Emergency silence	dididididahdah	•••• – –	$\overline{HM}$
Executive follows	dididahdididah	•• – •• –	$\overline{IX}$
Break–in signal	dahdahdahdahdah	– – – – –	$\overline{TTTTT}$
Emergency signal	didididahdahdahdididit	••• – – – •••	$\overline{SOS}$
Relay of distress	dahdididahdididahdidit	– •• – •• – ••	$\overline{DDD}$

Morse Abbreviated Numbers

Numeral		*Long Number*		*Abbreviated Number*	*Equivalent Character*
1	didahdahdahdah	• – – – –	didah	• –	A
2	dididahdahdah	•• – – –	dididah	•• –	U
3	didididahdah	••• – –	didididah	••• –	V
4	dididididah	•••• –	dididididah	•••• –	4
5	dididididit	•••••	dididididit	••••• or •	5 or E
6	dahdididdit	– ••••	dahdididdit	– ••••	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 7.63
Morse Abbeviated (“Cut”) Numbers

Numeral		*Long Number*		*Abbreviated Number*	*Equivalent Character*
1	didahdahdahdah	• – – – –	didah	• –	A
2	dididahdahdah	• • – – –	dididah	• • –	U
3	didididahdah	• • • – –	didididah	• • • –	V
4	dididididah	• • • • –	dididididah	• • • • –	4
5	dididididit	• • • • •	dididididit	• • • • • or •	5 or E
6	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

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

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% inter-ference-free operation is an unrealistic expectation in today's congested bands.

1.800-1.810	Digital Modes
1.810	CW QRP
1.800-2.000	CW
1.843-2.000	SSB, SSTV and other wideband modes
1.910	SSB QRP
1.995-2.000	Experimental
1.999-2.000	Beacons
3.500-3.510	CW DX
3.590	RTTY DX
3.580-3.620	Data
3.620-3.635	Automatically controlled data stations
3.790-3.800	DX window
3.845	SSTV
3.885	AM calling frequency
3.985	QRP SSB calling frequency
7.040	RTTY DX
	QRP CW calling frequency
7.075-7.100	Phone in KH/KL/KP *only*
7.080-7.100	Data
7.100-7.105	Automatically controlled data stations
7.171	SSTV
7.290	AM calling frequency
10.106	QRP CW calling frequency
10.130-10.140	Data
10.140-10.150	Automatically controlled data stations
14.060	QRP CW calling frequency
14.070-14.095	Data
14.095-14.0995	Automatically controlled data stations
14.100	IBP/NCDXF beacons
14.1005-14.112	Automatically controlled data stations
14.230	SSTV
14.285	QRP SSB calling frequency
14.286	AM calling frequency
18.100-18.105	Data
18.105-18.110	Automatically controlled data stations
21.060	QRP CW calling frequency
21.070-21.090	Data
21.090-21.100	Automatically controlled data stations
21.340	SSTV
21.385	QRP SSB calling frequency
24.920-24.925	Data
24.925-24.930	Automatically controlled data stations
28.060	QRP CW calling frequency
28.070-28.120	Data
28.120-28.189	Automatically controlled data stations
28.190-28.225	Beacons
28.385	QRP SSB calling frequency
28.680	SSTV
29.000-29.200	AM
29.300-29.510	Satellite downlinks
29.520-29.580	Repeater inputs
29.600	FM simplex
29.620-29.680	Repeater outputs

Notes

ARRL band plans for frequencies above 28.300 MHz are shown in *The ARRL Repeater Directory* *The FCC Rule Book* *QST*

Table 7.66
VHF/UHF/EHF Calling Frequencies

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

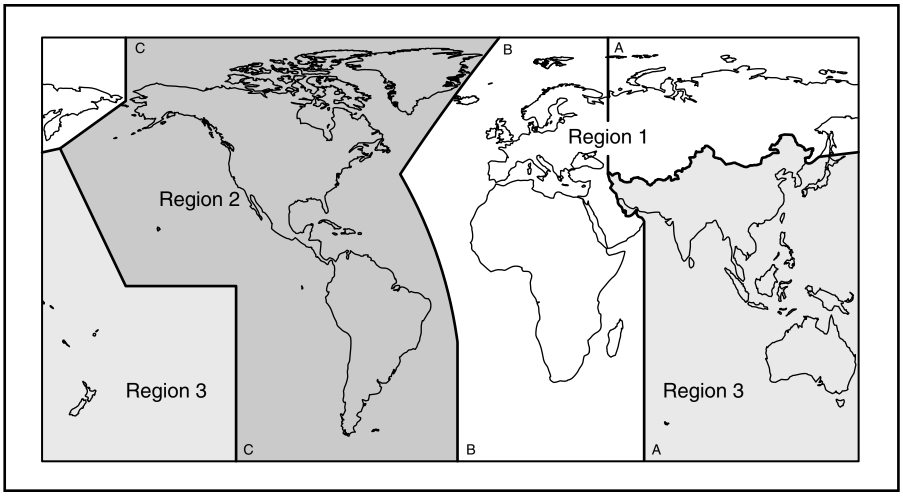
VHF/UHF Activity Nights

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

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

Table 7.67

ITU Regions



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

Table 7.68

Allocation of International Call Signs

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

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

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

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

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 $\overline{KN}$, $\overline{AR}$ 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	Teleprinter Bulletin				
4 PM	5 PM	6 PM	7 PM	Slow Code	Fast Code	Slow Code	Fast Code	Slow Code
5 PM	6 PM	7 PM	8 PM	Code Bulletin				
6 PM	7 PM	8 PM	9 PM	Teleprinter Bulletin				
6:45 PM	7:45 PM	8:45 PM	9:45 PM	Voice Bulletin				
7 PM	8 PM	9 PM	10 PM	Fast Code	Slow Code	Fast Code	Slow Code	Fast Code
8 PM	9 PM	10 PM	11 PM	Code Bulletin				

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

Morse code transmissions:

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

Slow Code = practice sent at 5, 71/2, 10, 13 and 15 wpm.

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

Code practice text is from the pages of *QST*. The source is given at the beginning of each practice session and alternate speeds within each session. For example, "Text is from June 2003 *QST*, pages 9 and 81," indicates that the plain text is from the article on page 9 and mixed number/letter groups are from page 81.

Code bulletins are sent at 18 wpm.

W1AW qualifying runs are sent on the same frequencies as the Morse code transmissions. West Coast qualifying runs are transmitted on approximately 3.590 MHz by K6YR. At the beginning of each code practice session, the schedule for the next qualifying run is presented. Underline one minute of the highest speed you copied, certify that your copy was made without aid, and send it to ARRL for grading. Please include your name, call sign (if any) and complete mailing address. The fee structure is $10 for a certificate and $7.50 for endorsements.

Teleprinter transmissions:

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

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

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

Voice transmissions:

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

Miscellanea:

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

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

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

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

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.

Situation	*CW*	*Voice*
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	$\overline{\text{AR}}$	over, end of message
invite any station to transmit	K	go
invite a specific named station to transmit	$\overline{\text{KN}}$	go only
invite receiving station to transmit	BK	back to you
all received correctly	R	received
please stand by	$\overline{\text{AS}}$	wait, stand by
end of contact (sent before call sign)	$\overline{\text{SK}}$	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 ______.
QRG	Will you tell me my exact frequency (or that of _____)? Your exact frequency (or that of _____) is _____ kHz.
QRH	Does my frequency vary? Your frequency varies.
QRI	How is the tone of my transmission? The tone of your transmission is _____ (1. Good; 2. Variable; 3. Bad).
QRJ	Are you receiving me badly? I cannot receive you. Your signals are too weak.
QRK	What is the intelligibility of my signals (or those of _____)? The intelligibility of your signals (or those of _____) is _____ (1. Bad; 2. Poor; 3. Fair; 4. Good; 5. Excellent).
QRL	Are you busy? I am busy (or I am busy with _____). Please do not interfere.
QRM	Is my transmission being interfered with? Your transmission is being interfered with (1. Nil; 2. Slightly; 3. Moderately; 4. Severely; 5. Extremely.)
QRN	Are you troubled by static? I am troubled by static _____ (1-5 as under QRM).
QRO	Shall I increase power? Increase power.
QRP	Shall I decrease power? Decrease power.
QRQ	Shall I send faster? Send faster (_____ WPM).
QRS	Shall I send more slowly? Send more slowly (_____ WPM).
QRT	Shall I stop sending? Stop sending.
QRU	Have you anything for me? I have nothing for you.
QRV	Are you ready? I am ready.
QRW	Shall I inform _____ that you are calling on _____ kHz? Please inform _____ that I am calling on _____ kHz.
QRX	When will you call me again? I will call you again at _____ hours (on _____ kHz).
QRY	What is my turn? Your turn is numbered _____
QRZ	Who is calling me? You are being called by _____ (on _____ kHz).
QSA	What is the strength of my signals (or those of ____)? The strength of your signals (or those of _____) is _____ (1. Scarcely perceptible; 2. Weak; 3. Fairly good; 4. Good; 5. Very good).
QSB	Are my signals fading? Your signals are fading.
QSD	Is my keying defective? Your keying is defective.
QSG	Shall I send _____ messages at a time? Send _____ messages at a time.
QSK	Can you hear me between your signals and if so can I break in on your transmission? I can hear you between my signals; break in on my transmission.
QSL	Can you acknowledge receipt? I am acknowledging receipt.
QSM	Shall I repeat the last message which I sent you, or some previous message? Repeat the last message which you sent me [or message(s) number(s) _____].
QSN	Did you hear me (or _____) on _____ kHz? I did hear you (or _____) on _____ kHz.
QSO	Can you communicate with _____ direct or by relay? I can communicate with _____ direct (or by relay through _____).
QSP	Will you relay to _____? I will relay to _____
QST	General call preceding a message addressed to all amateurs and ARRL members. This is in effect “CQ ARRL.”
QSU	Shall I send or reply on this frequency (or on _____ kHz)? Send or reply on this frequency (or _____ kHz).
QSV	Shall I send a series of Vs on this frequency (or on _____ kHz)? Send a series of Vs on this frequency (or on _____ kHz).
QSW	Will you send on this frequency (or on _____ kHz)? I am going to send on this frequency (or on ____ kHz).
QSX	Will you listen to _____ on _____ kHz? I am listening to _____ on _____ kHz.
QSY	Shall I change to transmission on another frequency? Change to transmission on another frequency (or on _____ kHz).

QSZ Shall I send each word or group more than once? Send each word or group twice (or _____ times).

QTA Shall I cancel message number _____? Cancel message number _____

QTB Do you agree with my counting of words? I do not agree with your counting of words. I will repeat the first letter or digit of each word or group.

QTC How many messages have you to send? I have ______ messages for you (or for _____).

QTH What is your location? My location is _____

QTR What is the correct time? The correct time is _____

QTV Shall I stand guard for you? Stand guard for me.

QTX Will you keep your station open for further communication with me? Keep your station open for me.

QUA Have you news of _____? I have news of _____.

ARRL QN Signals

QNA* Answer in prearranged order.

QNB Act as relay between _____ and _____.

QNC All net stations copy. I have a message for all net stations.

QND* Net is Directed (Controlled by net control station.)

QNE* Entire net stand by.

QNF Net is Free (not controlled).

QNG Take over as net control station

QNH Your net frequency is High.

QNI Net stations report in. I am reporting into the net. (Follow with a list of traffic or QRU.)

QNJ Can you copy me?

QNK* Transmit messages for _____ to _____.

QNL Your net frequency is Low.

QNM* You are QRMing the net. Stand by.

QNN Net control station is _____. What station has net control?

QNO Station is leaving the net.

QNP Unable to copy you. Unable to copy _____.

QNQ* Move frequency to _____ and wait for _____ to finish handling traffic. Then send him traffic for _____.

QNR* Answer _____ and Receive traffic.

QNS Following Stations are in the net.* (follow with list.) Request list of stations in the net.

QNT I request permission to leave the net for _____ minutes.

QNU* The net has traffic for *you*. Stand by.

QNV* Establish contact with _____ on this frequency. If successful, move to _____ and send him traffic for _____.

QNW How do I route messages for _____?

QNX You are excused from the net.*

QNY* Shift to another frequency (or to _____ kHz) to clear traffic with _____.

QNZ Zero beat your signal with mine.

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

Notes on Use of QN Signals

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

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

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

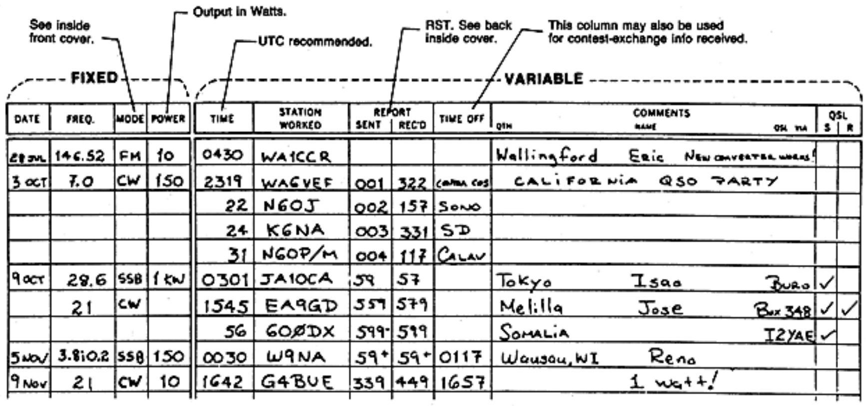
Table 7.76

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



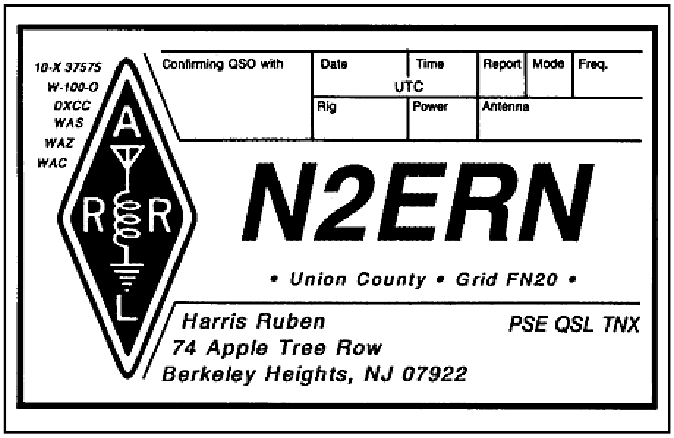
DATE	FREQ.	MODE	POWER	TIME	STATION WORKED	REPORT SENT	REPORT REC'D	TIME OFF	COMMENTS QTH	NAME	QSL VIA	QSL S	QSL R
28 JUL	146.52	FM	10	0430	WA1CCR				Wallingford	Eric	New converter works!		
3 OCT	7.0	CW	150	2319	WA6VEF	001	322	Contra Cos	CALIFORNIA QSO PARTY				
				22	N6OJ	002	157	Sono					
				24	K6NA	003	331	SD					
				31	N6OP/M	004	117	Calav					
9 OCT	28.6	SSB	1 kW	0301	JA1OCA	59	57		Tokyo	Isao	Buro	✓	
	21	CW		1545	EA9GD	559	579		Melilla	Jose	Box 348	✓	✓
				56	6OØDX	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 watt!			

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	*Qualification*
Worked All States (WAS)	QSLs from all 50 US states
Worked All Continents (WAC)	QSLs from all six continents
DX Century Club (DXCC)	QSLs from at least 100 different countries
VHF/UHF Century Club (VUCC)	QSLs from many grid squares
A-1 Operator Club	Recommendation by two A-1 operators
Code Proficiency	One minute of perfect copy from W1AW qualifying run
ARRL Membership	ARRL membership for 25, 40, 50, 60 or 70 years

Table 7.79
ARRL Membership QSL Card

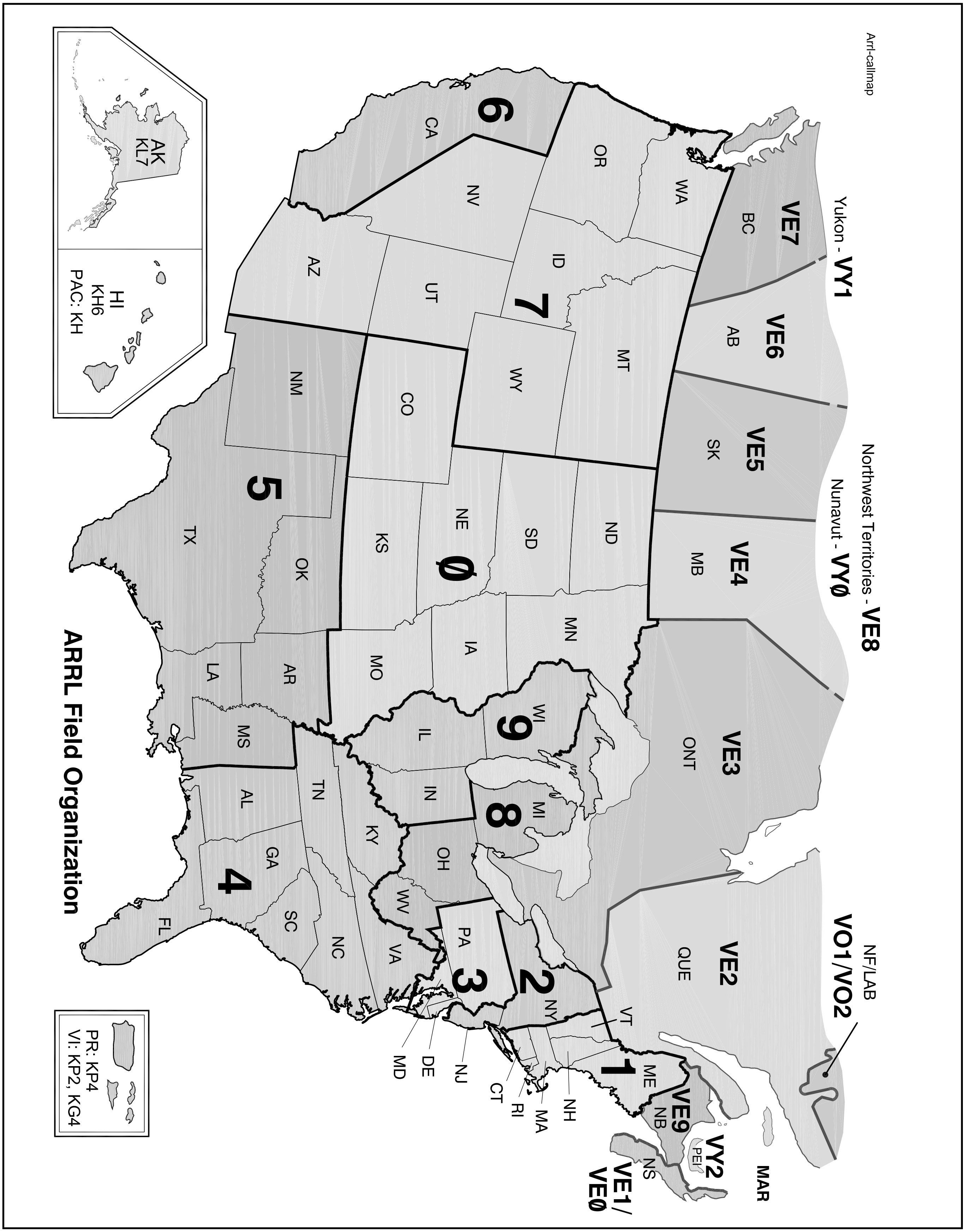


The ARRL membership QSL card. This example is from Harris Ruben, N2ERN, who designed the card. Your card would reflect your own call sign and address; awards and VUCC grid-square are optional. ARRL does not print or sell the cards. Inquire with printers who advertise in the *QST* Ham Ads.

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

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



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

Table 7.82

ARRL Grid Locator Map for North America

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

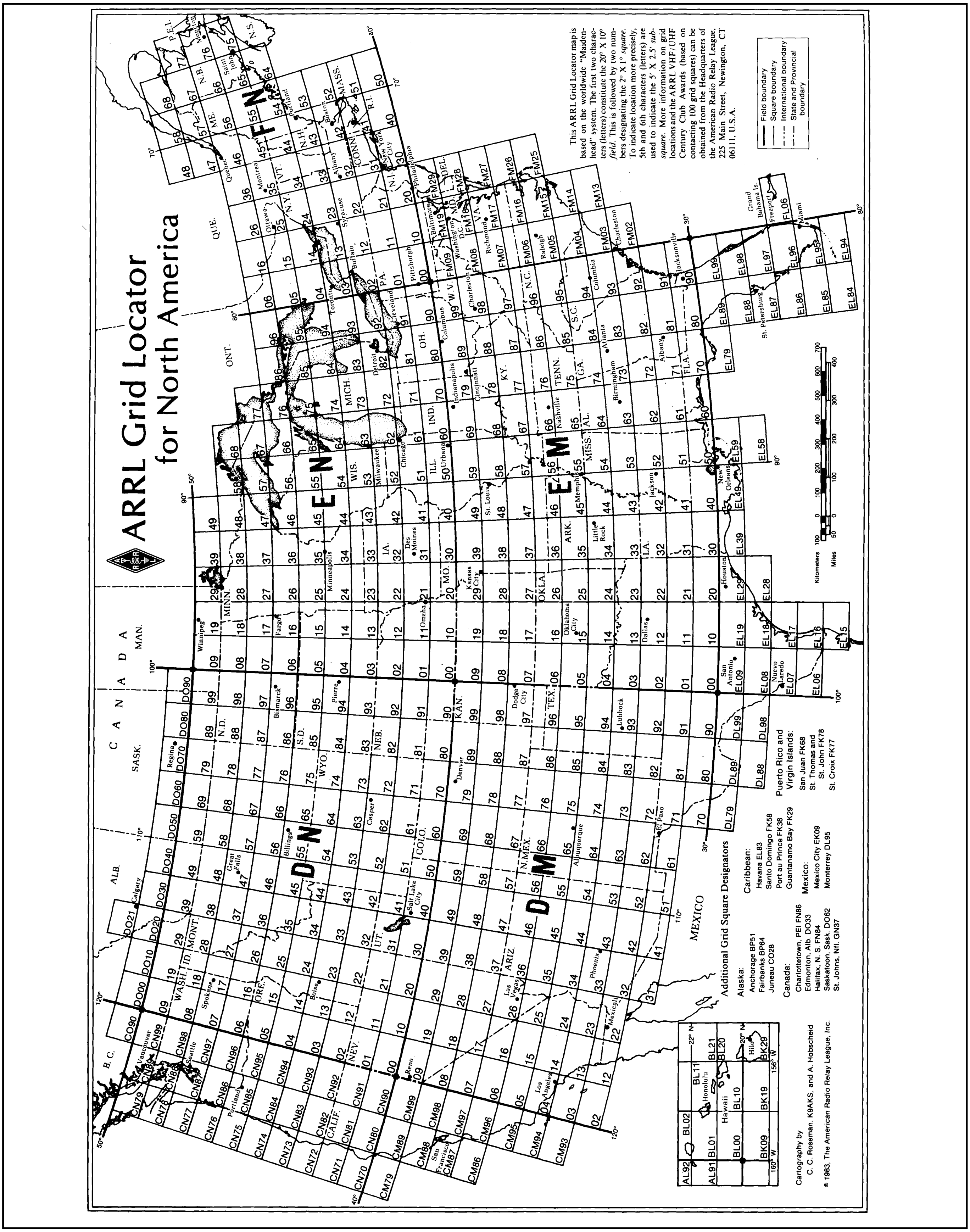


Table 7.83
Amateur Message Form

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 of 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 $\overline{AA}$
160 EAST SIXTH AVE $\overline{AA}$
NORTH RIVER CITY MO 00789 $\overline{AA}$
733 4868 $\overline{BT}$

III HAPPY BIRTHDAY X SEE YOU SOON X LOVE $\overline{BT}$

IV DIANA $\overline{AR}$

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

CW: The prosign $\overline{AA}$ separates the parts of the message. $\overline{BT}$ separates the address from the text the text from the signature. $\overline{AR}$ 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 $\overline{AA}$; (2) omit CW procedure sign $\overline{BT}$ 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 $\overline{AA}$ and $\overline{AR}$ 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 within ……miles. (If no number, authorization is unlimited.)
HXB—(Followed by number.) Cancel message if not delivered within ……hours of filing time; service originating station.
HXC—Report date and time of delivery (TOD) to originating station.
HXD—Report to originating station the 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 *Public Service Communications Manual* or *The ARRL Operating Manual*, both published by the ARRL.

Table 7.84
A Simple NTS Formal Message

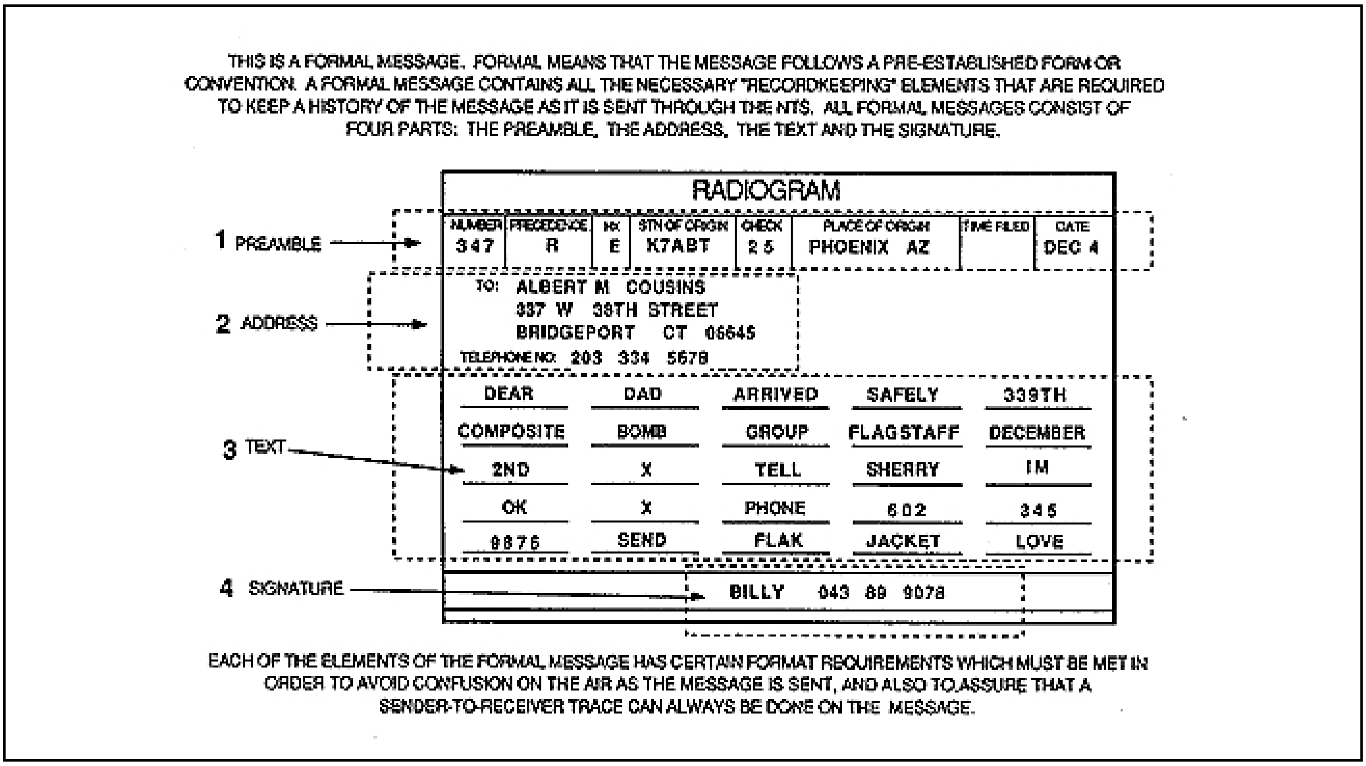


Table 7.85
Handling Instructions

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. For more information on packet radio, see *Practical Packet Radio*, published by the ARRL.