6 MTR 4 EL SIX BAND QUAD

Bob Hume KG6B AUG 23, 2004

This paper is an extension of a prior paper titled "Design of a Five Band Quad and Its Coax Feed System" which described a large 4 EL (5 EL on 10 Meters) five band cubical quad antenna covering the 20, 17, 15, 12, and 10 Meter bands. This paper adds a 6 Meter 4 element quad to the previously described quad to create a six-band quad. The total five-band quad boom length remains unchanged at 30 feet. A 4 element 6 Meter quad was added to the front 14 foot section of the 30 foot boom. The 6 Meter reflector is spaced 4.0 feet from the driven element. The first director is spaced 5.0 feet from the driven element. The second director is spaced 5.0 feet from the first director. The 6 Meter driven element and second director wires are placed on existing quad arms that support the 20 Meter first and second directors. The 6 Meter reflector and first director require adding special quad support arms to the boom.

Initial EZNEC 4.0 modeling of the six-band quad with the 6 Meter reflector on the same quad arms that support the reflectors for the other five bands indicated that the patterns of the 10 and 6 meter quads were poor. The patterns were much better when the 14 foot segment of the 6 Meter array was moved to the front of the boom. This paper uses EZNEC 4.0 to evaluate the performance of the 6 Meter six band quad and a mono band 6 Meter quad of the same physical dimensions. The 6 Meter antenna dBi gains were evaluated at the same 55 foot antenna height over real ground (see details in EZNEC 4.0 antenna description at back of this paper) at the first vertical wave angle maximum of 4.9 degrees. A reference dipole resonant at 51 Mhz with the same height, ground model, and wave angle has a gain of 7.8 dBi. The 6 Meter quad antenna gain in dBd over a dipole is therefore the dBi gain minus 7.8.

A picture of the six-band quad is shown in Figure A

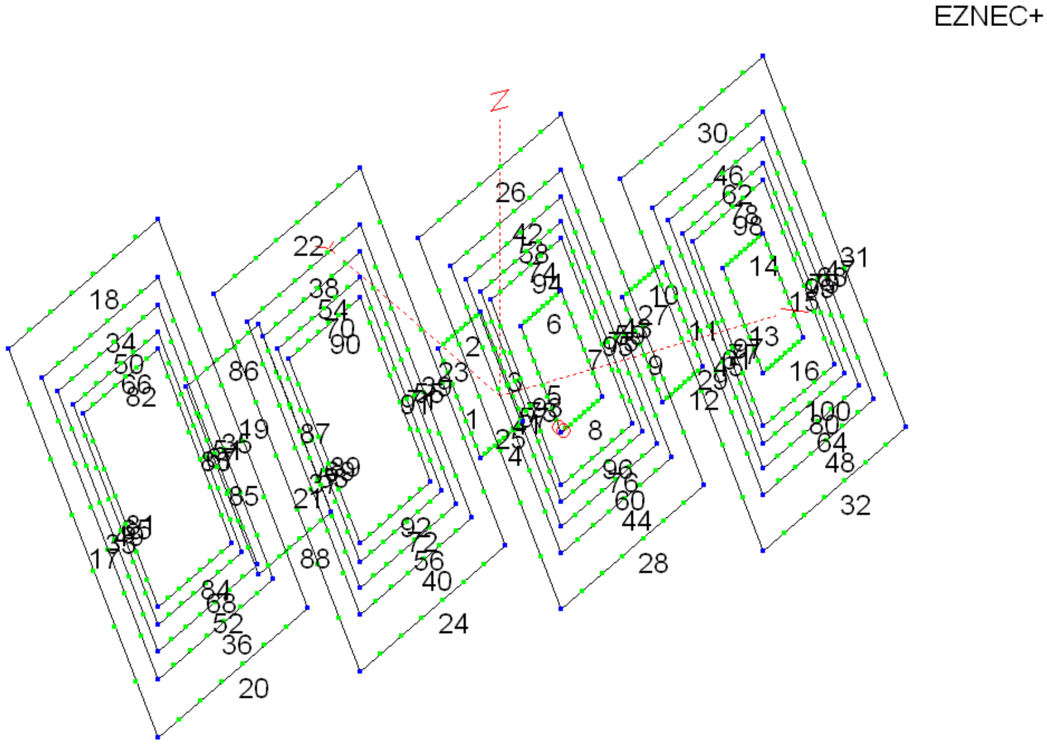


FIGURE A SIX BAND QUAD PICTURE

The EZNEC 4.0 wire table for the Figure A six band quad was generated by a MATLAB program named quadmod89.m (see program listing at the back of this paper). The wire table file qwall.m generated by this program was exported to EZNEC 4.0. A printout of the MATLAB program antenna description is shown in Table 1.

TABLE 1 6 METER SIX BAND QUAD DIMENSIONS

```
>> quadmod89

MONO OR MULTI BAND CUBICAL QUAD DESIGN CONSTANTS @ DIAMOND
ELEMENT SHAPES

FIRST BAND LISTED IS THE DRIVEN BAND. "DE" STANDS FOR DRIVEN
ELEMENT
DATA ELEMENT ORDER IS REF, DE, DIR1, DIR2, ...DIRn

6 MTR QUAD DESIGN CONSTANTS
DE LENGTH CONSTANTS:   k=1011.238   f=51   DE in FT=19.8282
ELEMENT LENGTHS AS A % FROM DE=3          0       -1.9       -1.7
ELEMENT BOOM LOCATIONS IN FT=16  20  25  30
SEGMENTS PER WIRE=9


20 MTR QUAD DESIGN CONSTANTS
DE LENGTH CONSTANTS:   k=997.6767   f=14.15   DE in FT=70.5072
ELEMENT LENGTHS AS A % FROM DE=2.976          0     -1.704      -1.725
ELEMENT BOOM LOCATIONS IN FT=0  10  20  30
SEGMENTS PER WIRE=7

17 MTR QUAD DESIGN CONSTANTS
DE LENGTH CONSTANTS:   k=987.6525   f=18.11   DE in FT=54.5363
ELEMENT LENGTHS AS A % FROM DE=3          0      -1.75      -1.75
ELEMENT BOOM LOCATIONS IN FT=0  10  20  30
SEGMENTS PER WIRE=7

15 MTR QUAD DESIGN CONSTANTS
DE LENGTH CONSTANTS:   k=996.9452   f=21.2   DE in FT=47.0257
ELEMENT LENGTHS AS A % FROM DE=3.071          0     -1.848      -1.77
ELEMENT BOOM LOCATIONS IN FT=0  10  20  30
SEGMENTS PER WIRE=7
```

12 MTR QUAD DESIGN CONSTANTS
DE LENGTH CONSTANTS: k=993.935 f=24.93 DE in FT=39.869
ELEMENT LENGTHS AS A % FROM DE=3 0 -1.75 -1.75
ELEMENT BOOM LOCATIONS IN FT=0 10 20 30
SEGMENTS PER WIRE=7

10 MTR QUAD DESIGN CONSTANTS
DE LENGTH CONSTANTS: k=997.528 f=28.45 DE in FT=35.0625
ELEMENT LENGTHS AS A % FROM DE=3.014 0 -2.066 -1.744 -
1.723
ELEMENT BOOM LOCATIONS IN FT=0 5 10 20 30
SEGMENTS PER WIRE=7

MTR BAND	BAND WIRES	SEGS PER WIRE	TOTAL WIRES	TOTAL #WIRE SEGS	DRIVEN ELEMENT WIRES 0% DEa#	100% DEb#
6	16	9	16	144	5	8
20	16	7	32	256	21	24
17	16	7	48	368	37	40
15	16	7	64	480	53	56
12	16	7	80	592	69	72
10	20	7	100	732	85	88

There are 100 wires and 732 wire segments in this EZNEC 4.0 antenna model. EZNEC 4.0 can handle a maximum of 1500 wire segments. The five non driven driven elements in the six band quad have a zero Ohm termination impedance in the EZNEC 4.0 model. The quad model assumes that all wires are #12 bare copper wire.

The shorthand notation for the antenna element dimensions, spacing, and boom locations in Table 1 are explained in more detail using the 6 Meter antenna as an example.

The 6 Meter driven element (DE) wire length is 19.8282 feet

The 6 Meter reflector wire is +3% larger than the DE or (1+.03)*DE=20.4230 feet

The 6 Meter first director wire is -1.9% shorter than the DE or (1-.019)*DE=19.4515 feet

The 6 Meter second director wire is -1.7% shorter than the DE or (1-.017)*DE=19.4911 feet

The arbitrary zero point along the boom is the back end tip where the 20 Meter reflector is located. The 6 Meter reflector is 16 foot down the boom from this point. The 6 Meter driven element is located 20 foot down the boom for a reflector to driven element spacing of (20-16)=4 feet. The driven element to first director spacing is (25-20)=5 feet. The 6 Meter first director to second director spacing is (30-25)=5 feet.

Figure 1A shows the 6 Meter six band quad gain in dBi, front to back ratio FB in dB, front to back region FBR in dB, and ten times the SWR (required to use the same Y axis scale for all plots) with a 50 Ohm coax feed versus frequency. Figure 1B shows the 6 Meter six band quad antenna driving point impedance real and imaginary parts versus frequency. Figures 2A and 2B show similar results for a 6 Meter mono band quad with the same physical dimensions and antenna height etc. The 6 Meter six-band quad has a peak gain of 16.68 dBi or 8.88 dBd at 51.3 Mhz and a peak FBR of 20.75 dB at 50.95 Mhz. The 6 Meter mono band quad has a peak gain of 17.06 dBi or 9.26 dBd at 51.35 Mhz and a peak FBR of 22.67 dB at 51.05 Mhz. The 6 Meter six band quad has an SRW of less than 2.5 to one between 49.8 and 51.36 Mhz or a 1.56 Mhz range. The 6 Meter mono band quad has an SWR of less than 2.5 to one between 50.23 and 51.41 Mhz or a 1.18 Mhz range. The SWR<2.5 bandwidth of the 6 Meter six band quad is therefore 32% larger than the 6 Meter mono band quad. The listings of the MATLAB program quad6Ab.m and its EZNEC 4.0 data output subroutine program quad6A.m used to generate Figures 1A, 1B, 2A, and 2B and are at the back of this paper.

If one were just interested in the 6 Meter DX widow performance around 50.2 Mhz and was willing to give up coverage above 50.8 Mhz, all the wires of the previously described 6 Meter antenna could be scaled 1.6% larger. This would get the sweet spot of the array on the DX window. The reflector could also be moved another 0.5 foot down the boom to the 16.5 foot point for a reflector to driven element spacing of 3.5 foot. This would place the reflector 1.5 foot rather than 1.0 foot from the mast assuming that the mast is at the middle 15 foot point of the 30 foot boom. The array performance is about the same for 4.0 or 3.5 foot reflector to driven element spacing. The 1.5 foot mast spacing to the 6 Meter reflector would give some more elbow room when working around the mast.

FIG 1A 6 MTR 4EL SIX BAND QUAD GAIN, FB, FBR, and SWR PLOTS

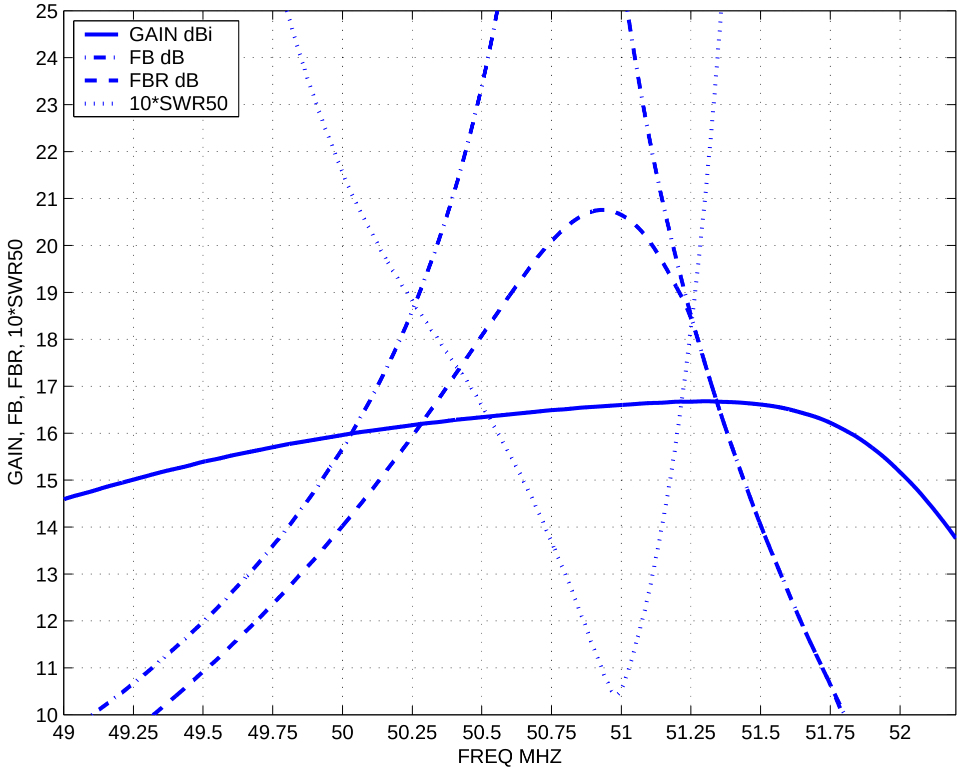
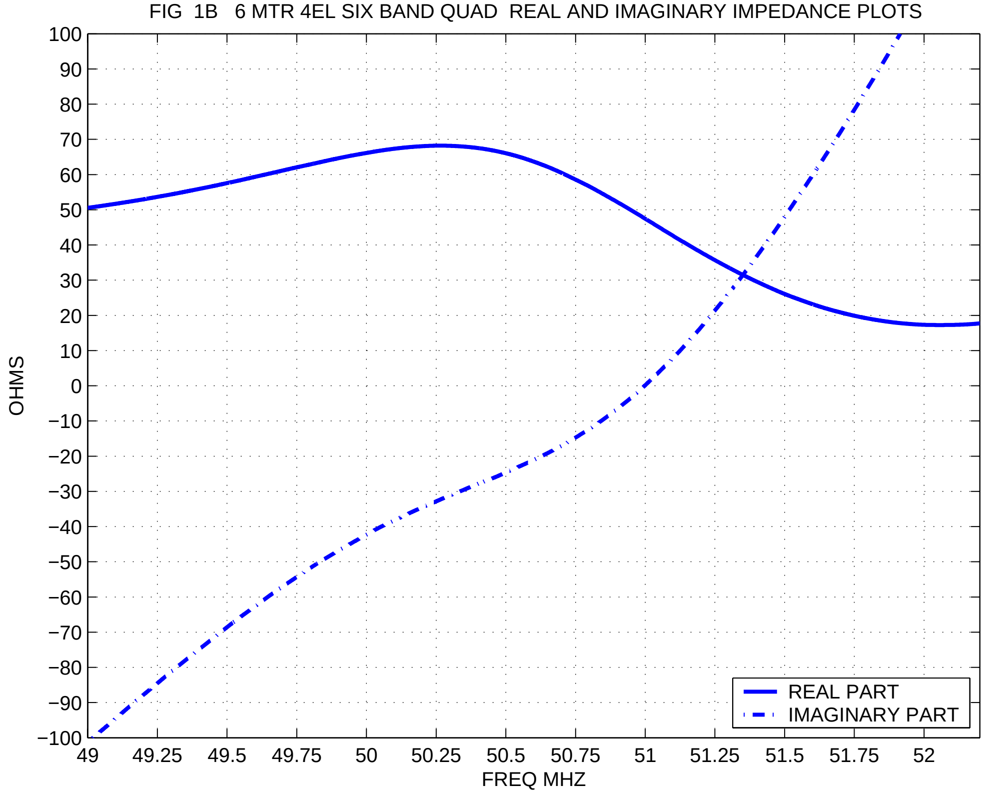


FIG 1B 6 MTR 4EL SIX BAND QUAD REAL AND IMAGINARY IMPEDANCE PLOTS



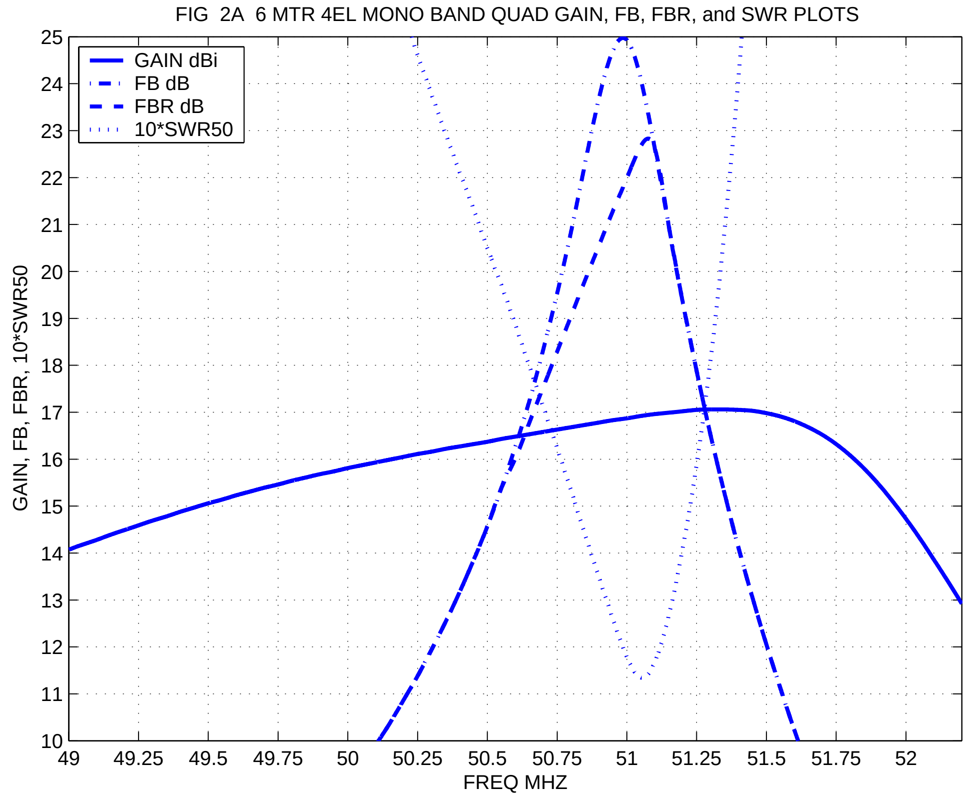


FIG 2A 6 MTR 4EL MONO BAND QUAD GAIN, FB, FBR, and SWR PLOTS
GAIN dBi
FB dB
FBR dB
10*SWR50
GAIN, FB, FBR, 10*SWR50
FREQ MHZ

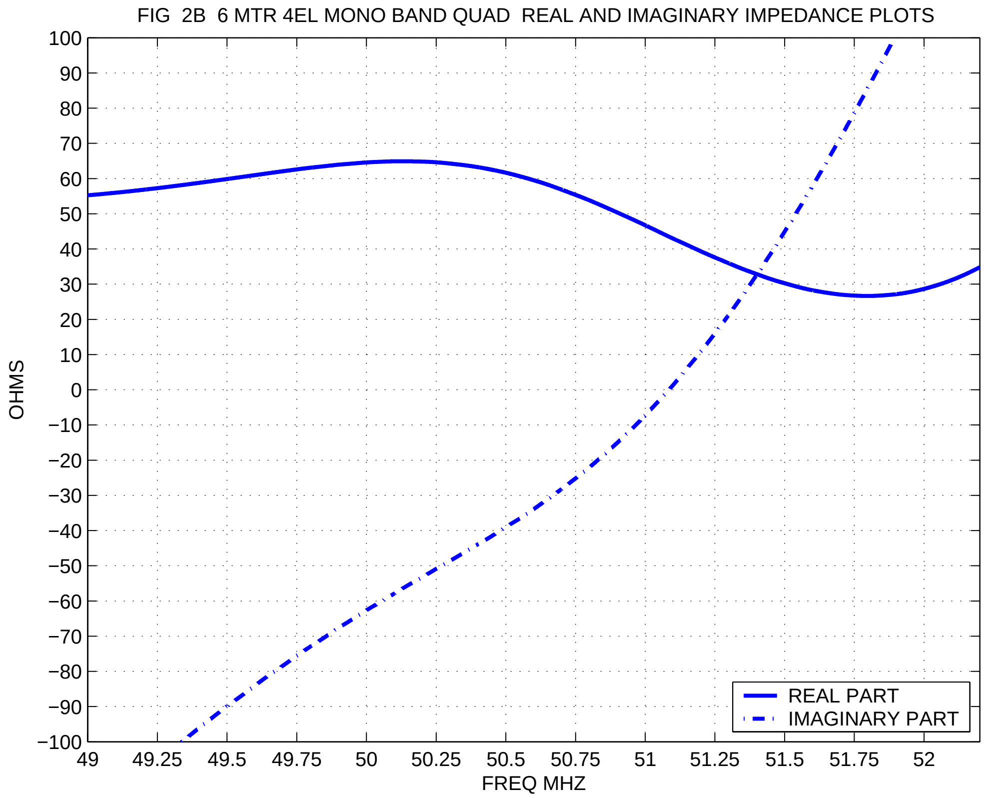


FIG 2B 6 MTR 4EL MONO BAND QUAD REAL AND IMAGINARY IMPEDANCE PLOTS
OHMS
REAL PART
IMAGINARY PART
FREQ MHZ

Table 2 shows the affect of adding the 6 Meter quad to the five band quad to create a six band quad. The affect on gain, FBR, and SWR on the 20, 17, 15, 17, and 12 Meter band performance is minor by adding the 6 Meter quad. The 10 Meter quad is tuned to a higher frequency since the 28.025 Mhz performance is degraded and the 28.85 Mhz performance is improved. This makes sense since the four 6 Meter elements which are sitting out in front of the 10 Meter driven element look like directors tuned to 51 Mhz. Runs of the EZNEC SWR scan for the 10 Meter 5 band and six band quads indicate that the five bander resonance (i.e. pure resistive driving point impedance) is at 28.505 Mhz with a resistance of 50.28 Ohms while the six bander resonance is at 28.598 Mhz and has a resistance of 50.13 Ohms. Adding the 6 Meter quad therefore increased the 10 Meter quad resonant frequency by 93 Khz or 0.33%. This increase in 10 Meter quad resonant frequency can be offset by rescaling all of the 10 Meter quad wires by +0.33% in length. This would help in retrieving the performance loss on the lower CW end of the 10 Meter band at 28.025 Mhz. The 10 Meter 5 band quad was optimized for performance at 28.5 Mhz with SWR compromised at 28.0. The issue is not to let the 28.025 Mhz SWR get out of hand. The 10 Meter quad dimensions with the +0.33 % increase in wire lengths are:

10 MTR QUAD DESIGN CONSTANTS
DE LENGTH CONSTANTS: k=1000.82 f=28.45 DE in FT=35.1782
ELEMENT LENGTHS AS A % FROM DE=3.014 0 -2.066 -1.744 -1.723
ELEMENT BOOM LOCATIONS IN FT=0 5 10 20 30
SEGMENTS PER WIRE=9

Table 3 shows that the above +0.33% scaling of the 10 Meter quad section of the six band quad retrieves the five band quad 10 Meter CW performance at 28.025 Mhz without a significant change of performance on the 6 and 12 Meter bands. The resonant frequency on 10 Meters with the +0.33% wire scaling is 28.506 Mhz. The resonant resistance of is 49.94 Ohms.

TABLE 2 AFFECT OF ADDING 6 METER QUAD TO FIVE BAND QUAD

METER BAND	FREQUENCY IN MHZ	ARRAY PERFORMANCE ITEM	FIVE BAND QUAD	SIX BAND QUAD	(SIX BAND- FIVE BAND) DIFFERENCE
20	14.025	GAIN dBi	14.13	14.14	0.01
		FBR dB	19.11	19.29	0.18
		SWR	2.12	2.14	0.02
20	14.225	GAIN dBi	13.65	13.68	0.03
		FBR dB	10.45	10.65	0.2
		SWR	1.35	1.36	0.01
17	18.11	GAIN dBi	14.32	14.5	0.18
		FBR dB	15.06	19.11	4.05
		SWR	1.22	1.46	0.24
15	21.025	GAIN dBi	14.41	14.41	0
		FBR dB	16.22	15.84	-0.38
		SWR	1.26	1.24	-0.02
15	21.325	GAIN dBi	14.46	14.5	0.04
		FBR dB	14.31	14.52	0.21
		SWR	1.48	1.49	0.01
12	24.93	GAIN dBi	14.49	14.41	-0.08
		FBR dB	16.84	18.21	1.37
		SWR	1.74	1.69	-0.05
10	28.025	GAIN dBi	14.12	13.54	-0.58
		FBR dB	7.14	4.95	-2.19
		SWR	3.07	4.2	1.13
10	28.5	GAIN dBi	16.14	15.89	-0.25
		FBR dB	21.48	20.81	-0.67
		SWR	1.02	1.31	0.29
10	28.85	GAIN dBi	16.63	16.64	0.01
		FBR dB	15.99	17.98	1.99
		SWR	2.35	2.15	-0.2

TABLE 3 AFFECT OF MODIFICATION SCALING 10 METER QUAD WIRES BY +0.33%

METER BAND	FREQUENCY IN MHZ	ARRAY PERFORMANCE ITEM	FIVE BAND QUAD	SIX BAND QUAD	MODIFIED SIX BAND QUAD
12	24.93	GAIN dBi	14.49	14.41	14.38
		FBR dB	16.84	18.21	17.96
		SWR	1.74	1.69	1.71
10	28.025	GAIN dBi	14.12	13.54	14.12
		FBR dB	7.14	4.95	7
		SWR	3.07	4.2	3.14
10	28.5	GAIN dBi	16.14	15.89	16.15
		FBR dB	21.48	20.81	21.57
		SWR	1.02	1.31	1.02
10	28.85	GAIN dBi	16.63	16.64	16.61
		FBR dB	15.99	17.98	14.91
		SWR	2.35	2.15	2.44
6	51	GAIN dBi	NA	16.6	16.6
		FBR dB	NA	20.65	20.63
		SWR	NA	1.054	1.053

The listing of MATLAB program quad6Ab.m and its subroutine quad6A.m which generated Figures 1A, 1B, 2A, and 2B follows:

```
% M-file quad6Ab.m
global ant4A theta DPLdBi
quad6A % MATLAB program souce for two array data matrices
names=[' 6 MTR 4EL SIX BAND QUAD';  % 1 array ID numbers
      '6 MTR 4EL MONO BAND QUAD'];  % 2
%
plots=['  GAIN, FB, AND FBR PLOTS';
       '  SWR PLOT                 '];
fmin=[49 49]; % plot min freqs
fmax=[52.2 52.2]; % plot max freq
%
for i=1:2
   q=ant4A{i}; % Select i th of 2 antenna data matrices
   f=q(:,1); % Frequency in MHZ
   gain=q(:,4); % gain in dBi
   fb=q(:,5); % FB in dB
   fbr=q(:,6); % FBR in dB (Front to Back Region)
   real=q(:,2);
   imag=q(:,3);
   z=real+j*imag; % Complex antenna driving point impedance
   rho50=(z-50)./(z+50);
   swr50=(1+abs(rho50))./(1-abs(rho50));
   gg=1; % Set gg=1 for gain, fb, fbr, swr50 plots
   if gg==1
   plot(f,gain,'LineWidth',2)
   hold on
   plot(f,fb,'-.','LineWidth',2)
   plot(f,fbr,'--','LineWidth',2)
   plot(f,10*swr50,':','LineWidth',2)
   grid
   axis([fmin(i) fmax(i) 10 25])
   set(gca,'ytick',[10:1:25])
   set(gca,'xtick',[fmin(i):.25:fmax(i)])
   hold off
   legend('GAIN dBi','FB dB','FBR dB','10*SWR50',2)
   xlabel('FREQ MHZ')
   ylabel('GAIN, FB, FBR, 10*SWR50')
   title(['FIG  ',num2str(i),'A  ',names(i,:),' GAIN, FB, FBR, and SWR PLOTS'])
   %print
   fig
   keyboard
   end
```

```
   zz=1; % set zz=1 for real and imaginary parts of impedance plots
   if zz==1
      plot(f,real,'LineWidth',2)
      hold on
      plot(f,imag,'-.','LineWidth',2)
      axis([fmin(i) fmax(i) -100 100])
      set(gca,'ytick',[-100:10:100])
      set(gca,'xtick',[fmin(i):.25:fmax(i)])
      grid
      hold off
      legend('REAL PART','IMAGINARY PART',4)
      xlabel('FREQ MHZ')
      ylabel('OHMS')
      title(['FIG  ',num2str(i),'B  ',names(i,:),'  REAL AND IMAGINARY IMPEDANCE
PLOTS'])
      %print
      fig
      keyboard
   end

end
%
```

The listing of MATLAB program quad6A.m which contains all the EZNEC 4.0 antenna performance data output for the 6 Meter six band and mono band antennas follows:

```
% M-file quad6A.m
% This is a subroutine for program quad6Ab.m
% 6 Mtr 4 EL six band and mono band quad plots program
% Both quads have the same physical dimensions
% EZNEC 4.0 output data files are inputs
% Based on quadmod89.m and EZNEC 4.0 runs made 8-7-2004
% EZNEC antenna files QA6.EZ and QA6MONO.EZ
% Six band quad is 6,20,17,15,12,10 MTR bands
% #12 copper wire elements
% Both antenna are 55 foot above ground
% Unused driven elements shorted
global ant4A theta DPLdBi
% The Gain, FB, and FBR values are based on a fixed vertical wave
%   angle "theta" at the first vertical main lobe maximum.
% The theta vale for the 6 MTR band is 4.9 degrees
theta=[4.9 4.9]'; % values for 6 Mtr six band and mono band antennas
% 6 Mtr reference dipole dBi gain at 4.9 degree theta angle
%  and 55 foot height above ground follows
DPLdBi=[7.8 7.8]';
% For dBd antenna gain over a dipole subtract DPLdBi from dBi antenna gains
%
% Format of following z prefixed matrices is
% Column 1= Frequency in MHZ
% Column 2=Real part of driving point impedance in Ohms
% Column 3=Imaginary part of driving point impedance in Ohms
% Column 4=Gain in dBi
% Column 5=FB in dB
% Column 6=FBR in dB where FBR=Front to Back Region gain.
%   The back region is 180+/-90 degrees from the antenna heading.
%
% 6 MTR 4 EL SIX BAND QUAD DATA INPUT MATRIX FOLLOWS
z6b6=[49.0000   50.5558 -101.2616 14.59 9.57 8.52
  49.0500   51.0938  -97.9213 14.68 9.77 8.73
  49.1000   51.6882  -94.5568 14.76 9.99 8.95
  49.1500   52.3067  -91.1170 14.85 10.21 9.18
  49.2000   52.9594  -87.7962 14.93 10.43 9.41
  49.2500   53.6594  -84.5131 15.01 10.67 9.65
  49.3000   54.3670  -81.2037 15.09 10.91 9.89
  49.3500   55.1318  -78.0094 15.17 11.17 10.14
  49.4000   55.9281  -74.8561 15.24 11.43 10.39
  49.4500   56.7198  -71.7284 15.31 11.70 10.65
  49.5000   57.5736  -68.5853 15.39 11.98 10.92
  49.5500   58.4279  -65.5590 15.45 12.27 11.18
```

49.6000	59.3430	-62.6812	15.52	12.59	11.47
49.6500	60.2334	-59.7685	15.58	12.91	11.76
49.7000	61.1445	-56.9928	15.64	13.24	12.05
49.7500	62.0537	-54.3309	15.70	13.60	12.36
49.8000	62.9074	-51.6864	15.76	13.96	12.67
49.8500	63.7983	-49.1902	15.81	14.36	13.00
49.9000	64.6420	-46.8234	15.86	14.77	13.32
49.9500	65.4266	-44.5408	15.91	15.22	13.67
50.0000	66.1318	-42.3101	15.96	15.67	14.02
50.0500	66.7900	-40.1389	16.01	16.18	14.38
50.1000	67.3328	-38.2633	16.05	16.71	14.75
50.1500	67.7621	-36.3428	16.09	17.29	15.14
50.2000	68.0501	-34.5573	16.13	17.91	15.53
50.2500	68.2023	-32.8474	16.17	18.60	15.93
50.3000	68.1575	-31.1324	16.21	19.36	16.35
50.3500	67.9346	-29.5294	16.24	20.19	16.77
50.4000	67.5263	-27.8659	16.28	21.12	17.21
50.4500	66.8989	-26.3589	16.31	22.19	17.64
50.5000	66.0501	-24.6333	16.34	23.40	18.08
50.5500	64.9852	-22.8636	16.37	24.84	18.51
50.6000	63.6726	-21.0785	16.40	26.61	18.94
50.6500	62.1866	-19.1235	16.43	28.82	19.35
50.7000	60.4646	-17.0440	16.46	31.70	19.75
50.7500	58.5588	-14.7171	16.49	35.42	20.09
50.8000	56.5996	-12.2329	16.51	38.22	20.38
50.8500	54.4154	-9.5302	16.54	35.33	20.60
50.9000	52.1737	-6.5204	16.56	31.39	20.73
50.9500	49.8397	-3.3694	16.58	28.32	20.75
51.0000	47.4451	0.1557	16.60	25.91	20.65
51.0500	45.0125	3.9715	16.62	23.96	20.44
51.1000	42.5810	7.9042	16.64	22.31	20.10
51.1500	40.2205	12.1485	16.65	20.89	19.63
51.2000	37.9117	16.6135	16.67	19.65	19.09
51.2500	35.6797	21.3996	16.67	18.51	18.45
51.3000	33.5418	26.2847	16.68	17.49	17.49
51.3500	31.4949	31.4293	16.67	16.54	16.54
51.4000	29.5761	36.7899	16.66	15.66	15.66
51.4500	27.7699	42.2800	16.64	14.83	14.83
51.5000	26.0683	47.9878	16.61	14.04	14.04
51.5500	24.5741	53.8497	16.57	13.31	13.31
51.6000	23.1765	59.7800	16.51	12.60	12.60
51.6500	21.9182	65.8694	16.43	11.91	11.91
51.7000	20.8504	72.0473	16.34	11.27	11.27
51.7500	19.8926	78.3961	16.22	10.64	10.64
51.8000	19.0931	84.8523	16.07	10.02	9.91
51.8500	18.4294	91.3471	15.90	9.42	9.13

```
  51.9000   17.9087   98.0300 15.69 8.83 8.34
  51.9500   17.5478  104.6970 15.45 8.26 7.56
  52.0000   17.3178  111.4405 15.17 7.70 6.79
  52.0500   17.2511  118.2478 14.87 7.16 6.04
  52.1000   17.2828  125.1334 14.53 6.61 5.28
  52.1500   17.4223  132.0388 14.16 6.07 4.54
  52.2000   17.7190  139.0351 13.76 5.54 3.81];
%
% 6 MTR 4 EL MONO BAND QUAD DATA INPUT MATRIX FOLLOWS
z6b1=[49.0000   55.2511 -121.9044 14.07 3.21 3.21
  49.0500   55.5902 -118.5970 14.18 3.43 3.43
  49.1000   55.9751 -115.2688 14.28 3.64 3.64
  49.1500   56.3772 -112.0136 14.39 3.87 3.87
  49.2000   56.8154 -108.7865 14.49 4.10 4.10
  49.2500   57.2678 -105.5002 14.59 4.33 4.33
  49.3000   57.7568 -102.3529 14.69 4.58 4.58
  49.3500   58.2627  -99.2419 14.78 4.83 4.83
  49.4000   58.7813  -96.0378 14.88 5.10 5.10
  49.4500   59.3157  -92.9682 14.97 5.37 5.37
  49.5000   59.8654  -89.8872 15.06 5.65 5.65
  49.5500   60.4166  -87.0234 15.14 5.93 5.93
  49.6000   60.9703  -84.0464 15.23 6.23 6.23
  49.6500   61.5289  -81.1123 15.31 6.54 6.54
  49.7000   62.0704  -78.4050 15.39 6.85 6.85
  49.7500   62.5934  -75.5544 15.46 7.19 7.19
  49.8000   63.0875  -72.9048 15.54 7.53 7.53
  49.8500   63.5101  -70.3274 15.61 7.88 7.88
  49.9000   63.9366  -67.6485 15.68 8.26 8.26
  49.9500   64.2616  -65.1793 15.74 8.64 8.64
  50.0000   64.5772  -62.6209 15.81 9.05 9.05
  50.0500   64.7646  -60.3159 15.87 9.46 9.46
  50.1000   64.9036  -57.8787 15.93 9.91 9.91
  50.1500   64.8962  -55.4799 15.99 10.37 10.37
  50.2000   64.8125  -53.2660 16.05 10.87 10.87
  50.2500   64.6226  -50.8772 16.11 11.38 11.38
  50.3000   64.2596  -48.5902 16.16 11.94 11.94
  50.3500   63.8055  -46.2329 16.22 12.53 12.53
  50.4000   63.2321  -43.8942 16.27 13.16 13.16
  50.4500   62.5001  -41.5445 16.32 13.84 13.84
  50.5000   61.6569  -39.0043 16.37 14.57 14.57
  50.5500   60.6493  -36.5712 16.43 15.38 15.38
  50.6000   59.5185  -33.9073 16.48 16.26 16.01
  50.6500   58.2731  -31.0688 16.53 17.23 16.77
  50.7000   56.8462  -28.2003 16.58 18.33 17.53
  50.7500   55.3663  -25.1715 16.63 19.53 18.29
  50.8000   53.8003  -22.0147 16.68 20.85 19.05
```

```
   50.8500   52.1021  -18.5756 16.73 22.30 19.81
   50.9000   50.3537  -15.0405 16.78 23.69 20.55
   50.9500   48.5615  -11.2934 16.83 24.71 21.29
   51.0000   46.7325   -7.2523 16.87 24.93 21.99
   51.0500   44.8293   -3.0256 16.92 24.09 22.67
   51.1000   42.9425    1.3397 16.96 22.62 22.62
   51.1500   41.1452    6.0722 16.99 20.97 20.97
   51.2000   39.3154   10.9252 17.02 19.35 19.35
   51.2500   37.5815   15.9982 17.05 17.88 17.88
   51.3000   35.9217   21.3257 17.06 16.51 16.51
   51.3500   34.3047   26.9094 17.06 15.27 15.27
   51.4000   32.8518   32.6756 17.05 14.11 14.11
   51.4500   31.4521   38.6467 17.03 13.05 13.05
   51.5000   30.2626   44.9259 16.98 12.05 12.05
   51.5500   29.1705   51.2922 16.91 11.12 11.12
   51.6000   28.2626   57.8616 16.81 10.23 10.23
   51.6500   27.5780   64.6568 16.68 9.40 9.40
   51.7000   27.0443   71.5610 16.52 8.59 8.59
   51.7500   26.7539   78.6951 16.32 7.83 7.83
   51.8000   26.6412   85.9464 16.08 7.08 7.08
   51.8500   26.7984   93.3289 15.80 6.38 6.38
   51.9000   27.1468  100.9406 15.48 5.69 5.69
   51.9500   27.7627  108.5195 15.12 5.02 5.02
   52.0000   28.6521  116.3533 14.73 4.38 4.38
   52.0500   29.7852  124.1284 14.31 3.76 3.76
   52.1000   31.1787  132.1181 13.86 3.16 3.16
   52.1500   32.8528  140.0152 13.40 2.60 2.60
   52.2000   34.8032  147.9809 12.92 2.05 2.05];
%
%
ant4A1=cell(1,2);
ant4A1={z6b6 z6b1};
ant4A=cell(1,2);
for i=1:2
   ant1=ant4A1{i};
   f=ant1(:,1);
   ff=(min(f):.001:max(f))';
   ant2=zeros(length(ff),6);
   ant2(:,1)=ff;
   for k=2:6
      m=ant1(:,k);
      ant2(:,k)=spline(f,m,ff);
   end
   ant4A{i}=ant2;
   end
%
```

```
% Format of ant4A cell matrices is
% Column 1= Frequency in MHZ in .001 Mhz steps
% Column 2=Real part of driving point impedance in Ohms
% Column 3=Imaginary part of driving point impedance in Ohms
% Column 4=Gain in dBi
% Column 5=FB in dB
% Column 6=FBR in dB where FBR=Front to Back Region gain.
%   The back region is 180+/-90 degrees from the antenna heading.
%
```

The listing of MATLAB program quadmod89.m which created the 6 Meter six element quad wire table for export to EZNEC 4.0 follows:

```
% M-file quadmod89.m
% MATLAB program designed to create an exportable wire table for the EZNEC or
EZNEC-PRO
%   antenna modeling programs for any mono band or multi band
%   multi element Cubical Quad antenna in either the diamond or square loop
%   shape configuration.
%
% A note for radio amateurs not familiar with the MATLAB programming
% language follows. MATLAB is a powerful high level scientific programming
% language commonly used by college students and professional engineers.
% The student version of MATLAB can be downloaded from the Mathworks web
% site for $100. The professional version of MATLAB currently costs $1900.
% Both PC and MAC versions are available.
%
% Written by Bob Hume KG6B on 12/9/2003  (310) 376-4192 (H) 814-7557 (W)
%  e-mail: rwhume@adelphia.net
% Final EZNEC export file wire end locations and sizes are in meter units
%      with zero antenna height (i.e at center point of quad loops)
% Export wire file includes the number of EZNEC segments used to model
%      each wire.
% See detailed instructions on how export the quad wire table file generated
%      by this program to EZNEC at the end of this program listing.
%
%square=1; % Activate this line (remove leading %) for a square quad loop
configuration.
%          EZNEC should use a source at the middle of wire #5 for the
%          driven band.
square=0; % Activate this line for a diamond quad loop configuration.
%          EZNEC should use a split SI source at the 0% end of wire #5
%          for the driven band.
% Select all bands common bare copper wire diameter in feet "dia"
%      on following line(s).
%      Note that EZNEC 3.0 can not properly model wire with a thick layer of
%      insulation. Enamel covered magnet wire can be properly modeled
%      since the insulation layer is very thin.
%dia=.06408/12; % #14 wire diameter in feet
dia=.08081/12; % #12 wire diameter in feet (new wire gauge selected for 2004 design)
%dia=.09074/12; % #11 wire diameter in feet (actual 1989 wire gauge)
%
% Select Meter bands in quad on next line(s) that define matrix "bandset"
%bandset=[20 17 15 12 10]'; % MTR bands in quad. Choose one or all of the 20, 17,
%       15, 12, 10, or 6 MTR bands in any order except that the first band listed is
%       the driven band for which the antenna is evaluated. Consider the 500 wire
```

```
%       segment limit of EZNEC 3.0 ($100 cost) when choosing the number of bands and
%       elements in the quads. The driven band uses "segsA" segments per wire. The
%       non driven bands use "segsB" segments per wire. There are four wires per
%       quad loop. EZNEC may give a warning using 5 segments per wire but
%       this is OK since the currents in the non driven band element wires are
%       small. (Or use EZNEC 4.0 version with 1,500 wire
%       segment modeling limit).
segsA=9; % Segments per wire for driven band Quad wires (use odd integer)
segsB=7; % Segments per wire for non driven band Quad wires (use odd integer)
%
% Remove leading % on one of the below lines to activate and select a quad antenna
%       design option
%bandset=[20]'; % Mono band option 20
%bandset=[17]'; % Mono band option 17
%bandset=[15]'; % Mono band option 15
%bandset=[12]'; % Mono band option 12
%bandset=[10]'; % Mono band option 10
%bandset=[6]';  % Mono band option 6
%
%bandset=[20 15 10]'; % Tri band option 20 driven
%bandset=[15 10 20]'; % Tri band option 15 driven
%bandset=[10 20 15]'; % Tri band option 10 driven
%
%bandset=[20 17 15 12 10]';  % Five band option 20 driven
%bandset=[17 15 12 10 20]';  % Five band option 17 driven
%bandset=[15 12 10 20 17]';  % Five band option 15 driven
%bandset=[12 10 20 17 15]';  % Five band option 12 driven
%bandset=[10 20 17 15 12]';  % Five band option 10 driven
%
%bandset=[20 17 15 12 10 6]'; %  Six band option 20 driven
%bandset=[17 15 12 10 6 20]'; %  Six band option 17 driven
%bandset=[15 12 10 6 20 17]'; %  Six band option 15 driven
%bandset=[12 10 6 20 17 15]'; %  Six band option 12 driven
%bandset=[10 6 20 17 15 12]'; %  Six band option 10 driven
bandset=[6 20 17 15 12 10]'; %  Six band option 6 driven
%
%
NRbands=length(bandset);
wnr=zeros(NRbands,7);
wnr(:,1)=bandset;
nt=0;
segtotal=0;
%
disp(' ')
if square==1
```

```
   disp('MONO OR MULTI BAND CUBICAL QUAD DESIGN CONSTANTS @ 
SQUARE ELEMENT SHAPES')
else
   disp('MONO OR MULTI BAND CUBICAL QUAD DESIGN CONSTANTS @ 
DIAMOND ELEMENT SHAPES')
end
disp(' ')
disp('FIRST BAND LISTED IS THE DRIVEN BAND. "DE" STANDS FOR DRIVEN 
ELEMENT')
disp('DATA ELEMENT ORDER IS REF, DE, DIR1, DIR2, ...DIRn')
for bandNR=1:NRbands % Band case loop
MTRband=bandset(bandNR); % Selected MTR band in loop
%
% MODEL THE QUAD DESIGN CONSTANTS FOR EACH BAND ON THE 
FOLLOWING LINES.
%   THE PROGRAM QUAD MODEL ASSUMES THAT ONE REFLECTOR PER 
BAND IS USED.
%   ONLY QUAD METER BANDS USED IN THE MATRIX "bandset" NEED BE 
MODELED
if MTRband==20
% 20 MTR Quad design constants follow
k=997.6767; % Driven Element (DE) Length*Frequency Design Product in FT*MHZ 
units
f=14.15;    % DE Design Frequency in Mhz
if bandNR==1
   segs=segsA; % segs=EZNEC segments per wire. segs must be odd for square quad 
loops
else
   segs=segsB;
end
elper=[2.976 0 -1.704 -1.725]'; % Percent change from driven element (DE) size for
%                             each element.
%                             Order: REF, DE, DIR1, DIR2, ...DIRn etc
elspace=[0 10 20 30]'; % Element locations along boom in ft (@ Reflector=0)
%                      Order: REF, DE, DIR1, DIR2, ...DIRn etc
disp(' ')
disp('20 MTR QUAD DESIGN CONSTANTS')
end
%
%
if MTRband==17
% 17 MTR Quad design constants follow
k=987.6525; % DE Length*Frequency Design Product in FT*MHZ units
f=18.11;  % DE Design Frequency in Mhz
if bandNR==1
   segs=segsA; % segs=EZNEC segments per wire
```

```
else
   segs=segsB;
end
elper=[3 0 -1.75 -1.75]'; % Percent change from driven element (DE) size for
%                          each element.
%                          Order: REF, DE, DIR1, DIR2, ...DIRn etc
elspace=[0 10 20 30]'; % Element locations along boom in ft (@ Reflector=0)
%                              Order: REF, DE, DIR1, DIR2
disp(' ')
disp('17 MTR QUAD DESIGN CONSTANTS')
end
%
%
if MTRband==15
% 15 MTR Quad design constants follow
k=996.9452; % DE Length*Frequency Design Product in FT*MHZ units
f=21.2;  %  DE Design Frequency in Mhz
if bandNR==1
   segs=segsA; % segs=EZNEC segments per wire
else
   segs=segsB;
end
elper=[3.071 0 -1.848 -1.770]'; % Percent change from driven element (DE) size for
%                          each element.
%                          Order: REF, DE, DIR1, DIR2, ...DIRn etc
elspace=[0 10 20 30]'; % Element locations along boom in ft (@ Reflector=0)
%                              Order: REF, DE, DIR1, DIR2
disp(' ')
disp('15 MTR QUAD DESIGN CONSTANTS')
end
%
%
if MTRband==12
% 12 MTR Quad design constants follow
k=993.935; % DE Length*Frequency Design Product in FT*MHZ units
f=24.93;  % DE Design Frequency in Mhz
if bandNR==1
   segs=segsA; % segs=EZNEC segments per wire
else
   segs=segsB;
end
elper=[3 0 -1.75 -1.75]'; % Percent change from driven element (DE) size for
%                          each element.
%                          Order: REF, DE, DIR1, DIR2, ...DIRn etc
elspace=[0 10 20 30]'; % Element locations along boom in ft (@ Reflector=0)
%                              Order: REF, DE, DIR1, DIR2
```

```
disp(' ')
disp('12 MTR QUAD DESIGN CONSTANTS')
end
%
%
if MTRband==10
% 10MTR Quad design constants follow
k=997.528; % DE Length*Frequency Design Product in FT*MHZ units
f=28.45;  % DE Design Frequency in Mhz
if bandNR==1
   segs=segsA; % segs=EZNEC segments per wire
else
   segs=segsB;
end
elper=[3.014 0 -2.066 -1.744 -1.723]'; % Percent change from driven element (DE) size
for
%                          each element.
%                          Order: REF, DE, DIR1, DIR2, ...DIRn etc
elspace=[0 5 10 20 30]'; % Element locations along boom in ft (@ Reflector=0)
%                               Order: REF, DE, DIR1, DIR2, DIR3
disp(' ')
disp('10 MTR QUAD DESIGN CONSTANTS')
end
%
%
if MTRband==6
% 6 MTR Quad design constants follow
%k=1015.204 % For 6 Mtr mono bander max gain and FB
k=1011.238; % For 6 Mtr six bander max gain and FB
f=51.0;  % DE Design Frequency in Mhz for max gain and FB
if bandNR==1
   segs=segsA; % segs=EZNEC segments per wire
else
   segs=segsB;
end
elper=[3.0 0 -1.9 -1.7]'; % Percent change from driven element (DE) size for
%                          each element.
%                          Order: REF, DE, DIR1, DIR2, ...DIRn etc
elspace=[16 20 25 30]'; % @ Reflector at 16 ft point on boom
disp(' ')
disp('6 MTR QUAD DESIGN CONSTANTS')
end
%
%
disp(['DE LENGTH CONSTANTS:   k=',num2str(k),'   f=',num2str(f),'   DE in
FT=',num2str(k/f)])
```

```
disp(['ELEMENT LENGTHS AS A % FROM DE=',num2str(elper')])
disp(['ELEMENT BOOM LOCATIONS IN FT=',num2str(elspace')])
disp(['SEGMENTS PER WIRE=',num2str(segs)])
%
elcirc=(k/f)*(1+elper/100); % Element total length (i.e. of all four sides) matrix in ft
elarm=elcirc/(4*sqrt(2)); % Diamond Quad arm length matrix in ft
%
n=length(elper); % Number of elements in Quad
A=zeros(4*n,8); % Blank EZNEC wire table. Column 8 for number of segments per wire
%
if square==0 % Diamond quad loop configuration
for i=1:n % Quad element number index i
   s=elspace(i,1);
   a=elarm(i,1);
   m=[s 0 -a s a 0 dia segs; % Wire coordinates matrix for diamond Quad element i
      s a 0 s 0 a dia segs;
      s 0 a s -a 0 dia segs;
      s -a 0 s 0 -a dia segs];
   A(4*(i-1)+1:4*(i-1)+4,:)=m;  % Wire coordinate accumulation for all n Quad elements
end
end
%
if square==1 % Square quad loop configuration
for i=1:n % Quad element number index i
   s=elspace(i,1);
   c=elarm(i,1)/sqrt(2); % Half side dimension of loop
   m=[s -c -c s c -c dia segs; % Wire coordinates matrix for square Quad element i
      s c -c s c c dia segs;
      s c c s -c c dia segs;
      s -c c s -c -c dia segs];
   A(4*(i-1)+1:4*(i-1)+4,:)=m;  % Wire coordinate accumulation for all n Quad elements
end
end
%
A(:,1:7)=(12*2.54/100)*A(:,1:7); % Convert wire dimensions from Feet to Meters
%
nt=nt+length(A);
segtotal=segtotal+segs*length(A);
wnr(bandNR,2)=length(A);
wnr(bandNR,3)=segs;
wnr(bandNR,4)=nt;
wnr(bandNR,5)=segtotal;
wnr(bandNR,6)=nt-length(A)+5;
wnr(bandNR,7)=nt-length(A)+8;
%
if bandNR==1
```

```
   B=A;
else
   Bold=B;
   nB=length(Bold);
   nA=length(A);
   B=zeros((nB+nA),8);
   B(1:nB,:)=Bold;
   B((nB+1):(nB+nA),:)=A;
end
end % End of bands loop
%
qall=B; % EZNEC wire table matrix for use in other MATLAB programs.
% The next three lines of MATLAB code create an ASCII text file for
%  wire table file "qall" which is compatible with the EZNEC wire
%  table import file requirements.
fid = fopen('qallw','wt'); % Open and write to ASCII text file qallw
fprintf(fid,'%f %f %f %f %f %f %f %f\n',B'); % ASCII text file of B
fclose(fid); % close file
%
if square==1
disp(' ')
disp('              SEGS       TOTAL  DRIVEN ELEMENT WIRE NUMBER')
disp('   MTR   BAND   PER  TOTAL #WIRE  MIDDLE OR 50% POINT IN WIRE')
disp('   BAND  WIRES  WIRE WIRES SEGS   DE#')
disp([wnr(:,1:6)])
disp(' ')
   disp('For the square quad loop configuration EZNEC must use a single source')
   disp('  at the center (50%) of wire number 5')
else
disp(' ')
disp('              SEGS       TOTAL  DRIVEN ELEMENT WIRE NUMBERS')
disp('   MTR   BAND   PER  TOTAL #WIRE   0%   100%')
disp('   BAND  WIRES  WIRE WIRES SEGS   DEa#  DEb#')
disp([wnr])
disp(' ')
   disp('For the diamond quad loop configuration EZNEC must use a split SI source')
   disp('  at wire number 5 (0% end)')
end
disp(' ')
disp('The above table also lists the driven element wire number(s) for the non driven')
disp('  bands in case impedance termination effects are to be modeled in EZNEC')
disp(' ')
disp('EZNEC 4.0 can work with up to 1500 wire segments (SEGS) total')
disp('EZNEC-M Pro version can work with up to 10,000 wire segments total')
disp(' ')
disp(' ')
```

```
disp('EZNEC wire table output in Meter units with zero antenna height follows')
type qallw % EZNEC Wire table file in export compatible ASCII text file form
%
% To export the ASCII wire table file "qallw" to EZNEC follow these steps.
% 1.) Run program quadmod89.m in the MATLAB work space to create file "qallw"
% 2.) Open EZNEC
% 3.) Click on the "WIRES" tab
% 4.) Click on the "Other" button
% 5.) Select "Import Wires From ASCII File"
% 6.) Select "Replace Existing Wires"
% 7.) Locate file "qallw" on the path C:\MARLAB6p5\work\qallw
% 8.) Double click file "qallw"
% 9.) Click "Other" button
% 10.) Click "Change units"
% 11.) Select feet and click OK
% 12.) Click "Wire"
% 13.) Select "Change Height by ..."
% 14.) Enter antenna height in feet and click OK
% 15.) In EZNEC window click the "Ground Type" tab
% 16.) Select real or perfect ground option and click OK
% 17.) In EZNEC window click the "Sources tab"
% 18.) Enter the source as follows for the square or diamond loop
%      For square quad loops EZNEC should use a source at the middle of wire #5
%      For diamond quad loops EZNEC should use a split SI source at the
%           0% end of wire #5
%      The source only needs to be set up one time for all "bandset" case
%      runs
% The above steps 1 to 17 can be performed in about a minute for each
%   "bandset" case. The program thereby makes it possible to evaluate large
%   multiband multielement quad arrays very quickly using EZNEC. Manual
%   wire table entry errors and tedium are avoided using this program.
%
% Also see MATLAB programs zcon.m and quadk1.m which use the EZNEC
%  antenna impedance versus frequency data table output "LastZ.txt"
%  obtained from an EZNEC SWR plot run
%  to plot SWR versus frequency using a 75 Ohm RG11AU quarter wave Q
%  section match to a RG213U 50 Ohm coaxial feed line.
```

The EZNEC 4.0 antenna model description for the 6 Meter six band quad follows:

EZNEC+ ver. 4.0

6 MTR 5 EL MONO BAND QUAD 04A 8/11/2004 10:15:18 PM

--------------- ANTENNA DESCRIPTION ---------------

Frequency = 51 MHz
Wire Loss: Copper -- Resistivity = 1.74E-08 ohm-m, Rel. Perm. = 1

--------------- WIRES ---------------

No.	End 1 Conn.	End 1 Coord. (ft) X Y Z	End 2 Conn.	End 2 Coord. (ft) X Y Z	Dia (in)	Segs	Insulation Diel C	Insulation Thk(in)
1	W4E2	16, 0,51.3897	W2E1	16,3.61032, 55	.080827	9	1	0
2	W1E2	16,3.61032, 55	W3E1	16, 0,58.6103	.080827	9	1	0
3	W2E2	16, 0,58.6103	W4E1	16,-3.6103, 55	.080827	9	1	0
4	W3E2	16,-3.6103, 55	W1E1	16, 0,51.3897	.080827	9	1	0
5	W8E2	20, 0,51.4948	W6E1	20,3.50516, 55	.080827	9	1	0
6	W5E2	20,3.50516, 55	W7E1	20, 0,58.5052	.080827	9	1	0
7	W6E2	20, 0,58.5052	W8E1	20,-3.5052, 55	.080827	9	1	0
8	W7E2	20,-3.5052, 55	W5E1	20, 0,51.4948	.080827	9	1	0
9	W12E2	25, 0,51.5614	W10E1	25,3.43857, 55	.080827	9	1	0
10	W9E2	25,3.43857, 55	W11E1	25, 0,58.4386	.080827	9	1	0
11	W10E2	25, 0,58.4386	W12E1	25,-3.4386, 55	.080827	9	1	0
12	W11E2	25,-3.4386, 55	W9E1	25, 0,51.5614	.080827	9	1	0
13	W16E2	30, 0,51.5544	W14E1	30,3.44557, 55	.080827	9	1	0
14	W13E2	30,3.44557, 55	W15E1	30, 0,58.4456	.080827	9	1	0
15	W14E2	30, 0,58.4456	W16E1	30,-3.4456, 55	.080827	9	1	0
16	W15E2	30,-3.4456, 55	W13E1	30, 0,51.5544	.080827	9	1	0
17	W20E2	0, 0, 42.165	W18E1	0, 12.835, 55	.080827	7	1	0
18	W17E2	0, 12.835, 55	W19E1	0, 0, 67.835	.080827	7	1	0
19	W18E2	0, 0, 67.835	W20E1	0,-12.835, 55	.080827	7	1	0
20	W19E2	0,-12.835, 55	W17E1	0, 0, 42.165	.080827	7	1	0
21	W24E2	10, 0, 42.536	W22E1	10, 12.464, 55	.080827	7	1	0
22	W21E2	10, 12.464, 55	W23E1	10, 0, 67.464	.080827	7	1	0
23	W22E2	10, 0, 67.464	W24E1	10,-12.464, 55	.080827	7	1	0
24	W23E2	10,-12.464, 55	W21E1	10, 0, 42.536	.080827	7	1	0
25	W28E2	20, 0,42.7484	W26E1	20,12.2516, 55	.080827	7	1	0

26	W25E2	20,12.2516, 55	W27E1	20, 0,67.2516	.080827	7	1	0
27	W26E2	20, 0,67.2516	W28E1	20,-12.252, 55	.080827	7	1	0
28	W27E2	20,-12.252, 55	W25E1	20, 0,42.7484	.080827	7	1	0
29	W32E2	30, 0, 42.751	W30E1	30, 12.249, 55	.080827	7	1	0
30	W29E2	30, 12.249, 55	W31E1	30, 0, 67.249	.080827	7	1	0
31	W30E2	30, 0, 67.249	W32E1	30,-12.249, 55	.080827	7	1	0
32	W31E2	30,-12.249, 55	W29E1	30, 0, 42.751	.080827	7	1	0
33	W36E2	0, 0, 45.07	W34E1	0,9.92997, 55	.080827	7	1	0
34	W33E2	0,9.92997, 55	W35E1	0, 0, 64.93	.080827	7	1	0
35	W34E2	0, 0, 64.93	W36E1	0, -9.93, 55	.080827	7	1	0
36	W35E2	0, -9.93, 55	W33E1	0, 0, 45.07	.080827	7	1	0
37	W40E2	10, 0,45.3593	W38E1	10,9.64075, 55	.080827	7	1	0
38	W37E2	10,9.64075, 55	W39E1	10, 0,64.6407	.080827	7	1	0
39	W38E2	10, 0,64.6407	W40E1	10,-9.6407, 55	.080827	7	1	0
40	W39E2	10,-9.6407, 55	W37E1	10, 0,45.3593	.080827	7	1	0
41	W44E2	20, 0, 45.528	W42E1	20,9.47203, 55	.080827	7	1	0
42	W41E2	20,9.47203, 55	W43E1	20, 0, 64.472	.080827	7	1	0
43	W42E2	20, 0, 64.472	W44E1	20, -9.472, 55	.080827	7	1	0
44	W43E2	20, -9.472, 55	W41E1	20, 0, 45.528	.080827	7	1	0
45	W48E2	30, 0, 45.528	W46E1	30,9.47203, 55	.080827	7	1	0
46	W45E2	30,9.47203, 55	W47E1	30, 0, 64.472	.080827	7	1	0
47	W46E2	30, 0, 64.472	W48E1	30, -9.472, 55	.080827	7	1	0
48	W47E2	30, -9.472, 55	W45E1	30, 0, 45.528	.080827	7	1	0
49	W52E2	0, 0,46.4317	W50E1	0,8.56834, 55	.080827	7	1	0
50	W49E2	0,8.56834, 55	W51E1	0, 0,63.5683	.080827	7	1	0
51	W50E2	0, 0,63.5683	W52E1	0,-8.5683, 55	.080827	7	1	0
52	W51E2	0,-8.5683, 55	W49E1	0, 0,46.4317	.080827	7	1	0
53	W56E2	10, 0,46.6869	W54E1	10,8.31305, 55	.080827	7	1	0
54	W53E2	10,8.31305, 55	W55E1	10, 0, 63.313	.080827	7	1	0
55	W54E2	10, 0, 63.313	W56E1	10,-8.3131, 55	.080827	7	1	0
56	W55E2	10,-8.3131, 55	W53E1	10, 0,46.6869	.080827	7	1	0
57	W60E2	20, 0,46.8406	W58E1	20,8.15943, 55	.080827	7	1	0
58	W57E2	20,8.15943, 55	W59E1	20, 0,63.1594	.080827	7	1	0
59	W58E2	20, 0,63.1594	W60E1	20,-8.1594, 55	.080827	7	1	0
60	W59E2	20,-8.1594, 55	W57E1	20, 0,46.8406	.080827	7	1	0
61	W64E2	30, 0,46.8341	W62E1	30,8.16591, 55	.080827	7	1	0
62	W61E2	30,8.16591, 55	W63E1	30, 0,63.1659	.080827	7	1	0
63	W62E2	30, 0,63.1659	W64E1	30,-8.1659, 55	.080827	7	1	0

64	W63E2	30,-8.1659, 55	W61E1	30, 0,46.8341	.080827	7	1	0
65	W68E2	0, 0,47.7406	W66E1	0,7.25935, 55	.080827	7	1	0
66	W65E2	0,7.25935, 55	W67E1	0, 0,62.2593	.080827	7	1	0
67	W66E2	0, 0,62.2593	W68E1	0,-7.2594, 55	.080827	7	1	0
68	W67E2	0,-7.2594, 55	W65E1	0, 0,47.7406	.080827	7	1	0
69	W72E2	10, 0,47.9521	W70E1	10,7.04792, 55	.080827	7	1	0
70	W69E2	10,7.04792, 55	W71E1	10, 0,62.0479	.080827	7	1	0
71	W70E2	10, 0,62.0479	W72E1	10,-7.0479, 55	.080827	7	1	0
72	W71E2	10,-7.0479, 55	W69E1	10, 0,47.9521	.080827	7	1	0
73	W76E2	20, 0,48.0754	W74E1	20,6.92458, 55	.080827	7	1	0
74	W73E2	20,6.92458, 55	W75E1	20, 0,61.9246	.080827	7	1	0
75	W74E2	20, 0,61.9246	W76E1	20,-6.9246, 55	.080827	7	1	0
76	W75E2	20,-6.9246, 55	W73E1	20, 0,48.0754	.080827	7	1	0
77	W80E2	30, 0,48.0754	W78E1	30,6.92458, 55	.080827	7	1	0
78	W77E2	30,6.92458, 55	W79E1	30, 0,61.9246	.080827	7	1	0
79	W78E2	30, 0,61.9246	W80E1	30,-6.9246, 55	.080827	7	1	0
80	W79E2	30,-6.9246, 55	W77E1	30, 0,48.0754	.080827	7	1	0
81	W84E2	0, 0, 48.615	W82E1	0,6.38505, 55	.080827	7	1	0
82	W81E2	0,6.38505, 55	W83E1	0, 0, 61.385	.080827	7	1	0
83	W82E2	0, 0, 61.385	W84E1	0, -6.385, 55	.080827	7	1	0
84	W83E2	0, -6.385, 55	W81E1	0, 0, 48.615	.080827	7	1	0
85	W88E2	5, 0,48.8018	W86E1	5,6.19823, 55	.080827	7	1	0
86	W85E2	5,6.19823, 55	W87E1	5, 0,61.1982	.080827	7	1	0
87	W86E2	5, 0,61.1982	W88E1	5,-6.1982, 55	.080827	7	1	0
88	W87E2	5,-6.1982, 55	W85E1	5, 0,48.8018	.080827	7	1	0
89	W92E2	10, 0,48.9298	W90E1	10,6.07018, 55	.080827	7	1	0
90	W89E2	10,6.07018, 55	W91E1	10, 0,61.0702	.080827	7	1	0
91	W90E2	10, 0,61.0702	W92E1	10,-6.0702, 55	.080827	7	1	0
92	W91E2	10,-6.0702, 55	W89E1	10, 0,48.9298	.080827	7	1	0
93	W96E2	20, 0,48.9099	W94E1	20,6.09013, 55	.080827	7	1	0
94	W93E2	20,6.09013, 55	W95E1	20, 0,61.0901	.080827	7	1	0
95	W94E2	20, 0,61.0901	W96E1	20,-6.0901, 55	.080827	7	1	0
96	W95E2	20,-6.0901, 55	W93E1	20, 0,48.9099	.080827	7	1	0
97	W100E2	30, 0,48.9086	W98E1	30,6.09144, 55	.080827	7	1	0

98 W97E2 30,6.09144, 55 W99E1 30, 0,61.0914 .080827 7 1
0
99 W98E2 30, 0,61.0914 W100E1 30,-6.0914, 55 .080827 7 1
0
100 W99E2 30,-6.0914, 55 W97E1 30, 0,48.9086 .080827 7 1
0

Total Segments: 732

-------------- SOURCES --------------

No.	Specified Pos. Wire #	% From E1	Actual Pos. % From E1	Seg	Amplitude (V/A)	Phase (deg.)	Type
1	5	0.00	5.56	1	1	0	SI

No loads specified

No transmission lines specified

Ground type is Real, High-Accuracy

--------------- MEDIA ---------------

No.	Cond. (S/m)	Diel. Const.	Height (ft)	R Coord. (ft)
1	0.005	13	0	0