Measurement of Common Mode Chokes fabricated from type 31 material toroid cores

Tod Olson, K0TO August 28, 2011

During the period August 10 through August 28, 2011 I fabricated a series of RF common mode chokes using type 31 material and RG59 coax. I then measured them using the voltage divider measurement method outlined by Jim Brown, K9YC, to determine the magnitude of the choke impedance. No effort was made to determine the complex impedance values.

The chokes were fabricated using 2.4 inch O.D. toroid cores obtained from Fair-Rite. A single toroid was made by bundling cores using glass tape to hold the cores together. To space the turns of RG59 coax used to wind the chokes I fabricated two end piece spacers from plastic. A circle of eight holes, equally spaced, were drilled with a radius of approximately ½ inch. The diameter of each hole was sized to allow RG59 coax to pass through it.

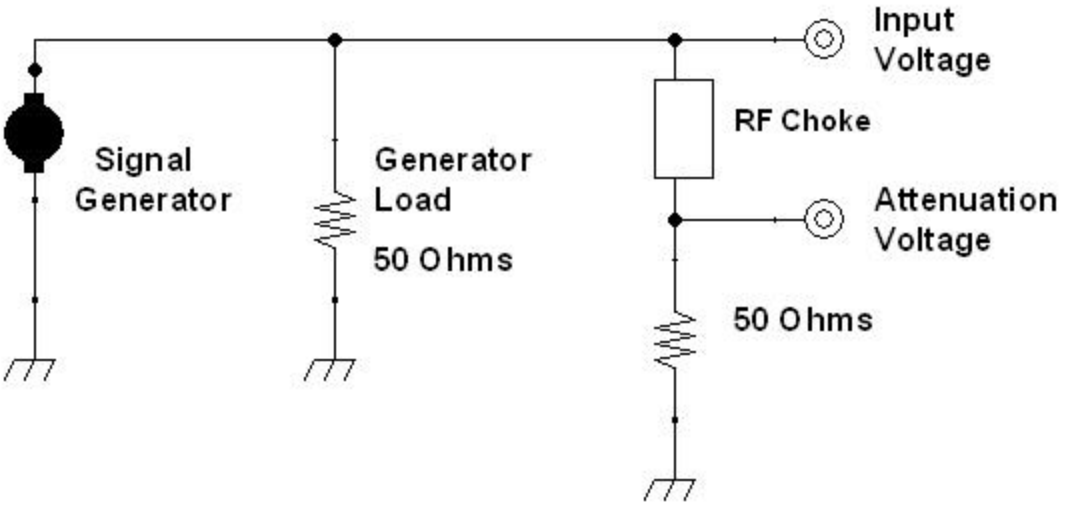
The measurements were made using an HP8640B Signal Generator and an HP 8405A Vector Voltmeter. The Vector Voltmeter was selected because it provided readings in dB which allowed direct determination of the attenuation provided by the choke in the measurement circuit and that in turn could be used to calculate the magnitude of the impedance of the choke. The chokes were held in a jig which incorporated the two Vector Voltmeter probes and the two MiniCircuits standard resistances used in the measurement circuit. Individual chokes were clipped into the circuit with small alligator clips. The measurement circuit diagram is shown at the end of this introduction.

The measurement setup was tested using several ¼ watt resistors to verify the setup and the calculations and to determine if the stray capacity might significantly affect the measurements. Once the measurement protocol had been determined, 18 common mode chokes were fabricated and then measured on the 160, 80,40 20, 15 and 10 meter bands. The results of these measurements are shown in the graphs which follow. Pictures of the measurement equipment, the jig and an assembled common mode choke are shown following the circuit diagram. There are a series of graphs after the pictures which show the results from the measurements. They are arranged by the number of cores used [two, three or four] and then the number of turns wound on the cores [3, 4, 5, 6, 7 or 8]. The bookmarks of this PDF file will allow you to quickly move between sections.

The graphs should provide guidance for persons wishing to fabricate their own common mode choke [or choke baluns] using type 31 cores of this size. The attenuation values are those which apply to the circuit used for the measurement. When the chokes are used in other circuits the attenuation may be different depending upon the other elements of the circuit. The Q of the common mode chokes fabricated from type 31 material is quite low and as a result most of the impedance can be expected to be resistive. I used RG59

because I had a supply and it is similar in size to the RG400U that I use for chokes for my amateur station. The RG400U allows one to use 1.5 KW transmitted power without problems if the SWR values are reasonable [less than 4:1 or so].

Circuit for Measuring Magnitude of Choke Impedance



dB attenuation = 20 log (Attenuation Voltage / Input Voltage)

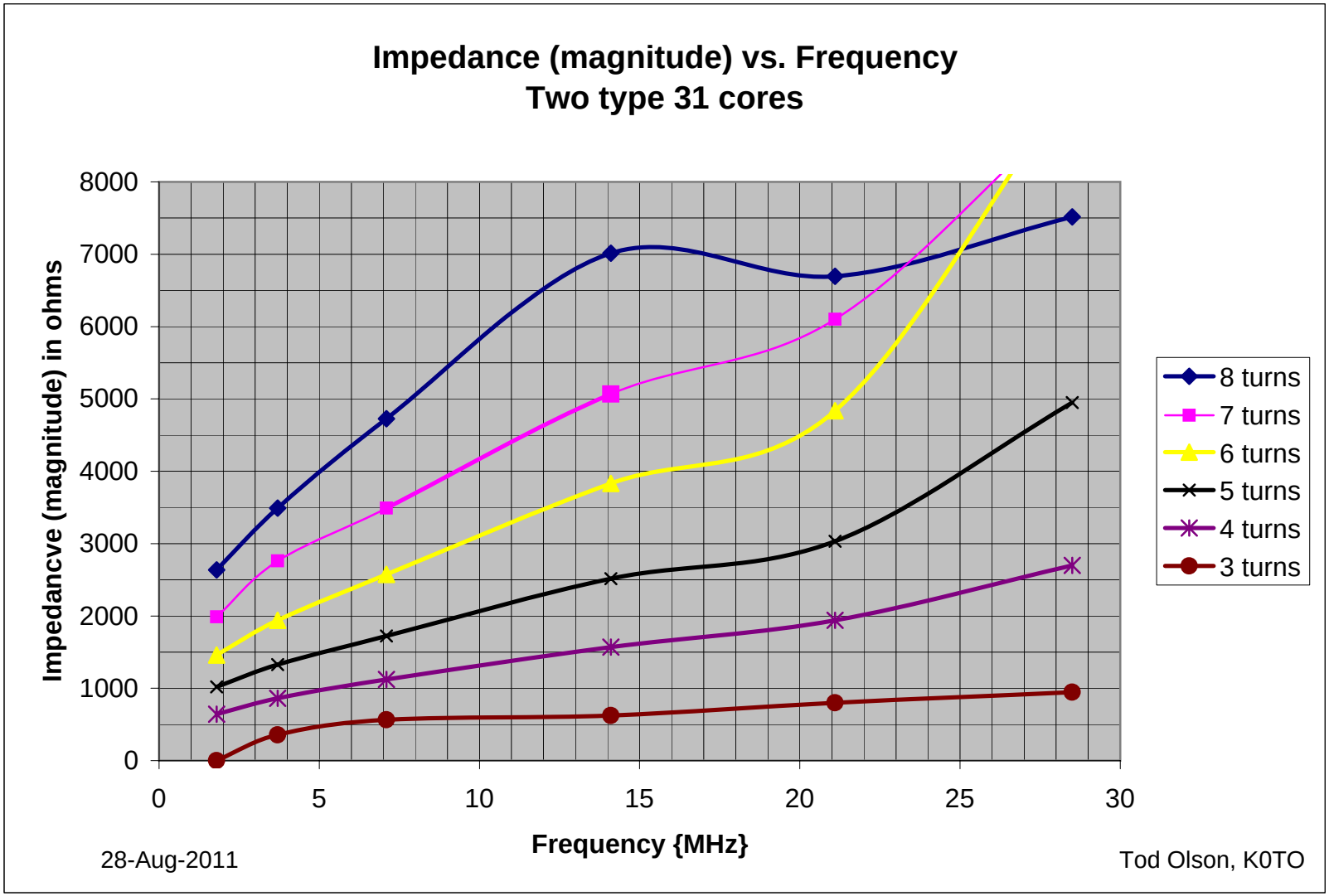
RF Choke Impedance (ohms) = 50 ((Input Voltage / Attenuation Voltage)-1)

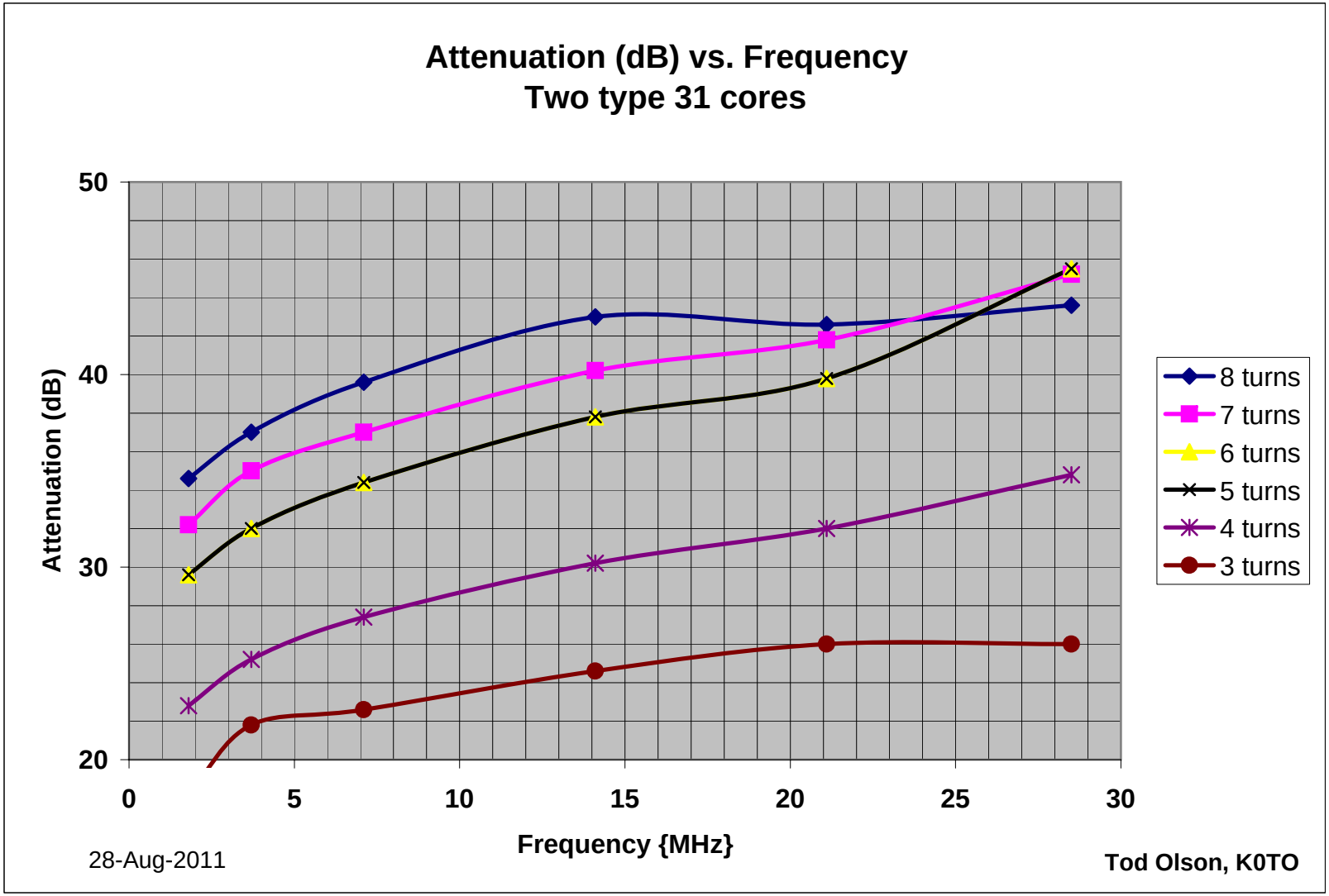

8640B SIGNAL GENERATOR
HEWLETT-PACKARD
COUNTER MODE
FREQUENCY MHz
140453
AM
FM
PEAK DEVIATION
RANGE
MHz
FREQUENCY TUNE
FINE TUNE
OUTPUT LEVEL
8405A VECTOR VOLTMETER
HEWLETT-PACKARD
FREQ RANGE - MHz
APC UNLOCKED
CHECK SIGNAL / FREQ RANGE
RMS VOLTS
DECIBELS
DEGREES
PROBE
LINE
CHANNEL
AMPLITUDE
RANGE
PHASE
METER OFFSET
2011.08.20


BLUE DIAMOND
2011.08.29


2011.08.29


RG-59/U
2011.08.26


Impedance (magnitude) vs. Frequency
Two type 31 cores
Impedancve (magnitude) in ohms
8000
7000
6000
5000
4000
3000
2000
1000
0
0
5
10
15
20
25
30
Frequency {MHz}
8 turns
7 turns
6 turns
5 turns
4 turns
3 turns
28-Aug-2011
Tod Olson, K0TO


Attenuation (dB) vs. Frequency
Two type 31 cores
Attenuation (dB)
50
40
30
20
0
5
10
15
20
25
30
Frequency {MHz}
8 turns
7 turns
6 turns
5 turns
4 turns
3 turns
28-Aug-2011
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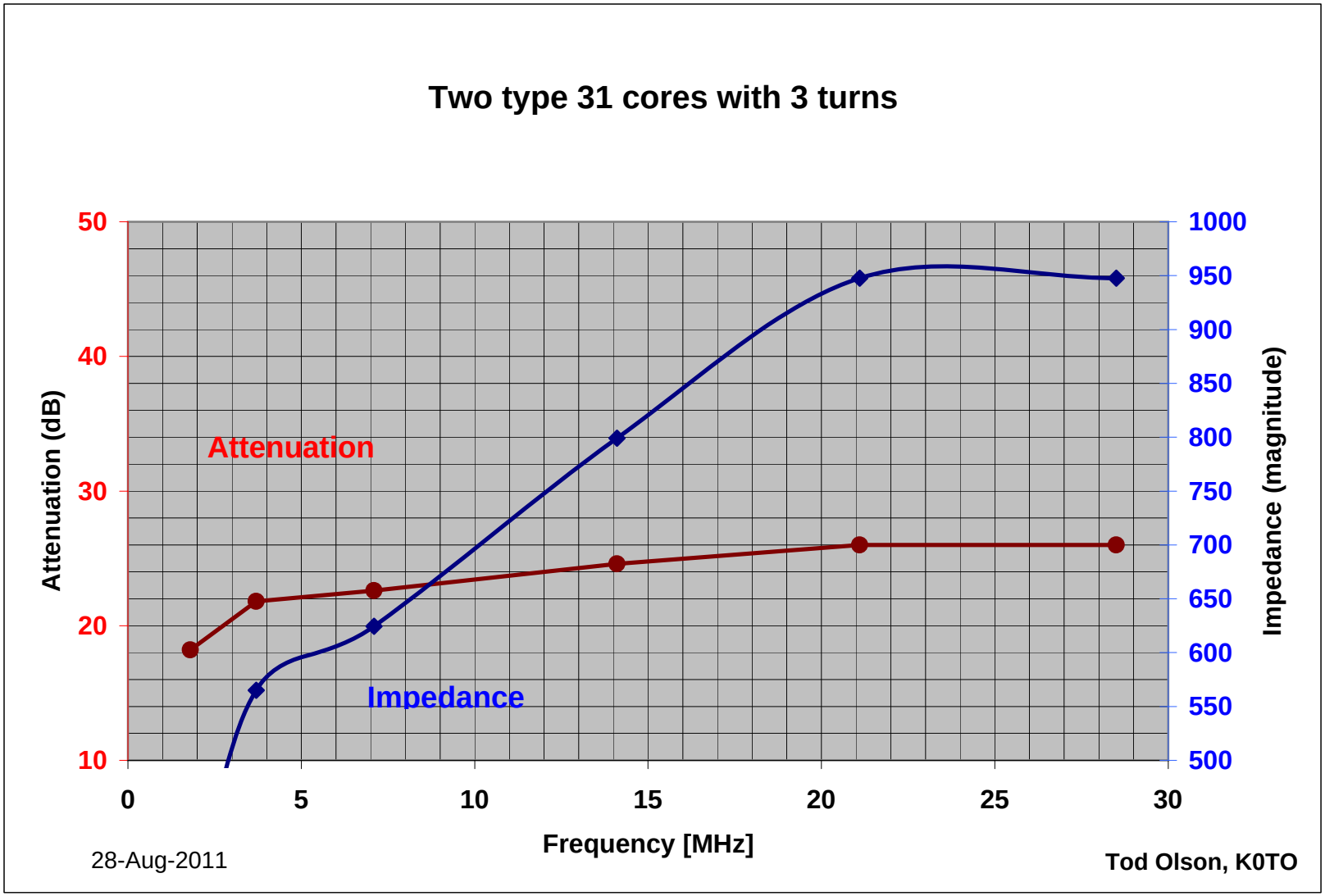
Two type 31 cores with 3 turns
Attenuation (dB)
50
40
30
20
10
Attenuation
Impedance
1000
950
900
850
800
750
700
650
600
550
500
Impedance (magnitude)
0
5
10
15
20
25
30
Frequency [MHz]
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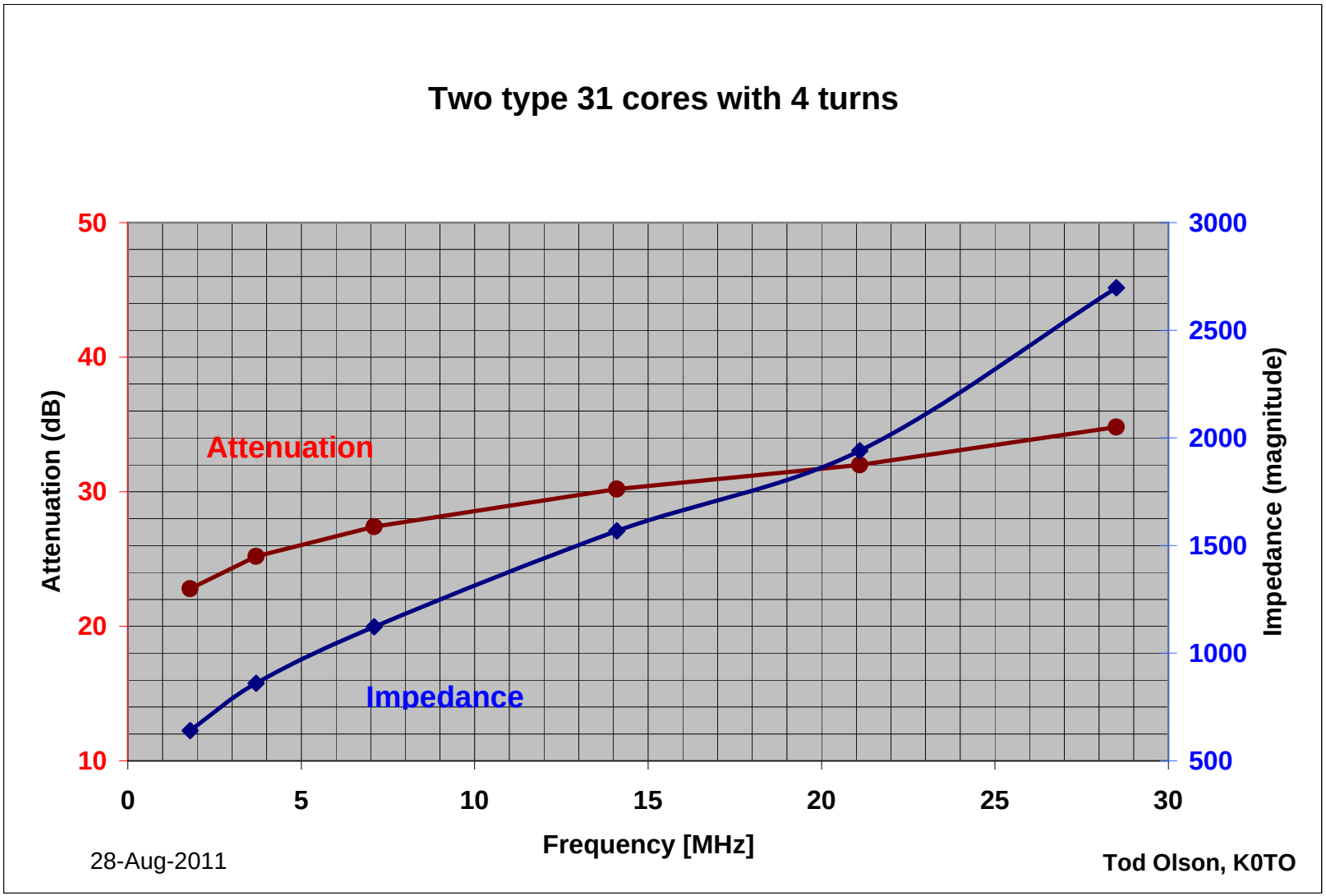
Two type 31 cores with 4 turns
Attenuation (dB)
Impedance (magnitude)
Frequency [MHz]
Attenuation
Impedance
50
40
30
20
10
3000
2500
2000
1500
1000
500
0
5
10
15
20
25
30
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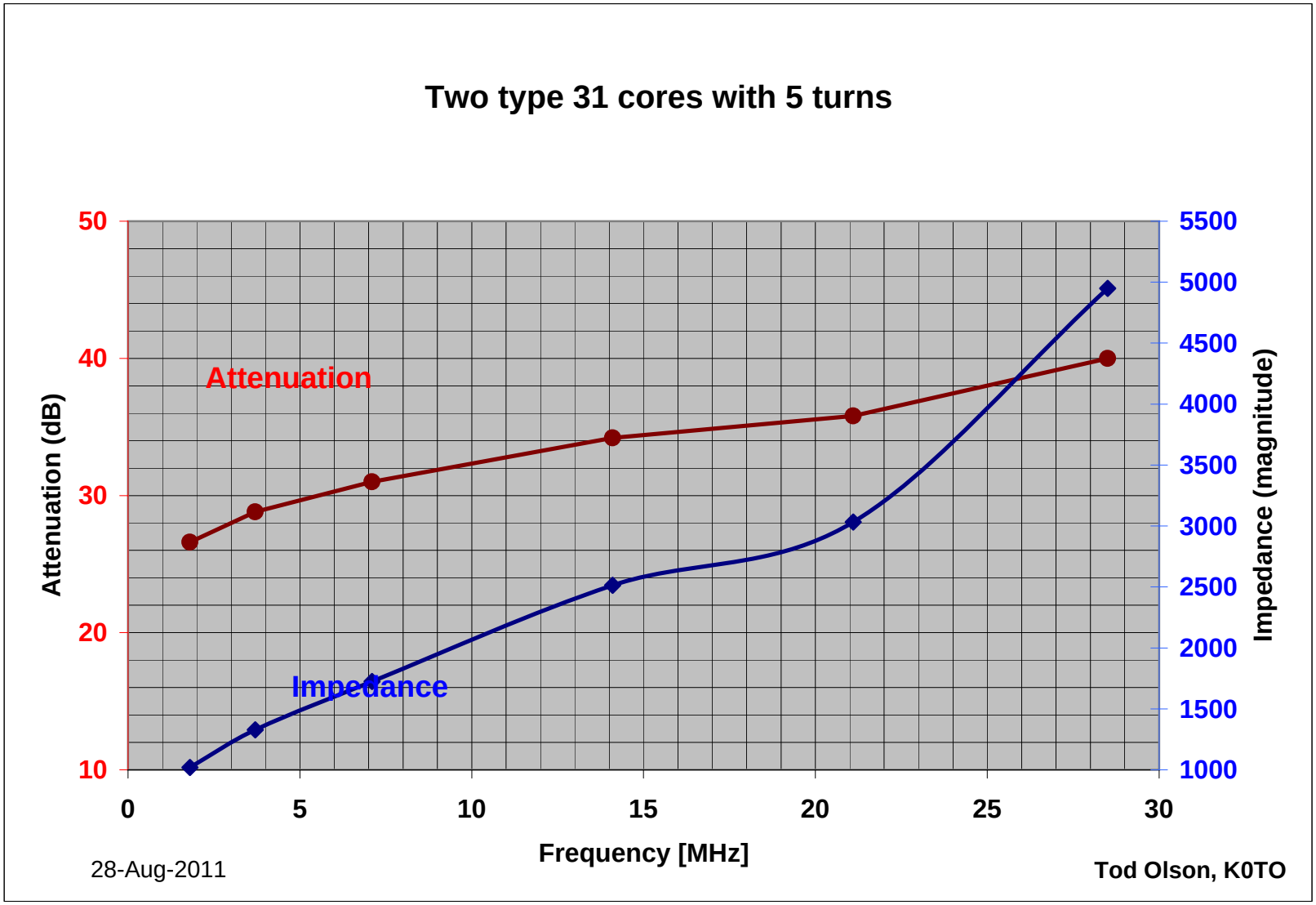
Two type 31 cores with 5 turns
Attenuation
Impedance
Attenuation (dB)
Impedance (magnitude)
Frequency [MHz]
50
40
30
20
10
5500
5000
4500
4000
3500
3000
2500
2000
1500
1000
0
5
10
15
20
25
30
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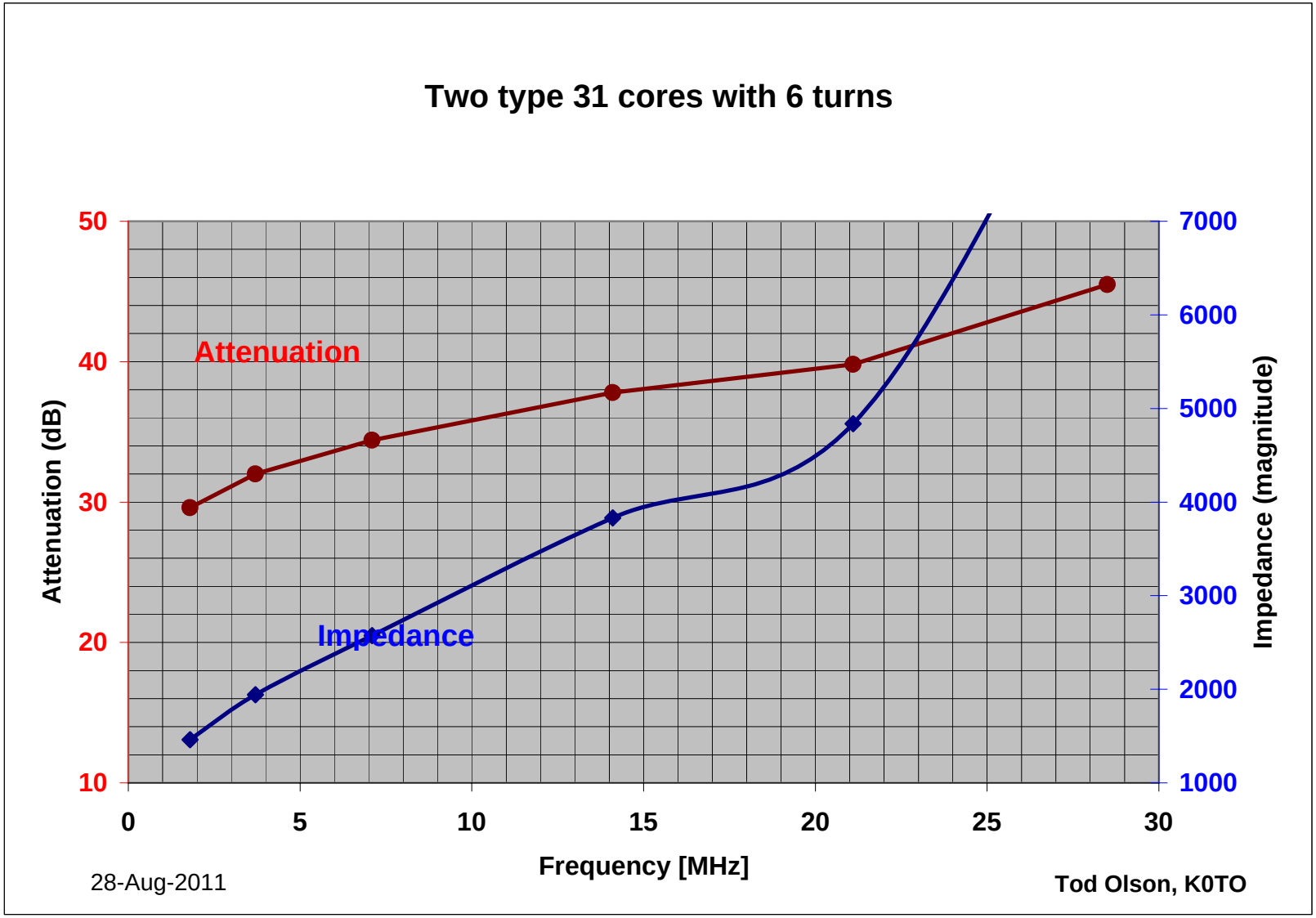
Two type 31 cores with 6 turns
Attenuation
Impedance
Attenuation (dB)
Impedance (magnitude)
Frequency [MHz]
50
40
30
20
10
7000
6000
5000
4000
3000
2000
1000
0
5
10
15
20
25
30
28-Aug-2011
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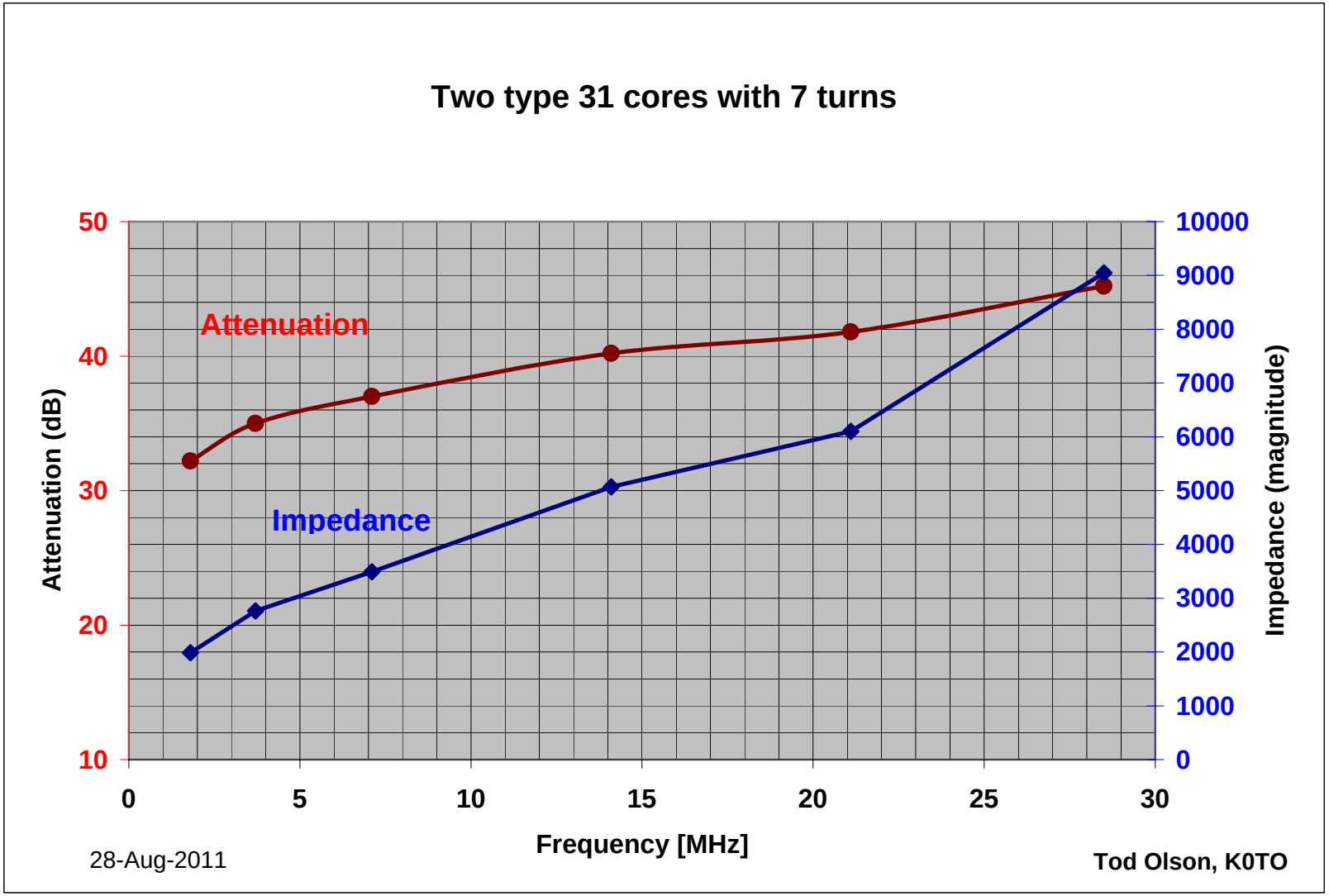
Two type 31 cores with 7 turns
Attenuation
Impedance
Attenuation (dB)
Impedance (magnitude)
Frequency [MHz]
50
40
30
20
10
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
0
5
10
15
20
25
30
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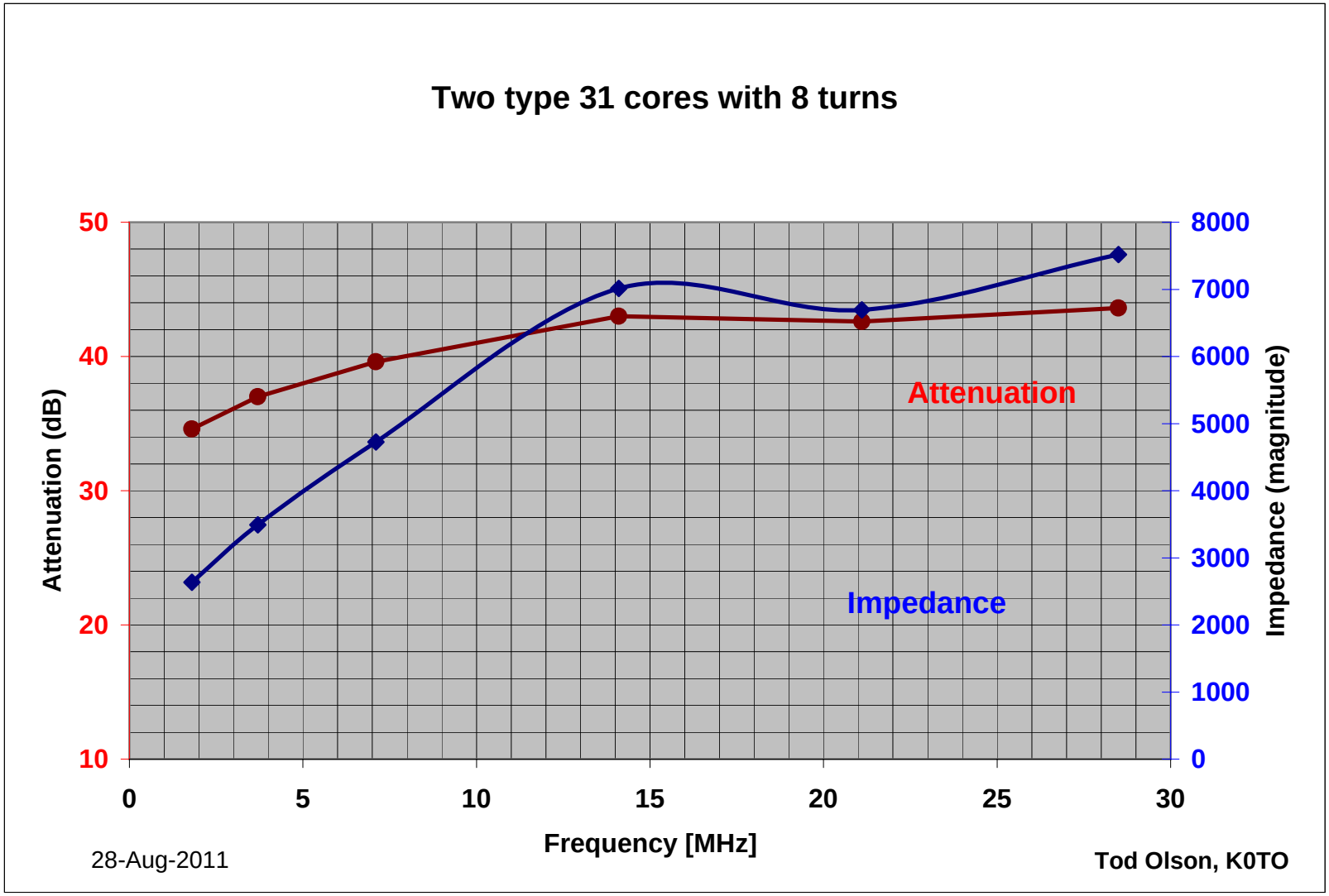
Two type 31 cores with 8 turns
50
40
30
20
10
Attenuation (dB)
8000
7000
6000
5000
4000
3000
2000
1000
0
Impedance (magnitude)
Attenuation
Impedance
0
5
10
15
20
25
30
Frequency [MHz]
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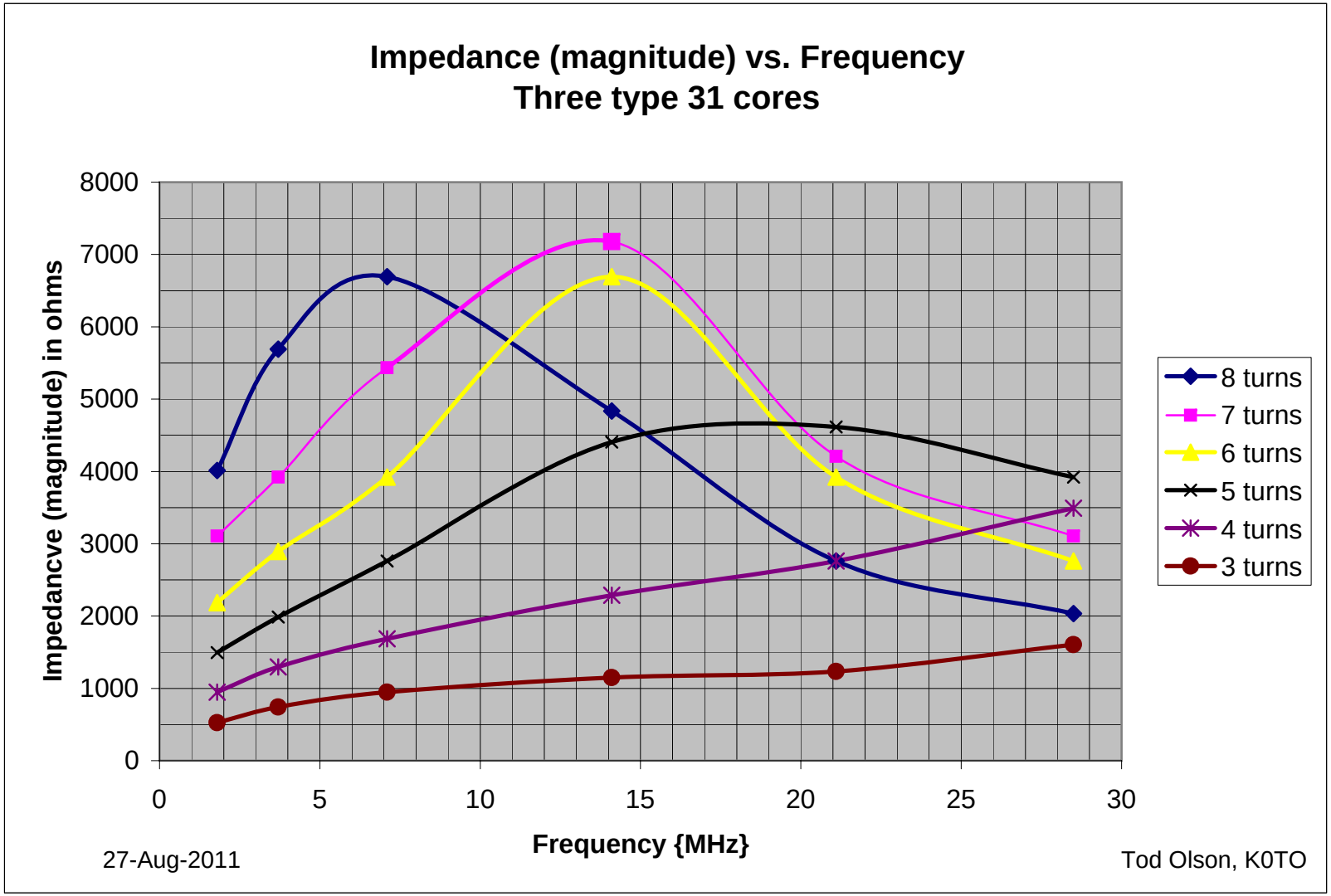
Impedance (magnitude) vs. Frequency
Three type 31 cores
Impedancve (magnitude) in ohms
8000
7000
6000
5000
4000
3000
2000
1000
0
0
5
10
15
20
25
30
Frequency {MHz}
8 turns
7 turns
6 turns
5 turns
4 turns
3 turns
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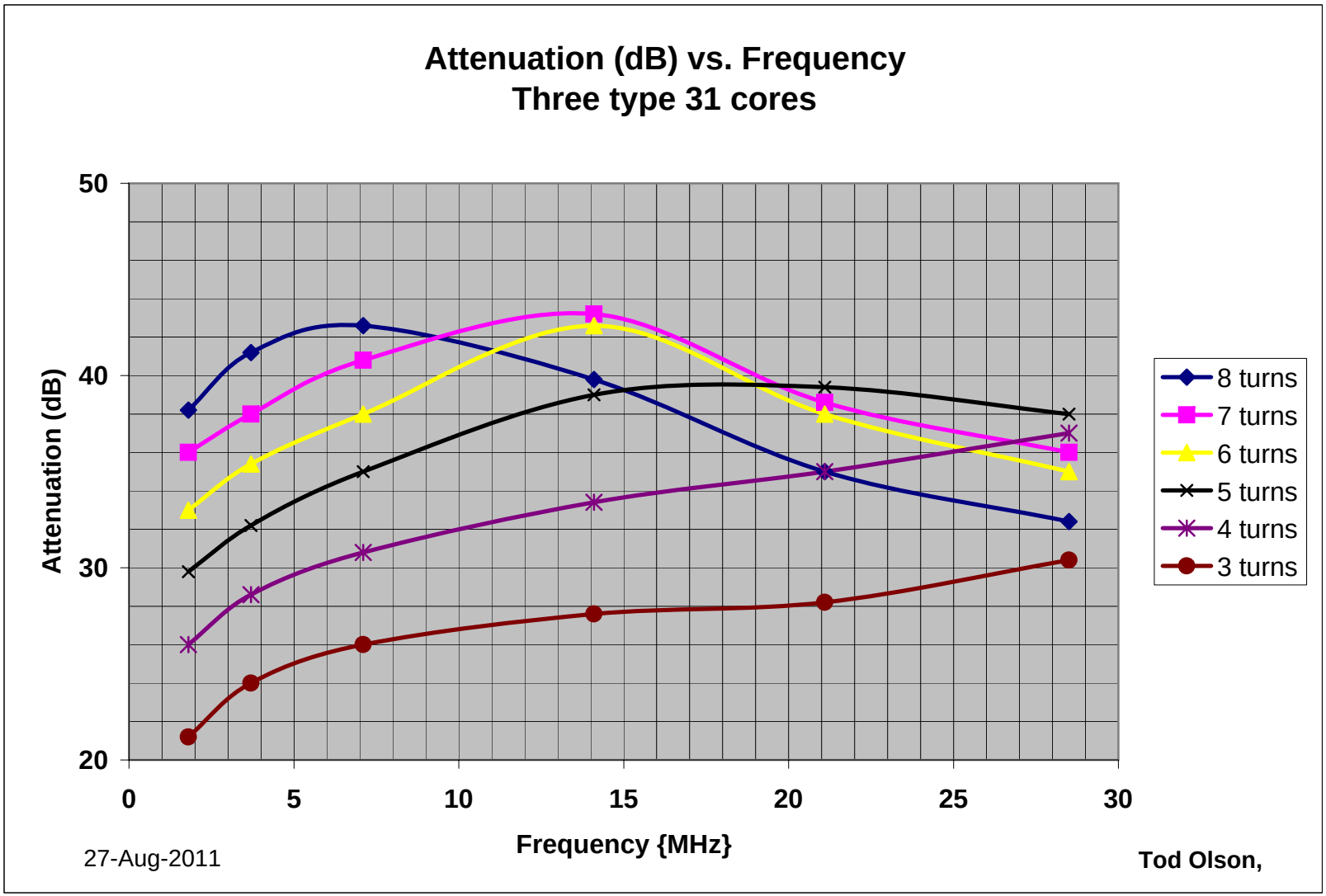
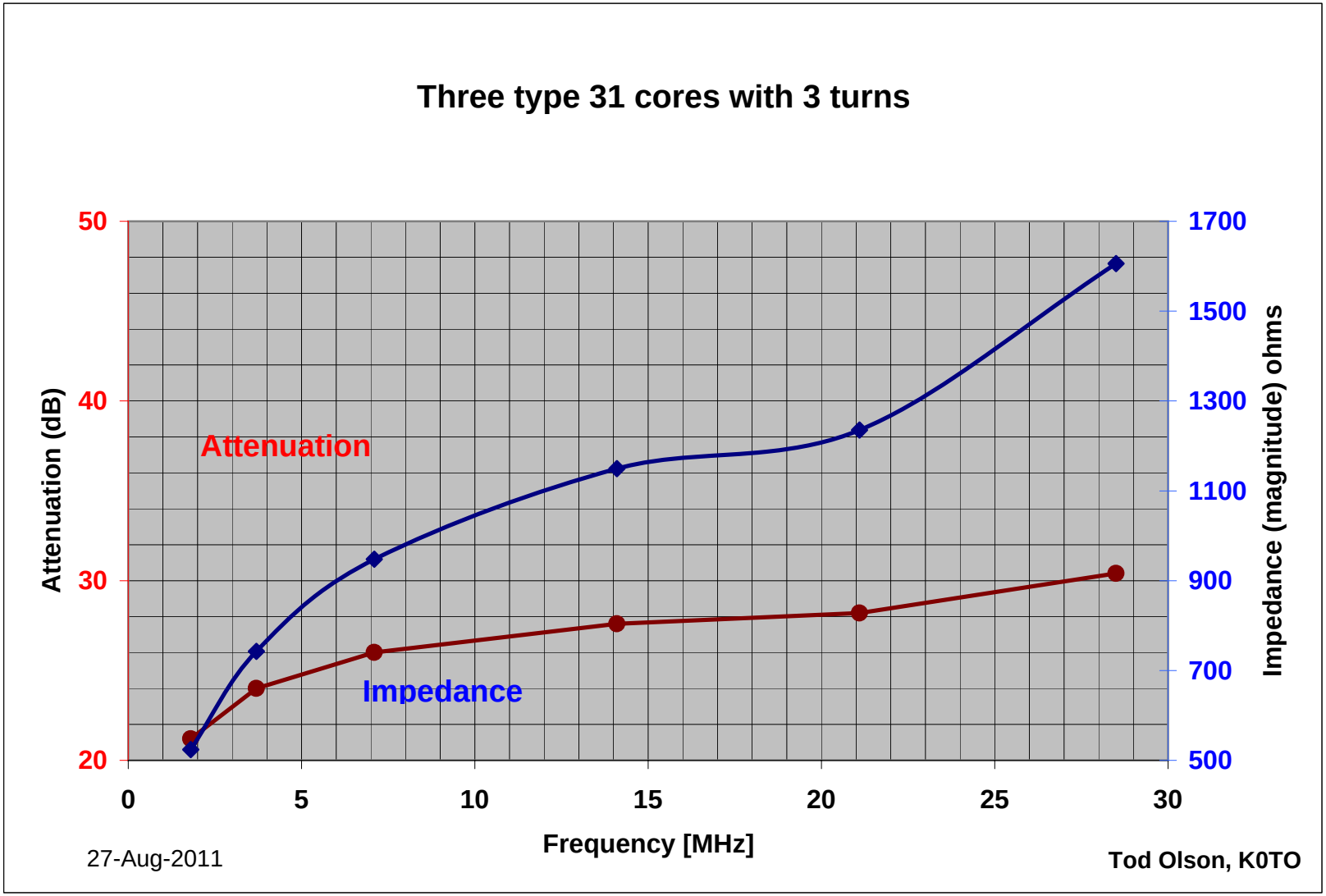

Attenuation (dB) vs. Frequency
Three type 31 cores
Attenuation (dB)
50
40
30
20
0
5
10
15
20
25
30
Frequency {MHz}
8 turns
7 turns
6 turns
5 turns
4 turns
3 turns
27-Aug-2011
Tod Olson,


Three type 31 cores with 3 turns
50
40
30
20
Attenuation (dB)
Attenuation
Impedance
1700
1500
1300
1100
900
700
500
Impedance (magnitude) ohms
0
5
10
15
20
25
30
Frequency [MHz]
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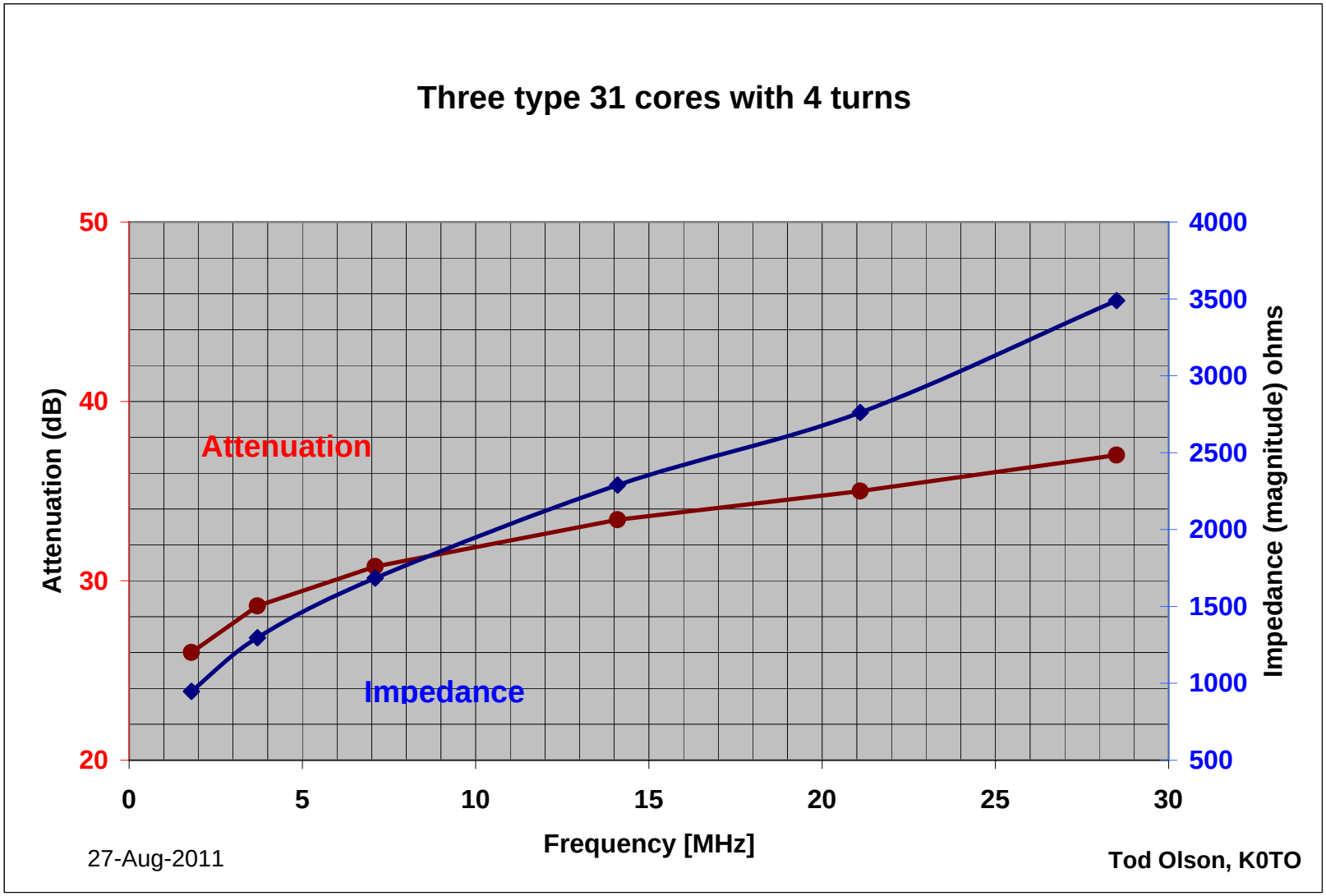
Three type 31 cores with 4 turns
Attenuation (dB)
50
40
30
20
Attenuation
Impedance
4000
3500
3000
2500
2000
1500
1000
500
Impedance (magnitude) ohms
0
5
10
15
20
25
30
Frequency [MHz]
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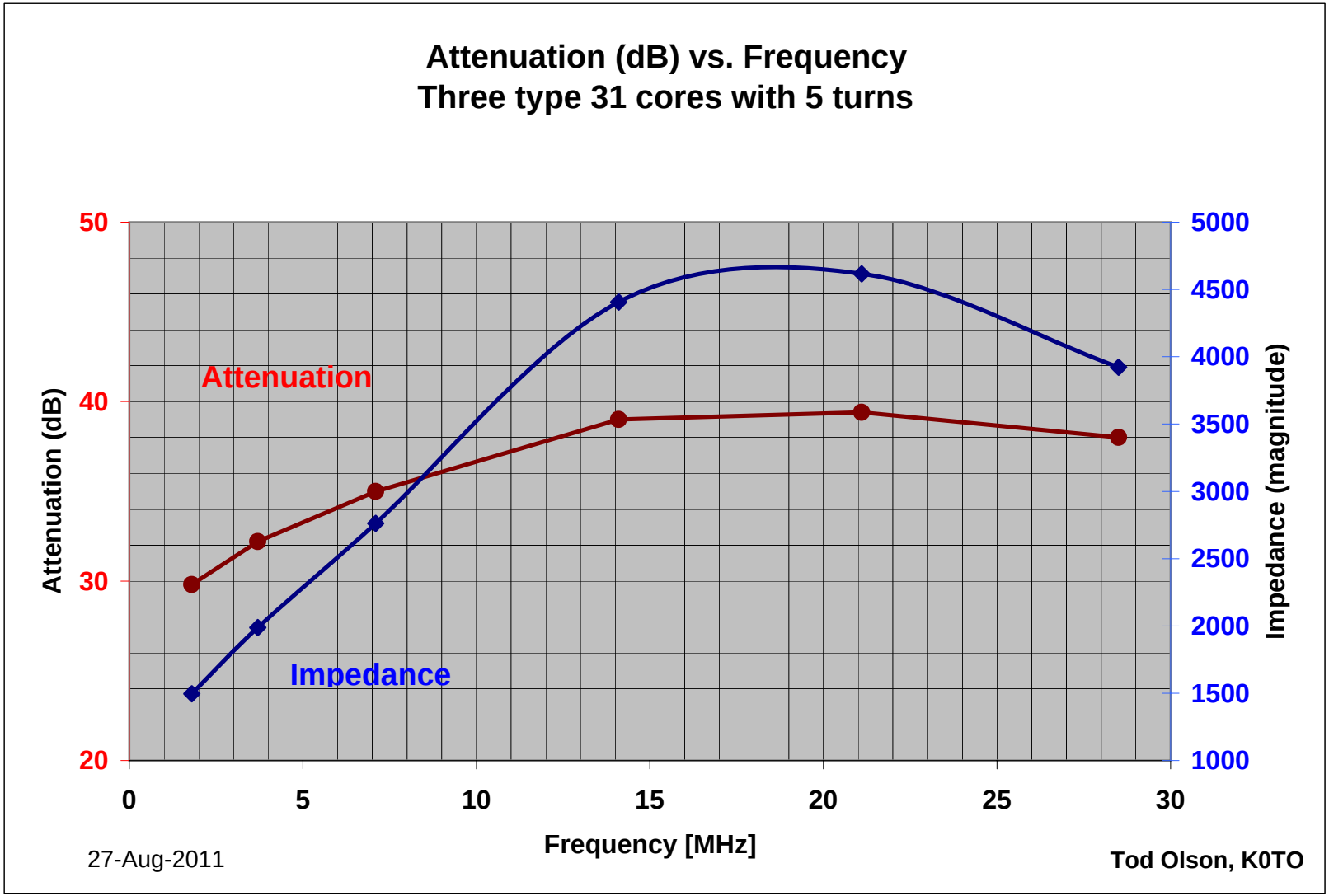
Attenuation (dB) vs. Frequency
Three type 31 cores with 5 turns
Attenuation
Impedance
Attenuation (dB)
Impedance (magnitude)
Frequency [MHz]
50
40
30
20
5000
4500
4000
3500
3000
2500
2000
1500
1000
0
5
10
15
20
25
30
27-Aug-2011
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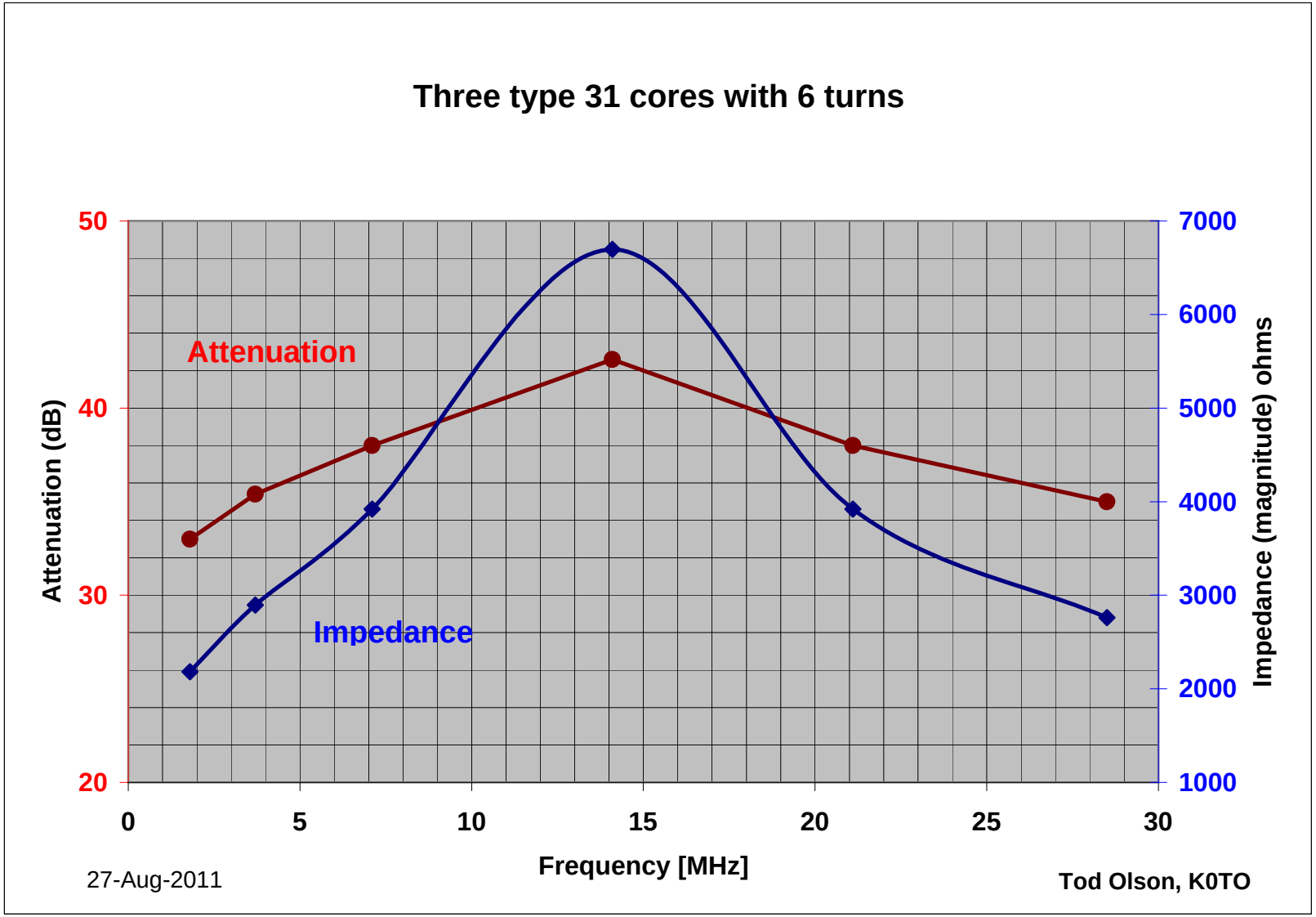
Three type 31 cores with 6 turns
Attenuation
Impedance
Attenuation (dB)
Impedance (magnitude) ohms
Frequency [MHz]
50
40
30
20
7000
6000
5000
4000
3000
2000
1000
0
5
10
15
20
25
30
27-Aug-2011
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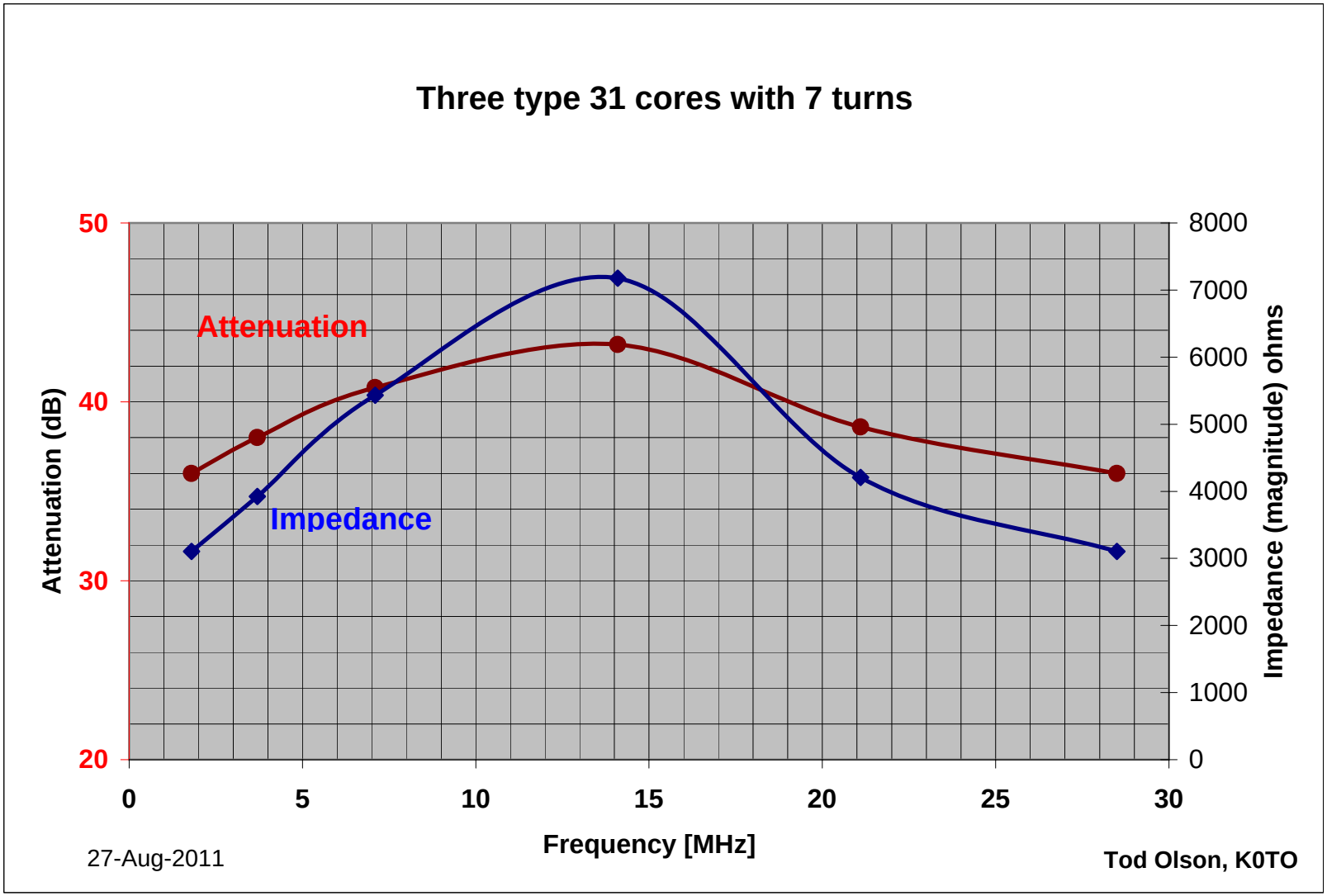
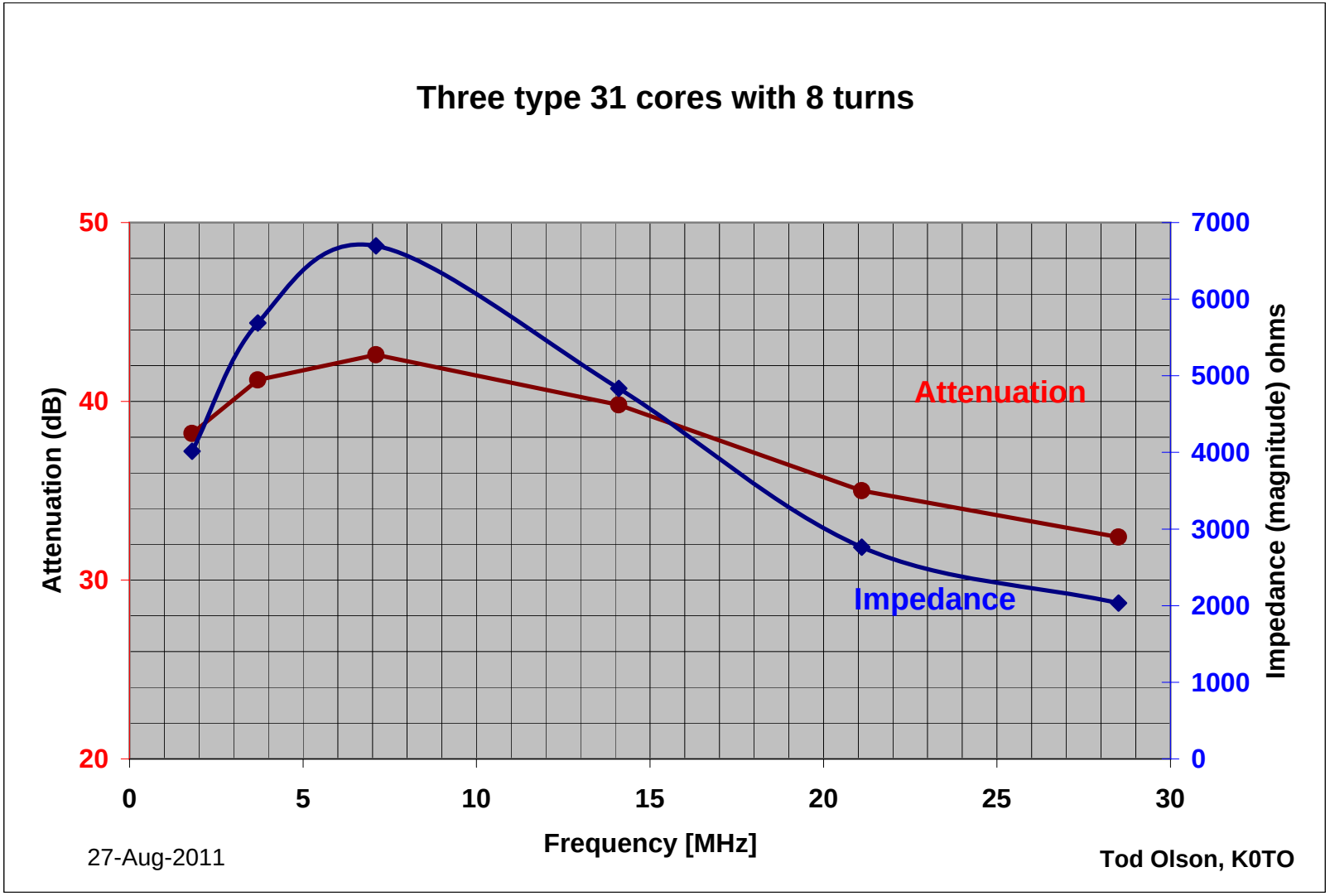

Three type 31 cores with 7 turns
Attenuation
Impedance
Attenuation (dB)
Impedance (magnitude) ohms
Frequency [MHz]
50
40
30
20
8000
7000
6000
5000
4000
3000
2000
1000
0
0
5
10
15
20
25
30
27-Aug-2011
Tod Olson, K0TO


Three type 31 cores with 8 turns
50
40
30
20
Attenuation (dB)
7000
6000
5000
4000
3000
2000
1000
0
Impedance (magnitude) ohms
Attenuation
Impedance
0
5
10
15
20
25
30
Frequency [MHz]
27-Aug-2011
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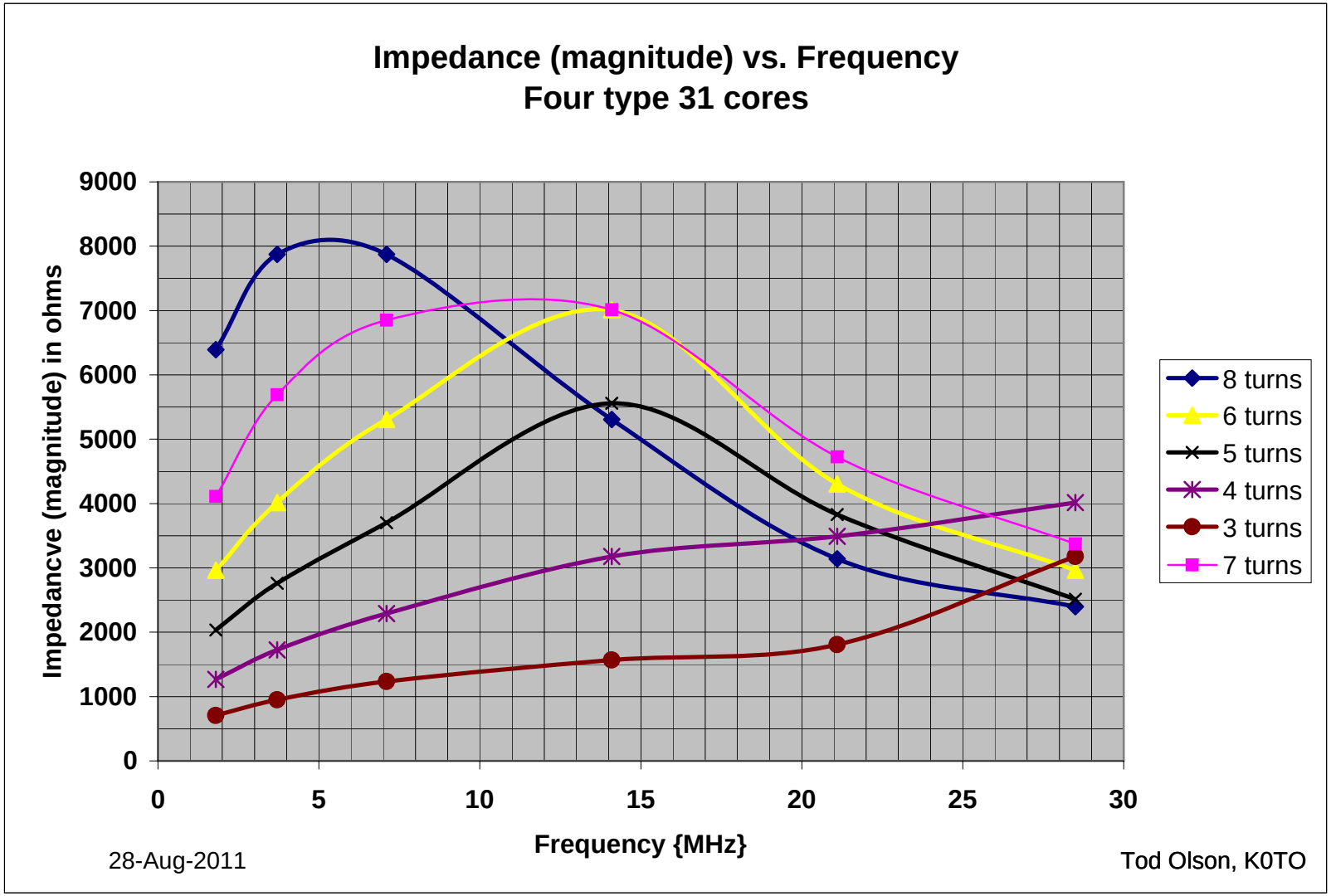
Impedance (magnitude) vs. Frequency
Four type 31 cores
Impedancve (magnitude) in ohms
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
0
5
10
15
20
25
30
Frequency {MHz}
8 turns
6 turns
5 turns
4 turns
3 turns
7 turns
28-Aug-2011
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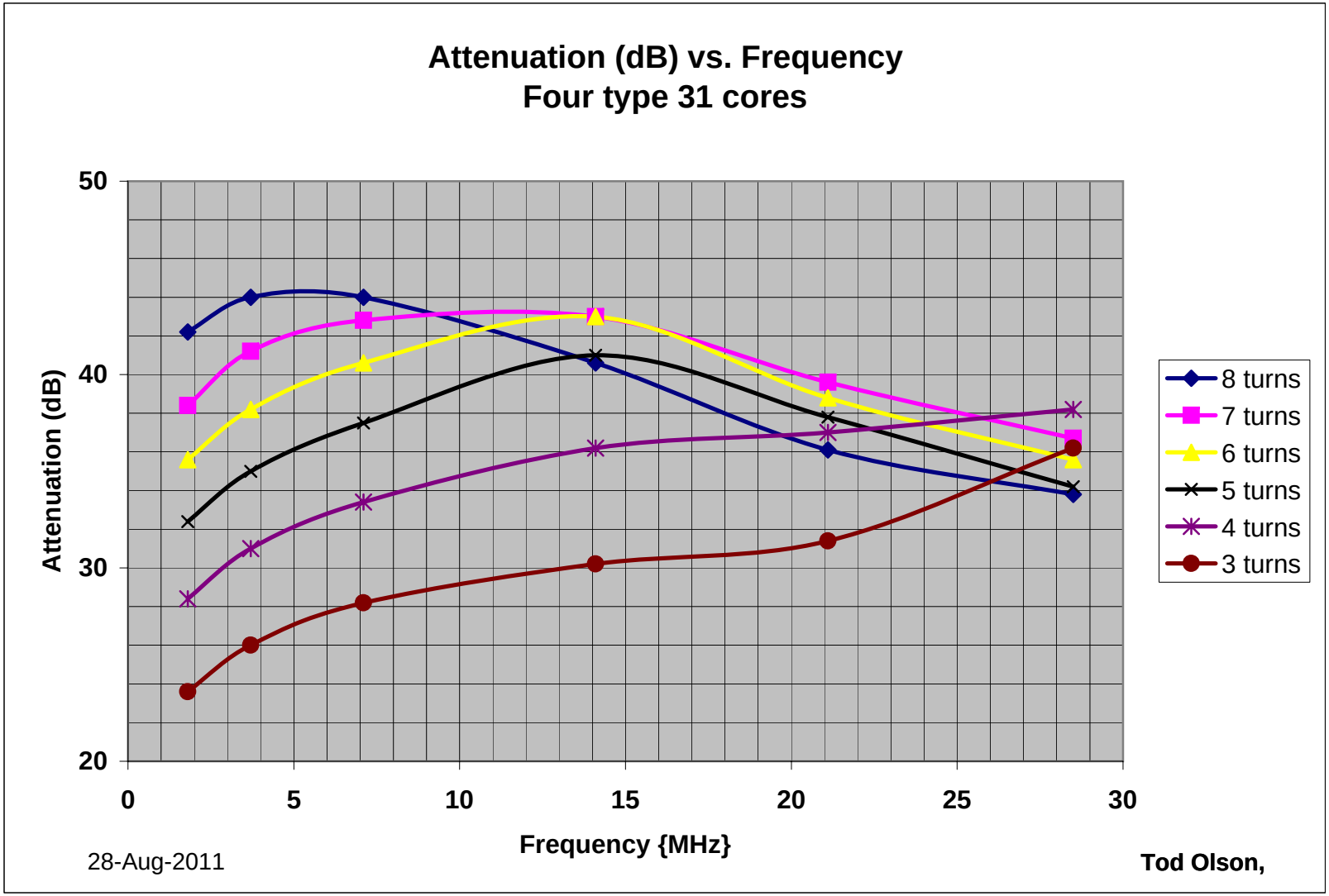
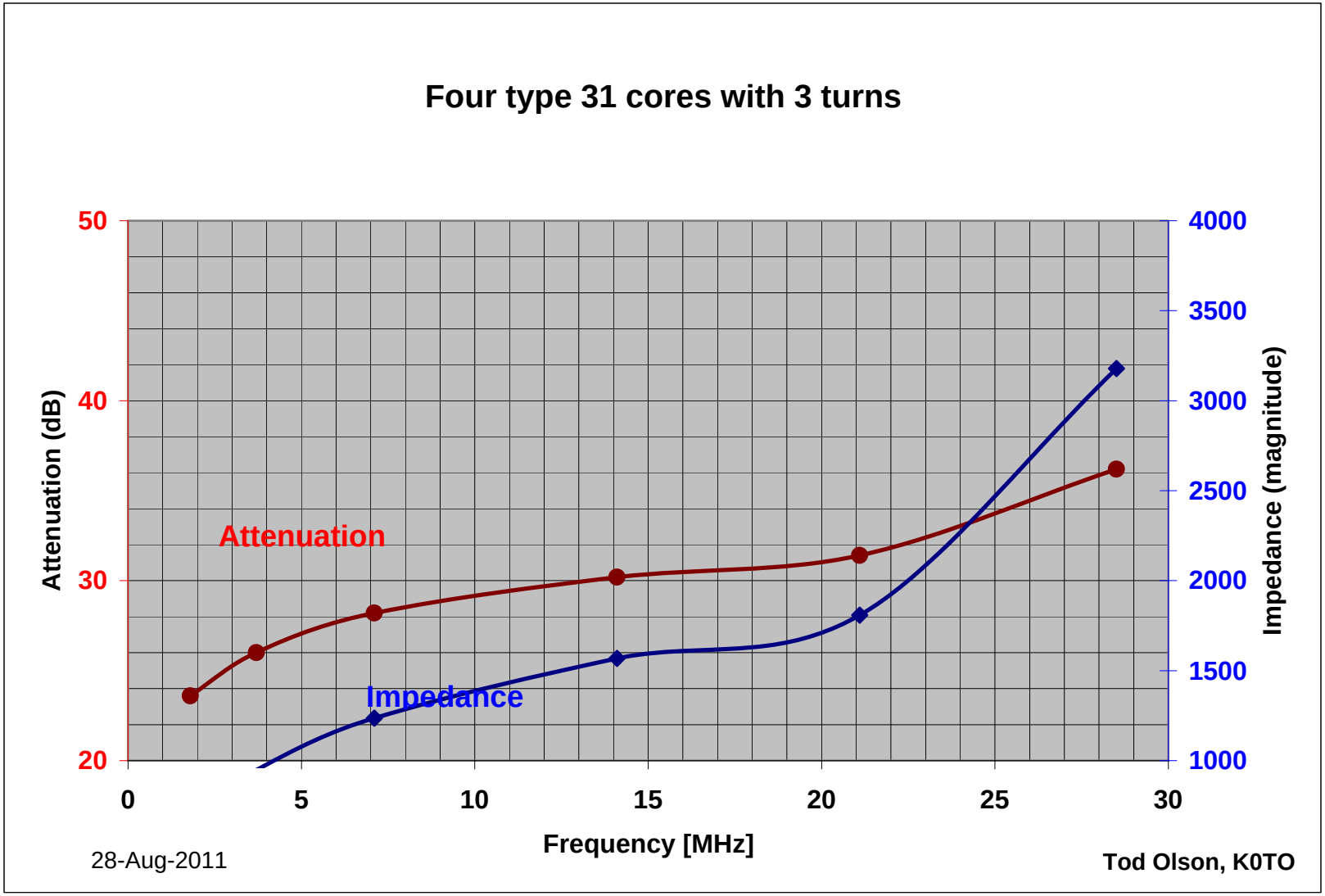
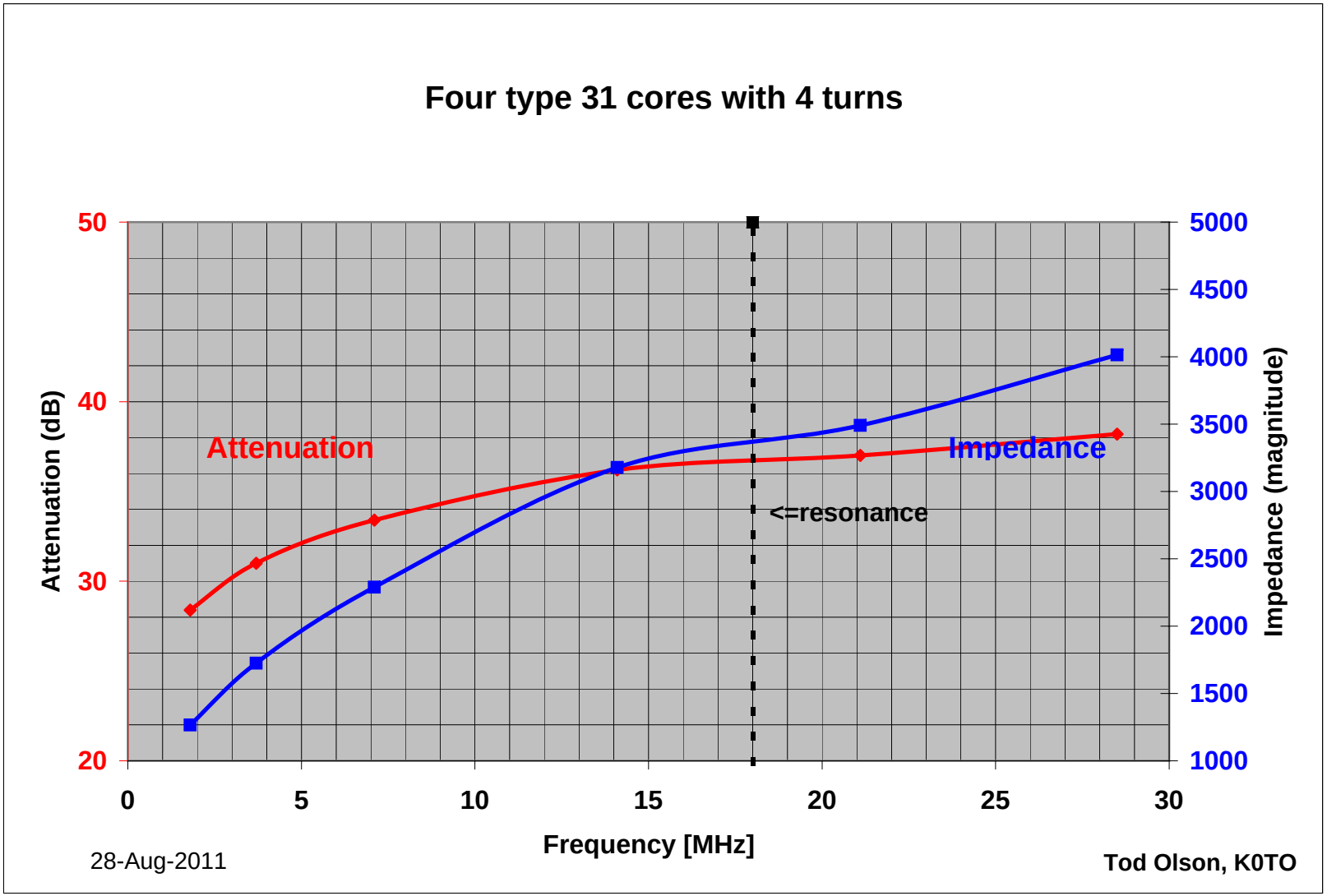

Attenuation (dB) vs. Frequency
Four type 31 cores
50
40
30
20
Attenuation (dB)
0
5
10
15
20
25
30
Frequency {MHz}
8 turns
7 turns
6 turns
5 turns
4 turns
3 turns
28-Aug-2011
Tod Olson,


Four type 31 cores with 3 turns
Attenuation (dB)
50
40
30
20
Impedance (magnitude)
4000
3500
3000
2500
2000
1500
1000
Attenuation
Impedance
0
5
10
15
20
25
30
Frequency [MHz]
28-Aug-2011
Tod Olson, K0TO


Four type 31 cores with 4 turns
Attenuation (dB)
50
40
30
20
Attenuation
Impedance
<=resonance
5000
4500
4000
3500
3000
2500
2000
1500
1000
Impedance (magnitude)
0
5
10
15
20
25
30
Frequency [MHz]
28-Aug-2011
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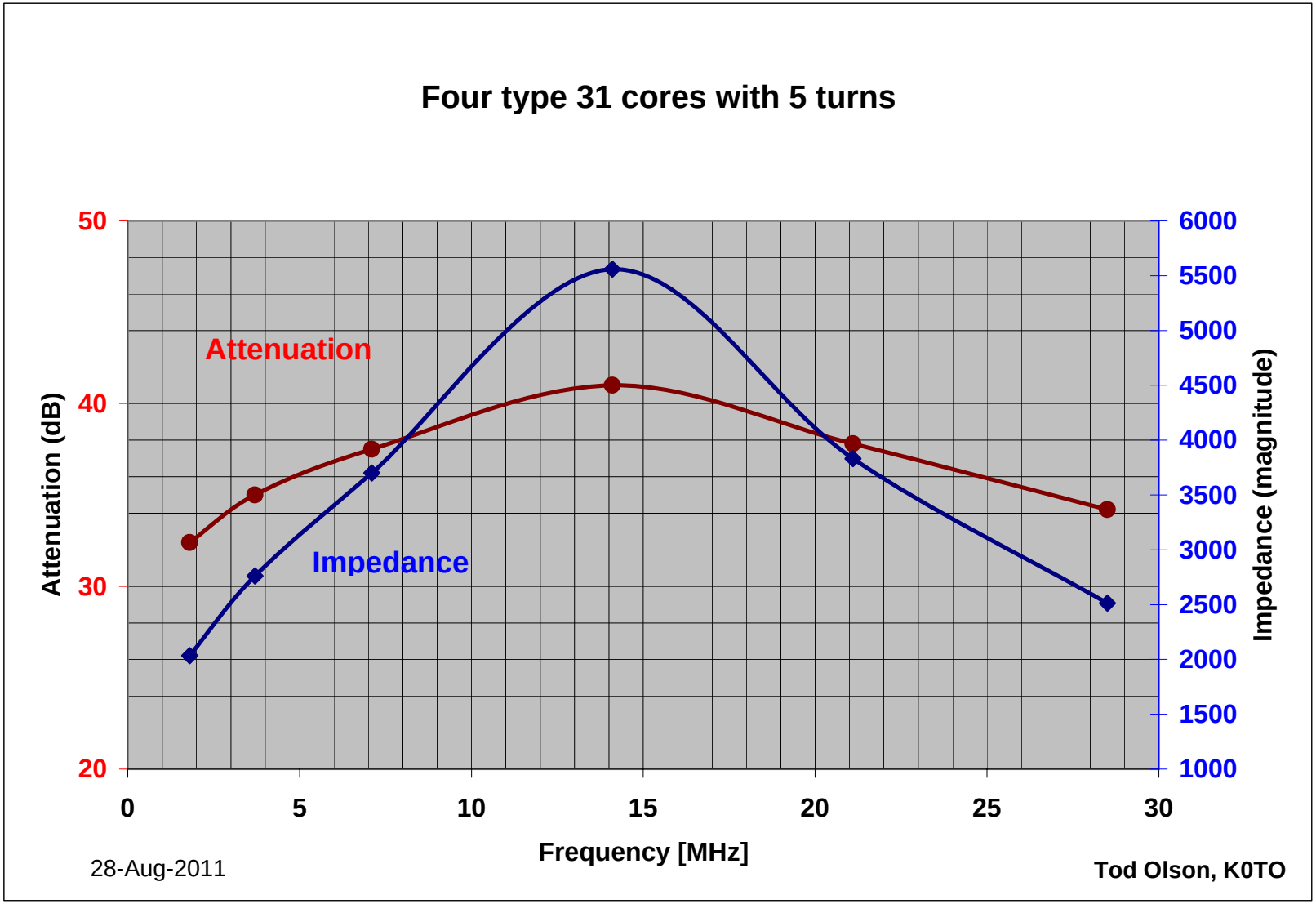
Four type 31 cores with 5 turns
Attenuation
Impedance
Attenuation (dB)
Impedance (magnitude)
Frequency [MHz]
50
40
30
20
6000
5500
5000
4500
4000
3500
3000
2500
2000
1500
1000
0
5
10
15
20
25
30
28-Aug-2011
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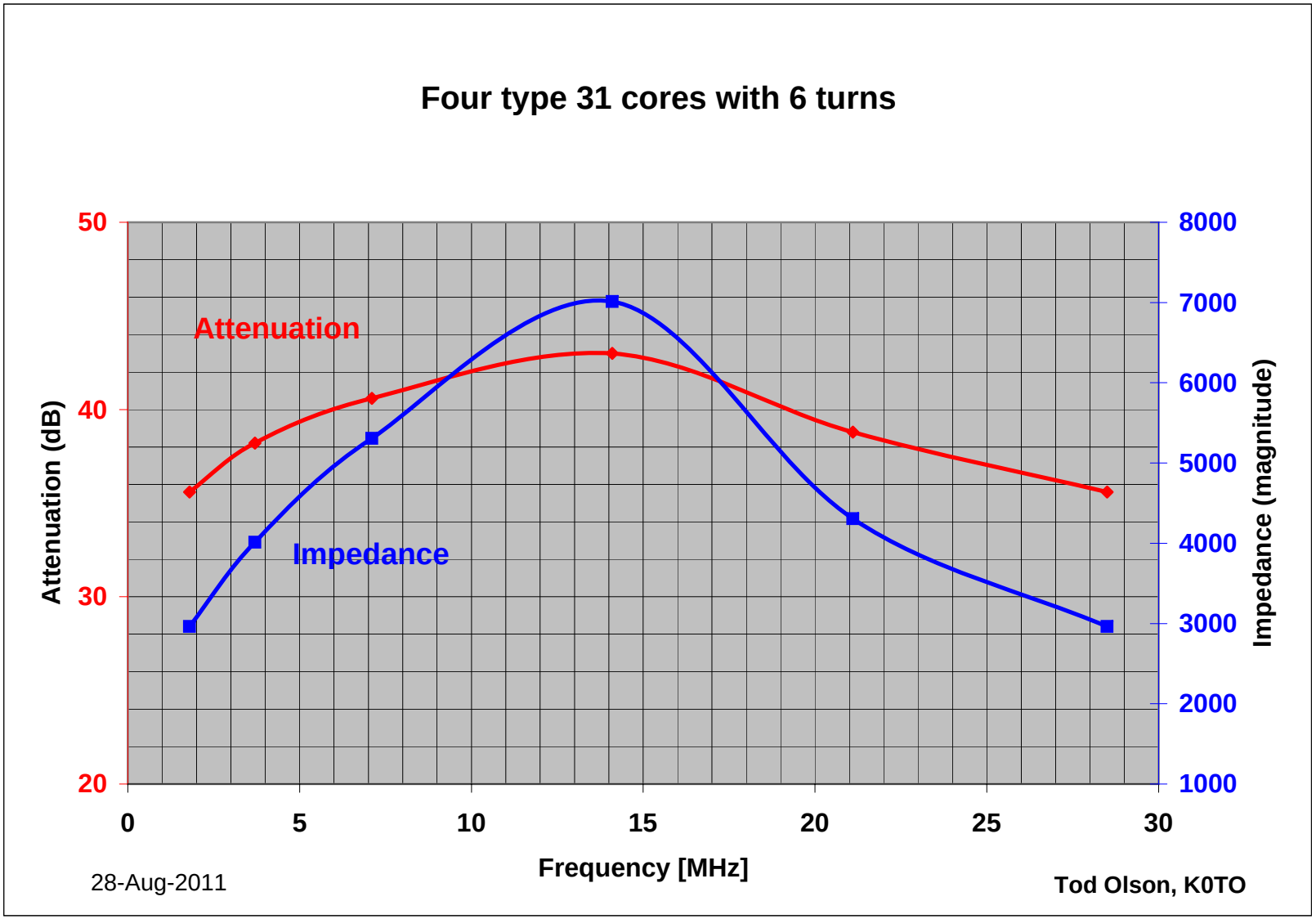
Four type 31 cores with 6 turns
Attenuation
Impedance
Attenuation (dB)
Impedance (magnitude)
Frequency [MHz]
50
40
30
20
8000
7000
6000
5000
4000
3000
2000
1000
0
5
10
15
20
25
30
28-Aug-2011
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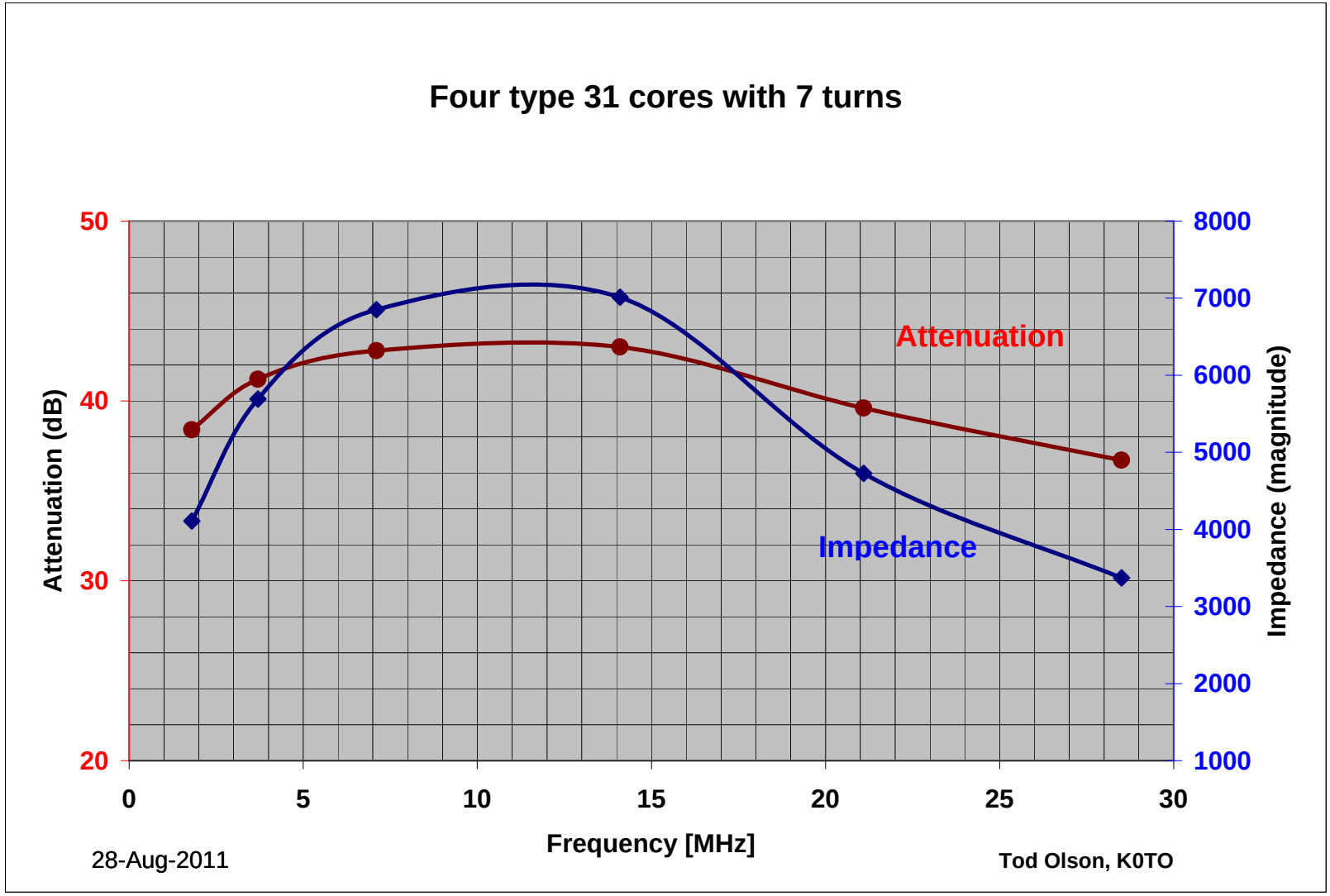
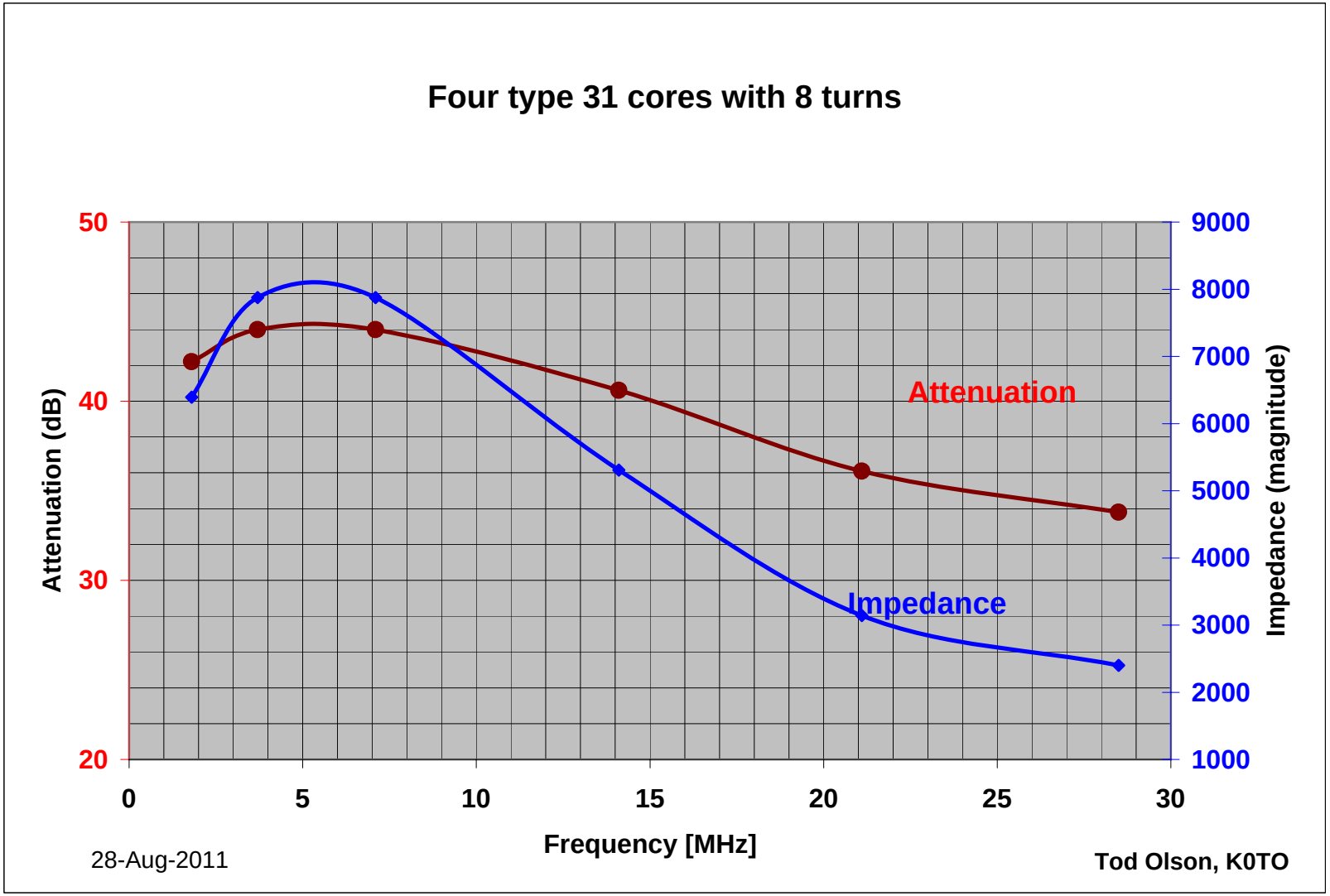
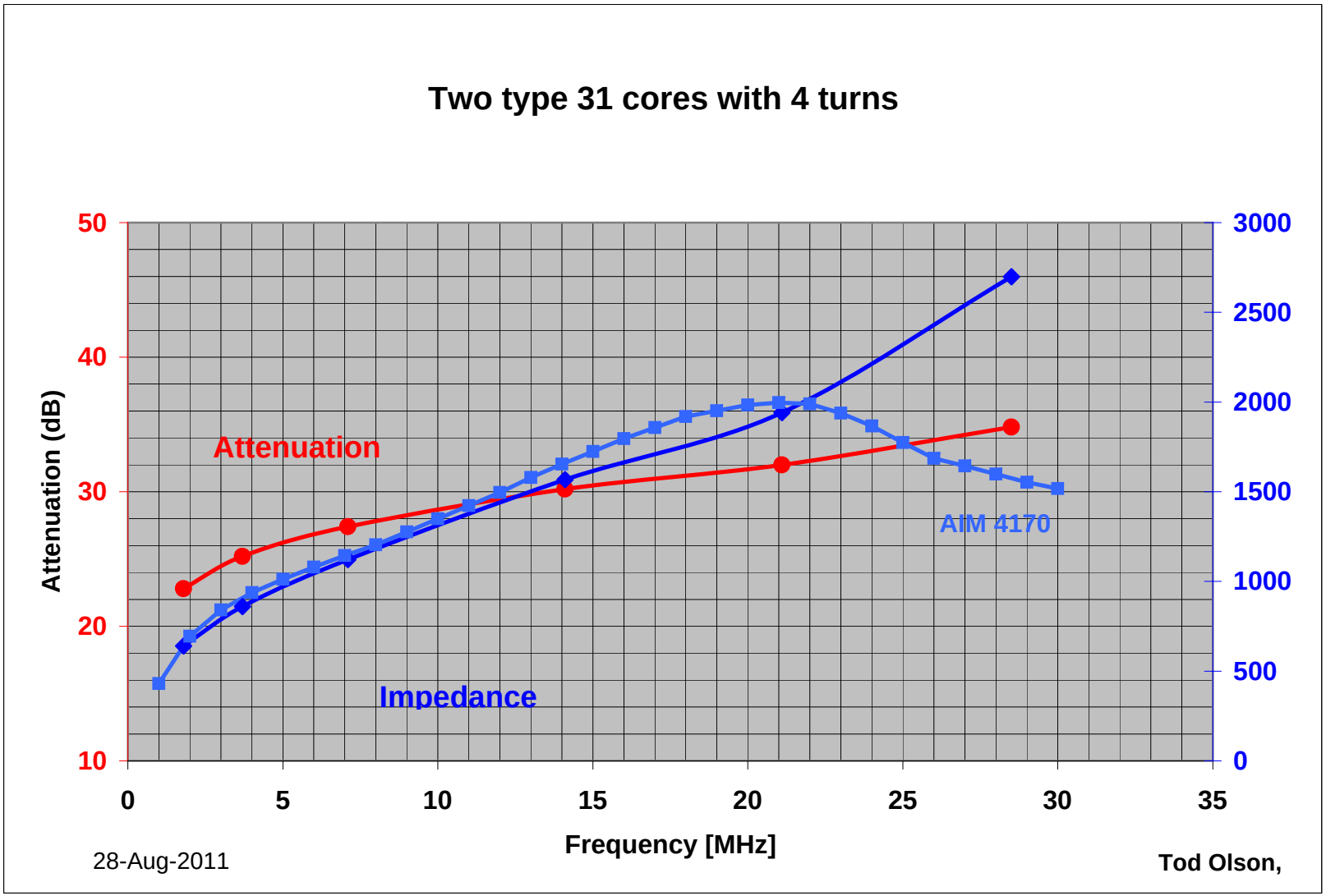
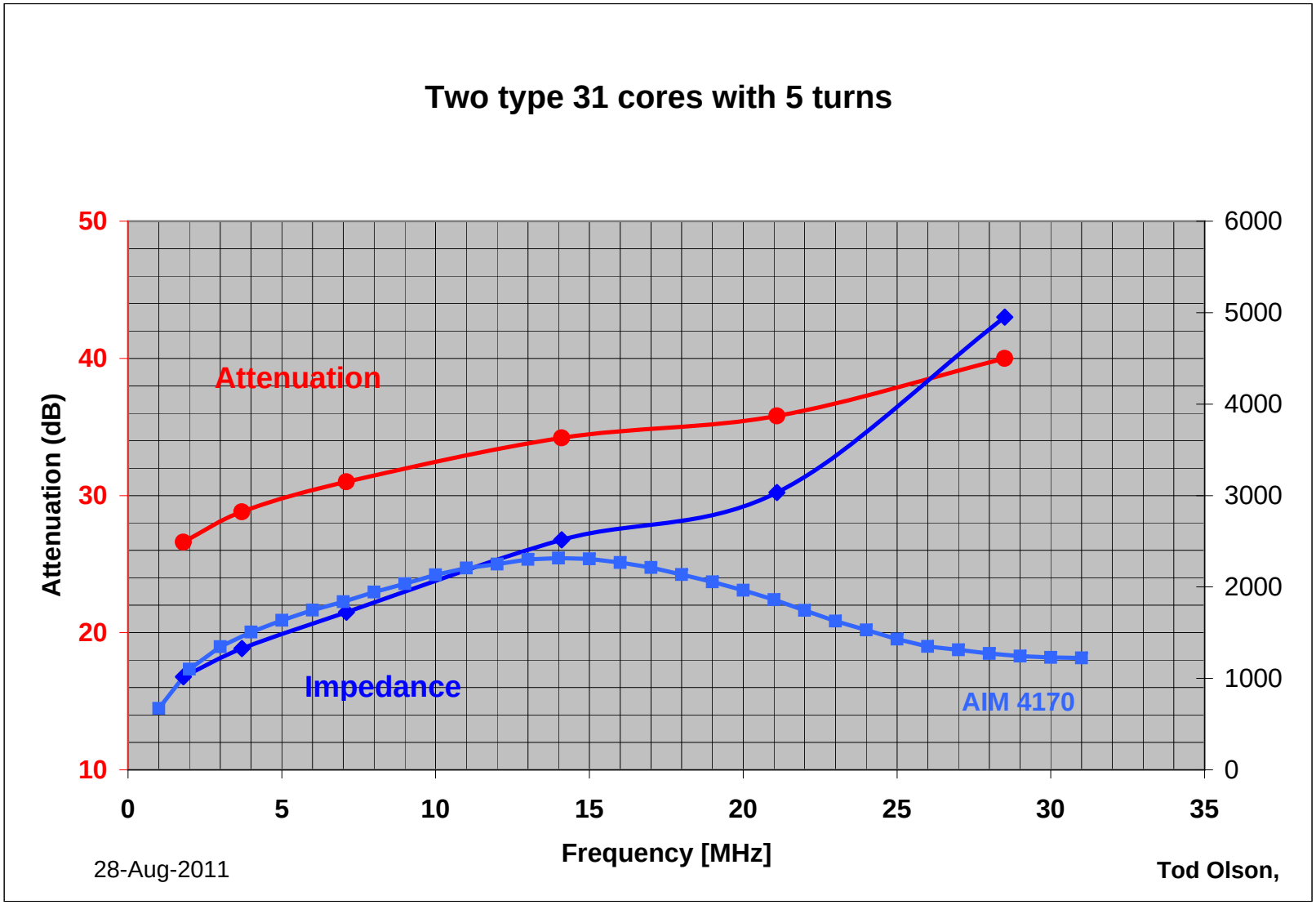

Four type 31 cores with 7 turns
Attenuation (dB)
50
40
30
20
Impedance (magnitude)
8000
7000
6000
5000
4000
3000
2000
1000
Attenuation
Impedance
0
5
10
15
20
25
30
Frequency [MHz]
28-Aug-2011
Tod Olson, K0TO


Four type 31 cores with 8 turns
50
40
30
20
Attenuation (dB)
9000
8000
7000
6000
5000
4000
3000
2000
1000
Impedance (magnitude)
Attenuation
Impedance
0
5
10
15
20
25
30
Frequency [MHz]
28-Aug-2011
Tod Olson, K0TO


Two type 31 cores with 4 turns
Attenuation (dB)
50
40
30
20
10
3000
2500
2000
1500
1000
500
0
Attenuation
Impedance
AIM 4170
0
5
10
15
20
25
30
35
Frequency [MHz]
28-Aug-2011
Tod Olson,


Two type 31 cores with 5 turns
Attenuation (dB)
50
40
30
20
10
6000
5000
4000
3000
2000
1000
0
Attenuation
Impedance
AIM 4170
0
5
10
15
20
25
30
35
Frequency [MHz]
28-Aug-2011
Tod Olson,