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This article is a "golden oldie", of sorts. I wrote the first version in 1988 and have been trying, half-heartedly, since then to get it into the QRP Quarterly.  It's not that it's a bad article, just that there were some substantial logistical problems in getting it from my computer to the publishers typesetting computer, since I didn't own an IBM compatible until 1991. Things started looking up when I got volcano'ed out of the Philippines, had to abandon my TRS-80 computer and buy a new one, this time an IBM compatible.  Now I could send an ASCII disk. And then Maryland Radio Center, the ham store where I work, eventually upgraded to a '386 computer with laser printer, and now I can submit camera-ready copy to the editor, totally eliminating all middle-men.  (My deepest thanks to MRC owner Jerry Johnson, WA3WZF, for use of his computer.)

Now for the 397th rewrite of the text...  Getting back into ham radio in 1986 after an absence of over 15 years, I began poring over the tremendous number of homebrew articles that I missed in the interim. In comparing design features of various projects using toroids, I often had to convert winding data to inductance or vice versa.  At other times, I found myself building something and didn't have the exact size of core called for.

I got tired of hauling out the Amidon charts every time, hunting up the formula and Al value, digging out the calculator and doing the calculations.  That seemed like a lot of unnecessary work, reinventing the wheel each time (how often did I calculate the inductance for 15 turns on a T50-2 core?), along with the ever present possibility of making mistakes when applying the formulas. It would be much quicker and simpler to refer to a chart and instantly see that X turns on core Y gives Z microhenries, and how many turns on another core would give approximately the same.  The obvious answer, then, was to write a BASIC program to compute and print out, once and for all, the inductance per turn for a variety of the most commonly used toroids.  Amidon provides similar charts, but only in multiples of ten turns.  Mine are tailored to the coils and cores most often used by QRPers.

USING THE CHARTS

Inductance for a given number of turns can be read directly from the charts.  When looking for the number of turns required to obtain a specific inductance, simply choose the nearest inductance value from the chart under the core(s) of interest and read across. (It is assumed that you already know which core material is suitable for the application at hand, having considered operating frequency, Q, etc.) While I could have run off a second set of charts indexed by inductance rather than turns, it would have been much larger and would also have given results in fractions of turns, which are not practical to implement on toroids.  If a slightly different value of inductance is required than that shown on the chart, the winding can be compressed or expanded slightly.

I originally made charts for every core size within these 4 materials, which are the most commonly used types.  It ran to 11 pages, but I quickly realized that only a small number of sizes were used most of the time.  (Do you remember the last time YOU used a T157-2 core?)  Also, most coils use a relatively small number of turns, hence the cut-off at 35.  In those relatively rare cases where pages, but I quickly realized that only a small number of sizes were used most of the time. (Do you remember the last time YOU used a T157-2 core?) Also, most coils use a relatively small number of turns, hence the cut-off at 35. In those relatively rare cases where some other size or material is used, or more turns, you can consult the published information, such as an Amidon flyer, and apply their formulas.

I moved the output of the BASIC program over to the word processor and dressed it up, including rounding off the values. There wasn't much point in showing additional decimal places; it implied a degree of precision that is unattainable in practice, as well as cluttering up the charts. (If you put 21 turns on an FT50-43 core, can you REALLY expect to get precisely 230.643 microhenries?) Anyone who has ever used a toroid knows how variable the inductance is for a given number of turns, depending on spacing of the turns as well as variations in permeability between nominally identical cores. In one of their catalogs, Micrometals (who makes the powdered iron cores sold by Amidon) indicates that inductance tolerance, due to core to core permeability variations, is plus or minus 5%

By the way, I've noticed over the years that under some circumstances the published Al values seem to be little more than a general guide to the actual inductances you'll get, and need to be taken with a grain of salt. I've done a fair amount of experimenting with my Boonton 260A Q meter, and notice that when I get to low values of inductance the "apparent Al value" deviates from the published value. This is most apparent with coils under one microhenry. The villains, which become significant factors at low inductance values, are the distributed capacitance of the coil, which makes the "apparent inductance" appear larger than the "true inductance", and the lead length. Even straight wire has finite inductance, and it adds up.

HOW MUCH WIRE TO USE?

Next, a different chart of great usefulness--how to figure out how much wire you need to wind those coils. I originally had this published in the October 1988 issue of the QRP Quarterly, and it's time to resurrect it again. You have three choices when winding a toroid: 1) cut off a random piece of wire which looks like it's long enough and hope for the best; you'll end up wasting wire or saying bad things when you run out of wire 5 turns before the end; 2) wind a single turn with a piece of thread, measure it and multiply by the number of turns you want; 3) look up the single turn length from the chart below.

Since I didn't have all core sizes on hand to do the single turn trick, I used the published dimensions from the Amidon flyer to figure out the circumferences. I wound some sample coils, and things didn't always work out right; the figures were the sum of dimensions, but real wire has finite thickness, and I needed more. After observing how much more wire was needed, from 7 to 13%, I settled on a fudge factor of 15%, which should cover just about every case, and that's built into the charts. On top of that, you also have to provide extra wire for leads; I usually add two or three inches. If you just cut the amount of wire shown, you'll end up with a coil that just fits on the core but no wire left over to connect to your circuit!

After the original publication, K3TKS pointed out to me that these values are only good for single layer coils. They don't apply if you do multiple layers (which we don't normally do in QRP building) or if you wind bifilar, trifilar, etc; in those cases you're on your own, but the chart gives a good starting point.

I hope these charts make life simpler for some of you homebrewers out there; it certainly helps speed things up for me, and makes comparing circuits and building much more enjoyable.

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circuits and building much more enjoyable.

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| Core types | T25-2 | T30-2 | T37-2 | T44-2 | T50-2 | T68-2 |
|---|---|---|---|---|---|---|
| Al value | 34 | 43 | 40 | 52 | 49 | 57 |
| # of turns | Inductance in microhenries | | | | | |
| 1 | .003 | .004 | .004 | .005 | .005 | .006 |
| 2 | .014 | .017 | .016 | .021 | .020 | .023 |
| 3 | .031 | .039 | .036 | .047 | .044 | .051 |
| 4 | .054 | .069 | .064 | .083 | .078 | .091 |
| 5 | .085 | .108 | .100 | .130 | .123 | .143 |
| 6 | .122 | .155 | .144 | .187 | .176 | .205 |
| 7 | .167 | .211 | .196 | .255 | .240 | .279 |
| 8 | .218 | .275 | .256 | .333 | .314 | .365 |
| 9 | .275 | .348 | .324 | .421 | .397 | .462 |
| 10 | .340 | .430 | .400 | .520 | .490 | .570 |
| 11 | .411 | .520 | .484 | .629 | .593 | .690 |
| 12 | .490 | .619 | .576 | .749 | .706 | .821 |
| 13 | .575 | .727 | .676 | .879 | .828 | .963 |
| 14 | .666 | .843 | .784 | 1.02 | .960 | 1.12 |
| 15 | .765 | .968 | .900 | 1.17 | 1.10 | 1.28 |
| 16 | .870 | 1.10 | 1.02 | 1.33 | 1.25 | 1.46 |
| 17 | .983 | 1.24 | 1.16 | 1.503 | 1.42 | 1.65 |
| 18 | 1.10 | 1.39 | 1.30 | 1.69 | 1.59 | 1.85 |
| 19 | 1.23 | 1.55 | 1.44 | 1.88 | 1.77 | 2.06 |
| 20 | 1.36 | 1.72 | 1.60 | 2.08 | 1.96 | 2.28 |
| 21 | 1.50 | 1.90 | 1.76 | 2.29 | 2.16 | 2.51 |
| 22 | 1.65 | 2.08 | 1.94 | 2.52 | 2.37 | 2.76 |
| 23 | 1.80 | 2.28 | 2.12 | 2.75 | 2.59 | 3.02 |
| 24 | 1.96 | 2.48 | 2.30 | 3.00 | 2.82 | 3.28 |
| 25 | 2.13 | 2.69 | 2.50 | 3.25 | 3.06 | 3.56 |
| 26 | 2.30 | 2.91 | 2.70 | 3.52 | 3.31 | 3.85 |
| 27 | 2.48 | 3.14 | 2.92 | 3.79 | 3.57 | 4.16 |
| 28 | 2.67 | 3.37 | 3.14 | 4.08 | 3.84 | 4.47 |
| 29 | 2.86 | 3.62 | 3.36 | 4.37 | 4.12 | 4.79 |
| 30 | 3.06 | 3.87 | 3.60 | 4.68 | 4.41 | 5.13 |
| 31 | 3.27 | 4.13 | 3.84 | 5.00 | 4.71 | 5.48 |
| 32 | 3.48 | 4.40 | 4.10 | 5.33 | 5.02 | 5.84 |
| 33 | 3.70 | 4.68 | 4.36 | 5.66 | 5.34 | 6.21 |
| 34 | 3.93 | 4.97 | 4.62 | 6.01 | 5.67 | 6.59 |
| 35 | 4.17 | 5.27 | 4.90 | 6.37 | 6.00 | 6.98 |

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| Core types | T25-6 | T30-6 | T37-6 | T44-6 | T50-6 | T68-6 |
|---|---|---|---|---|---|---|
| Al values | 27 | 36 | 30 | 42 | 40 | 47 |
| # of turns | Inductance in microhenries | | | | | |
| 1 | .003 | .004 | .003 | .004 | .004 | .005 |
| 2 | .011 | .014 | .012 | .017 | .016 | .019 |
| 3 | .024 | .032 | .027 | .038 | .036 | .042 |
| 4 | .043 | .058 | .048 | .067 | .064 | .075 |
| 5 | 068 | .090 | .075 | .105 | .100 | .118 |
| 6 | .097 | .130 | .108 | .151 | .144 | .169 |
| 7 | .132 | .176 | .147 | .206 | .196 | .230 |
| 8 | .173 | .230 | .192 | .269 | .256 | .301 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 6 | .097 | .130 | .108 | .151 | .144 | .169 |
| 7 | .132 | .176 | .147 | .206 | .196 | .230 |
| 8 | .173 | .230 | .192 | .269 | .256 | .301 |
| 9 | .219 | .292 | .243 | .340 | .324 | .381 |
| 10 | .270 | .360 | .300 | .420 | .400 | .470 |
| 11 | .327 | .436 | .363 | .508 | .484 | .569 |
| 12 | .389 | .518 | .432 | .605 | .576 | .677 |
| 13 | .456 | .608 | .507 | .710 | .676 | .794 |
| 14 | .529 | .706 | .588 | .823 | .784 | .921 |
| 15 | .608 | .810 | .675 | .945 | .900 | 1.06 |
| 16 | .691 | .922 | .768 | 1.08 | 1.02 | 1.20 |
| 17 | .780 | 1.04 | .867 | 1.21 | 1.16 | 1.36 |
| 18 | .875 | 1.17 | .972 | 1.36 | 1.30 | 1.52 |
| 19 | .975 | 1.30 | 1.08 | 1.52 | 1.44 | 1.70 |
| 20 | 1.08 | 1.44 | 1.20 | 1.68 | 1.60 | 1.88 |
| 21 | 1.19 | 1.59 | 1.32 | 1.85 | 1.76 | 2.07 |
| 22 | 1.31 | 1.74 | 1.45 | 2.03 | 1.94 | 2.28 |
| 23 | 1.43 | 1.90 | 1.59 | 2.22 | 2.12 | 2.49 |
| 24 | 1.56 | 2.07 | 1.73 | 2.42 | 2.30 | 2.71 |
| 25 | 1.69 | 2.25 | 1.88 | 2.63 | 2.50 | 2.94 |
| 26 | 1.83 | 2.43 | 2.03 | 2.84 | 2.70 | 3.18 |
| 27 | 1.97 | 2.62 | 2.19 | 3.06 | 2.92 | 3.43 |
| 28 | 2.12 | 2.82 | 2.35 | 3.29 | 3.14 | 3.69 |
| 29 | 2.27 | 3.03 | 2.52 | 3.53 | 3.36 | 3.95 |
| 30 | 2.43 | 3.24 | 2.70 | 3.78 | 3.60 | 4.23 |
| 31 | 2.60 | 3.46 | 2.88 | 4.04 | 3.84 | 4.52 |
| 32 | 2.77 | 3.69 | 3.07 | 4.30 | 4.10 | 4.81 |
| 33 | 2.94 | 3.92 | 3.27 | 4.57 | 4.36 | 5.12 |
| 34 | 3.12 | 4.16 | 3.47 | 4.86 | 4.62 | 5.43 |
| 35 | 3.31 | 4.41 | 3.68 | 5.15 | 4.90 | 5.76 |

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| Core types | FT23-43 | FT37-43 | FT50-43 | FT23-61 | FT37-61 | FT50-61 |
|---|---|---|---|---|---|---|
| Al values | 188 | 420 | 523 | 24.8 | 55.3 | 68 |

| # of turns | Inductance in microhenries | | | | | |
|---|---|---|---|---|---|---|
| 1 | .188 | .420 | .523 | .025 | .055 | .068 |
| 2 | .752 | 1.68 | 2.09 | .099 | .221 | .272 |
| 3 | 1.69 | 3.78 | 4.71 | .223 | .498 | .612 |
| 4 | 3.01 | 6.72 | 8.37 | .397 | .885 | 1.09 |
| 5 | 4.70 | 10.5 | 13.1 | .620 | 1.38 | 1.70 |
| 6 | 6.77 | 15.1 | 18.8 | .893 | 1.99 | 2.45 |
| 7 | 9.21 | 20.6 | 25.6 | 1.22 | 2.71 | 3.33 |
| 8 | 12.0 | 26.9 | 33.5 | 1.51 | 3.54 | 4.35 |
| 9 | 15.2 | 34.0 | 42.4 | 2.03 | 4.48 | 5.51 |
| 10 | 18.8 | 42.0 | 52.3 | 2.48 | 5.53 | 6.80 |
| 11 | 22.7 | 50.8 | 63.3 | 3.00 | 6.69 | 8.23 |
| 12 | 27.1 | 60.5 | 75.3 | 3.57 | 7.96 | 9.79 |
| 13 | 31.8 | 71.0 | 88.4 | 4.19 | 9.35 | 11.5 |
| 14 | 36.8 | 82.3 | 102 | 4.86 | 10.8 | 13.3 |
| 15 | 42.3 | 94.5 | 118 | 5.58 | 12.4 | 15.3 |
| 16 | 48.1 | 107 | 134 | 6.35 | 14.2 | 17.4 |
| 17 | 54.3 | 121 | 151 | 7.17 | 16.0 | 19.7 |
| 18 | 60.9 | 136 | 169 | 8.04 | 17.9 | 22.0 |
| 19 | 67.9 | 152 | 189 | 8.95 | 20.0 | 24.5 |
| 20 | 75.2 | 168 | 209 | 9.92 | 22.1 | 27.2 |
| 21 | 82.9 | 185 | 231 | 10.9 | 24.4 | 30.0 |

| | | | | | | |
|---|---|---|---|---|---|---|
| [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| 20 | 75.2 | 168 | 209 | 9.92 | 22.1 | 27.2 |
| 21 | 82.9 | 185 | 231 | 10.9 | 24.4 | 30.0 |
| 22 | 91.0 | 203 | 253 | 12.0 | 26.8 | 32.9 |
| 23 | 99.5 | 222 | 277 | 13.1 | 29.3 | 36.0 |
| 24 | 108 | 242 | 301 | 14.3 | 31.9 | 39.2 |
| 25 | 118 | 262 | 327 | 15.5 | 34.6 | 42.5 |
| 26 | 127 | 284 | 354 | 16.8 | 37.4 | 46.0 |
| 27 | 137 | 306 | 381 | 18.1 | 40.3 | 49.6 |
| 28 | 147 | 329 | 410 | 19.4 | 43.4 | 53.3 |
| 29 | 158 | 353 | 440 | 20.9 | 46.5 | 57.2 |
| 30 | 169 | 378 | 471 | 22.3 | 49.8 | 61.2 |
| 31 | 181 | 404 | 503 | 23.8 | 53.1 | 65.3 |
| 32 | 192 | 430 | 536 | 25.4 | 56.6 | 69.6 |
| 33 | 205 | 457 | 570 | 27.0 | 60.2 | 74.1 |
| 34 | 217 | 486 | 605 | 28.7 | 63.9 | 78.6 |
| 35 | 230 | 515 | 641 | 30.4 | 67.7 | 83.3 |

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Wire Length vs. Turns--

(Be sure to include a few extra inches for leads--lead length is NOT included here!)

| Size | Inches per turn | Size | Inches per turn |
|---|---|---|---|
| FT23 | .26 | T37 | .49 |
| FT37 | .5 | T44 | .61 |
| FT50 | .68 | T50 | .67 |
| FT50A | .79 | T68 | .8 |
| FT50B | 1.37 | T80 | .92 |
| FT82 | .93 | T94 | 1.16 |
| FT87A | 1.53 | T106 | 1.57 |
| FT114 | 1.13 | T130 | 1.6 |
| FT114A | 1.7 | T157 | 2.02 |
| FT140 | 1.73 | T184 | 2.66 |
| FT150 | 1.44 | T200 | 2.13 |
| FT150A | 2.01 | T200A | 3.16 |
| FT193 | 2.22 | T225 | 2.24 |
| FT193A | 2.51 | T225A | 3.28 |
| FT240 | 2.3 | T300 | 2.39 |
| T12 | .19 | T300A | 3.54 |
| T16 | .23 | T400 | 3.51 |
| T20 | .29 | T400A | 4.31 |
| T25 | .37 | T500 | 4.28 |
| T30 | .47 | | |

[1995 note--that's not a typo--the list does go from FT82 to FT87A; not sure why I didn't include FT87, and I'm too lazy to go back and do the calculations for it :-) ]

--qrp--

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