FERRITE BEADS

A Ferrite bead is a dowel-like device which has a center hole and is composed of ferromagnetic material. When placed on to a current carrying conductor it will act as an RF choke. It offers a convenient, inexpensive, yet a very effective means of RF shielding, parasitic suppression and RF decoupling.

The most common noise generating suspects in high frequency circuits are power supply leads, ground leads and connections, and interstage connections. Adjacent leads and unshielded conductors can also provide a convenient path for the transfer of energy from one circuit to another. A few ferrite beads of the appropriate material placed on these leads can greatly reduce or completely eliminate the problem. Best of all, they can be added to most any existing electronic circuit.

The amount of impedance is a function of both the material and the frequency, as well as the size of the bead. As the frequency increases, the permeability will decline causing the losses to rise to a peak. With a rise in frequency the bead will present a series resistance with very little reactance. Since reactance is low there is little chance of resonance which could destroy the attenuation effect. Impedance is directly proportional to the length of the bead, therefore impedance will be additive as each similar bead is slipped onto the conductor. Since the magnetic field is totally contained within, it does not matter if the beads are touching or separated. Ferrite beads do not have to be grounded and they cannot be detuned by external magnetic fields.

We recommend the #73 or the #77 ferrite bead material for the attenuation of RFI resulting from transmissions in the amateur band. The #43 material will provide best RFI attenuation from 30 to 400 MHz, and the #64 material is most effective above 400 MHz. The #75 material is recommended for RFI from 1 to 20 MHz, but they can also be very effective even below the AM broadcast band.

Ferrite beads are usually quite small and as a result only one pass, or a small number of turns are possible. On the other hand, a toroidal core usually has a much larger ID and will accept a greater number of turns. If a large amount of impedance is required the ferrite core can be used to advantage, since the impedance increases as to the number of turns squared.

The number of turns on a single hole Ferrite bead or a toroidal core is identified by the number of times the conductor passes through the center hole. To physically complete one turn it would be necessary to cause the wires to meet on the outside of the device, however the bead or core does not care about the termination of each end of the wire and considers each pass through the center hole as one turn. (This does not apply to multihole beads)

When winding a six-hole bead, the impedance depends upon the exact winding pattern. For instance, it can be wound clock-wise or counter clock-wise progressively from hole to hole, or criss-crossed from side to side, or each turn can be completed around the outside of the bead. Each type of winding will produce very different results. The impedance figures for the six-hole bead in our chart is based on the current industry standard, which is two and one half turns threaded through the holes, criss-crossing from one side to the other.

Temperature rise above the Curie point will cause the bead to become non-magnetic, rendering it useless as a noise attenuating device. Depending on the material, Curie temperature can run anywhere from 120^{o}C to 500^{o}C . See 'Magnetic Properties' chart for specifics.

The #73 and #75 materials, as well as other very high permeability materials are semi-conductive and care should be taken not to position the cores or beads in such a manner that they would be able to short uninsulated leads together, or to ground. Other lower permeability materials with higher resistivity are non-conductive and this precaution is not necessary.

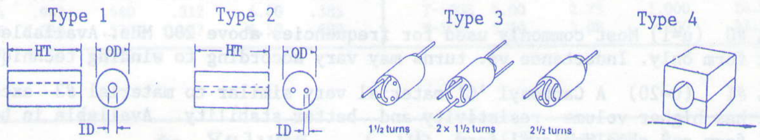
Ferrite Shielding Beads

Part number \/	Bead type	Dimensions (inches) OD	ID	Hgt	A_L of Materials (mh/1000 turns) 43	64	73	75	77	Impedance factor*
FB-(--)-101	1	.138	.051	.128	510	150	1500	3000	----	1.00
FB-(--)-201	1	.076	.043	.150	360	110	1100	----	----	0.70
FB-(--)-301	1	.138	.051	.236	1020	300	3000	----	----	2.00
FB-(--)-801	1	.296	.094	.297	1300	390	3900	----	----	2.60
FB-(64}-901	2	.250	.050	.417	----	1130	----	----	----	7.50 **
FB-(--)-1801	1	.200	.062	.437	2000	590	5900	----	----	3.90
FB-(--)-2401	1	.380	.197	.190	520	----	1530	----	----	1.02
FB-(--)-5111	3	.236	.032	.394	3540	1010	----	----	----	6.70 ***
FB-(--)-5621	1	.562	.250	1.125	3800	----	----	----	9600	6.40
FB-(--)-6301	1	.375	.194	.410	1100	----	----	----	2600	1.70
FB-(43)-1020	1	1.000	.500	1.112	3200	----	----	----	----	6.20
FB-(77)-1024	1	1.000	.500	.825	----	----	----	----	5600	3.70
2X-(43)-151	4	1.020	.500	1.125	Split bead, 43 Mat. Z=159 @ 25 MHz.				Z=245 @ 100 MHz	
2X-(43)-251	4	.590	.250	1.125	Split bead, 43 mat. Z=171 @ 25 Mhz.				Z=275 @ 100 MHz.	

Notes: Complete the part number by adding material number in space (--) provided.

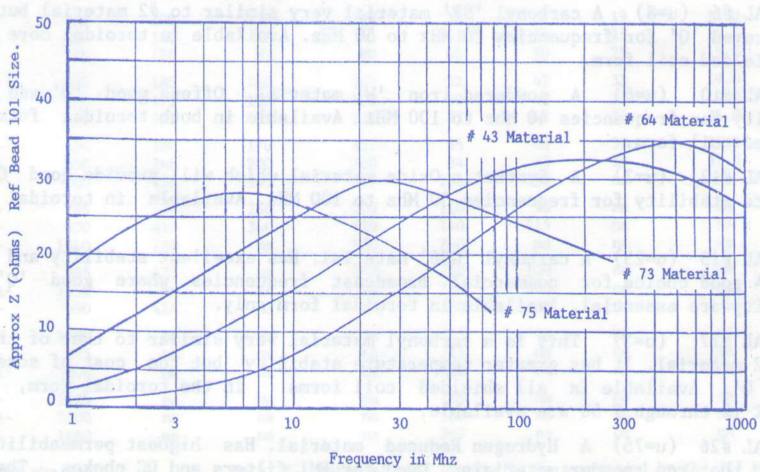
A_L values based on low frequency measurements. (mh/1000 turns) = nanohenries/turns^2

** Based on a single 'U-turn' winding. *** Based on a 2 1/2 turn, side to side winding.



Material vs Frequency vs Impedance

* Impedance Factor: This chart is based upon the '101' size bead. Impedances for other size beads may be approximated as follows: Find the 'Z' of the same material at your operating frequency in the chart below. Multiply that 'Z' by the Impedance Factor shown above.



Ferrites for RFI

Ferrite toroidal cores, as well as beads, can be very useful in attenuation of unwanted RF signals but we do not claim them to be a cure-all for all RFI problems. There are different types of noise sources, each of which may require a different approach. When dealing with any noise problem it is helpful to know the frequency of the interference. This is valuable when trying to determine the correct material as well as the maximum turns count.

RFI emanating from such sources as computers, flashing signs, switching devices, diathermy machines, etc. are very rich in harmonics and can create noise in the high and very high frequency regions. For this type of interference, the #43 material is probably the best choice since it has very good attenuation in the 20 MHz to 400 MHz. region. Some noise problems may require additional filtering with hi-pass or lo-pass filters. If the noise is of the differential-mode type, an AC line filter may be required. See section on AC line filters and DC chokes.

In some cases the selected core will allow only one pass of the conductor, which is considered to be one turn. In other cases it may be possible to wind several turns on to the core. When installing additional cores on the same conductor, impedance will be additive. When multiple turns are passed through a core, the impedance will increase in relation to the number of turns squared.

Keep in mind that because of the wide overlap in frequency range of the various materials, more than one material can provide acceptable results. Normally, the 43 material is recommended for frequency attenuation above 30 MHz., the 77, and 'F' materials for the amateur band, and the 'J' or materials for everything lower than the amateur band.

Computers are notorious for RF radiation, especially some of the older models which were made when RFI requirements were quite minimal. RFI can radiate from inter-connecting cables, AC power cords and even from the cabinet itself. ALL of these sources must be eliminated before complete satisfaction can be achieved. First, examine the computer cabinet to make sure that good shielding and grounding practices have been followed. If not, do what you can to correct it. If you suspect that RF is feeding back into the AC power system from your computer, wrap the power cord through an FT-240-77 toroidal core 6 to 9 times. This will act as an RF choke on the power cord and should prevent RF from feeding back into the power system where it can affect other electronic devices.

It is possible for an unwanted RF signal to enter a piece of equipment by more than one path, If so, ALL of these paths must be blocked before there will be noticeable effect. Don't overlook the fact that RFI may be entering the equipment by radiation directly from your antenna feed line due to high SWR. This, of course, can be checked with an SWR meter, and can be corrected by installing an antenna balun, or by placing a few ferrite beads, or sleeves, over the transmission line at the antenna feed point. This should prevent RF reflection back into the outside shield of the coax feed line, which could radiate RFI.

Split bars are especially designed for computer flat ribbon cables. Two or more cores can be placed on the same cable, in which case the impedance will be additive. See following page for more specific information.

RFI in telephones can be substantially reduced with the insertion of an RF choke in each side of the talk circuit. Wind two FT-50A-75 cores with about 20 turns each of #26 enamelled wire. If possible, place one in each side of the talk circuit within the telephone base. If this is not possible, try mounting them in a small box with phone modular input and output jacks mounted in each end. This can now be used 'in-line' between the phone and the wall jack. Similar results can be achieved by winding 6 to 9 turns of the telephone-to-wall cable through an FT-140-J ferrite toroidal core.