

## Modelling Non-Linear Transformer Cores for SPICE 2 and 3

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### Introduction

Vcores is a utility which produces a magnetic core model, based on the magnetic parameters of any of 480 Orthonol tape-wound, Permalloy 80 tape-wound or Ferroxcube 3c8 Ferrite core types.

Orthonol types range from 52000 to 80619, in sizes 1/8AMA, 1/4AMA, 1/2AMA and 1AMA. Certain types (M52000 to M52425) only have sizes of 1/2A, 1A, 2A and 4A

Permalloy types range from 52000 to 80619, in sizes 1/8DMA, 1/4DMA, 1/2DMA and 1DMA. Certain types (M52000 to M52425) only have sizes of 1/2D, 1D, 2D and 4D.

Supported Ferrite types are

Ferrite3C8 P1107  
Ferrite3C8 P1408  
Ferrite3C8 P1811  
Ferrite3C8 P2213  
Ferrite3C8 P2626  
Ferrite3C8 P3019  
Ferrite3C8 P3622  
Ferrite3C8 P4229  
Ferrite3C8 P6656  
Ferrite3C8 P704  
Ferrite3C8 P905

Vcores knows the following parameters of each magnetic material:

BI	Initial Flux density (gauss)
BR	Remanent Flux density (gauss)
FU3DB	Frequency (Hz): Imag reactance=loss resistance
UMAX	Maximum permeability (dB/dH)
USAT	Saturation/min permeability (dB/dH)
AC	Core area
LP	Magnetic path length
N	User supplied turns ratio (N:1)

A complete list of all supported part numbers is in the file **lib/mag/parts.list**.

A typical conversation with Vcores follows the following format:

**csh%[100] Vcores**

**Vcores can generate model params for the Middlebrook transformer model. It knows values for 480 core types in Orthonol, Permalloy or Ferrite**

**It will also create a GEX drawing of the core model which you can add to the transformer schematic.**

**You will be prompted for the type, then for the part number without the extension. e.g for M52000-1/2A enter 'M52000'  
Then, when prompted for the size, you can specify '1/2A' by typing '3'**

**Vcores will calculate the circuit values for the components of the core model, and create a schematic and body drawing. Use the core with the 'windings' template in the 'mag' library supplied with Vspice.**

**Note: these cores only work with this transformer model, and will NOT work with a simple SPICE transformer.**

**Enter core type (1=Orthonol 2=Permalloy 3=Ferrite):  
Enter 0 to hand-enter core characteristics:**

**1**

**Enter part number without suffix e.g M52000  
Or enter a name for a custom part you wish to define by hand:  
M52000**

**Turns (N:1) default=1:**

**1**

**Initial flux density (default=0) (gauss):**

**0**

**Enter 1 for 1/8AMA 2 for 1/4AMA**

**3 for 1/2AMA 4 for 1AMA:**

**5 for 1/2A 6 for 1A :**

**7 for 2A 8 for 4A :**

**7**

**AC = 8.6000e-02 LP = 4.9900e+00 FU3DB = 3.8000e+04  
BR = 1.4000e+04 UMAX = 7.5000e+04 USAT = 2.0000e+03  
Creating directory >m52000<**

**csh%[101] ls m52000**

**body.1.1 spice.1.1 spice\_cn.1.1**

If you do type 0 to hand-enter values for an unsupported part, you will be prompted as follows for the values of AC, LP, FU3DB, N, BI, BR, UMAX and USAT

**Enter 0 to hand-enter core characteristics:**

**0**

**Enter part number without suffix e.g M52000**

**Or enter a name for a custom part you wish to define by hand:**

**Ycore**

**Turns (N:1) default=1:**

**1**

**Initial flux density (default=0) (gauss):**

**0**

**Flux density at H=0 (gauss) for saturated loop:**

**14e3**

**Maximum permeability (db/dH):**

**75e3**

**Saturation/min permeability (db/dH):**

**2e3**

**Enter core area (cm<sup>2</sup>)**

**0.5**

**Magnetic path length (cm):**

**4.99**

**Frequency at which Imag reactance=loss resistance (Hz):**

**150e3**

**AC = 5.0000e-01 LP = 4.9900e+00 FU3DB = 1.5000e+05**

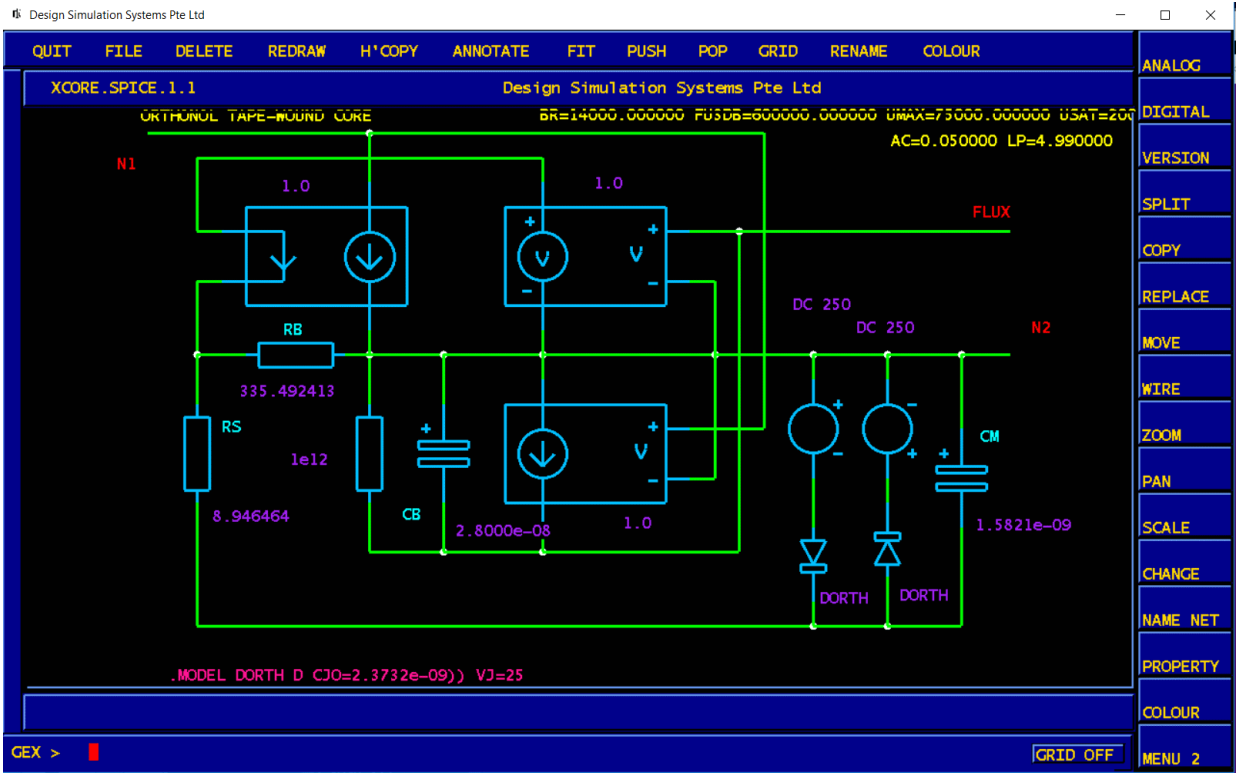
**BR = 1.4000e+04 UMAX = 7.5000e+04 USAT = 2.0000e+03**

**Creating directory >ycore<**

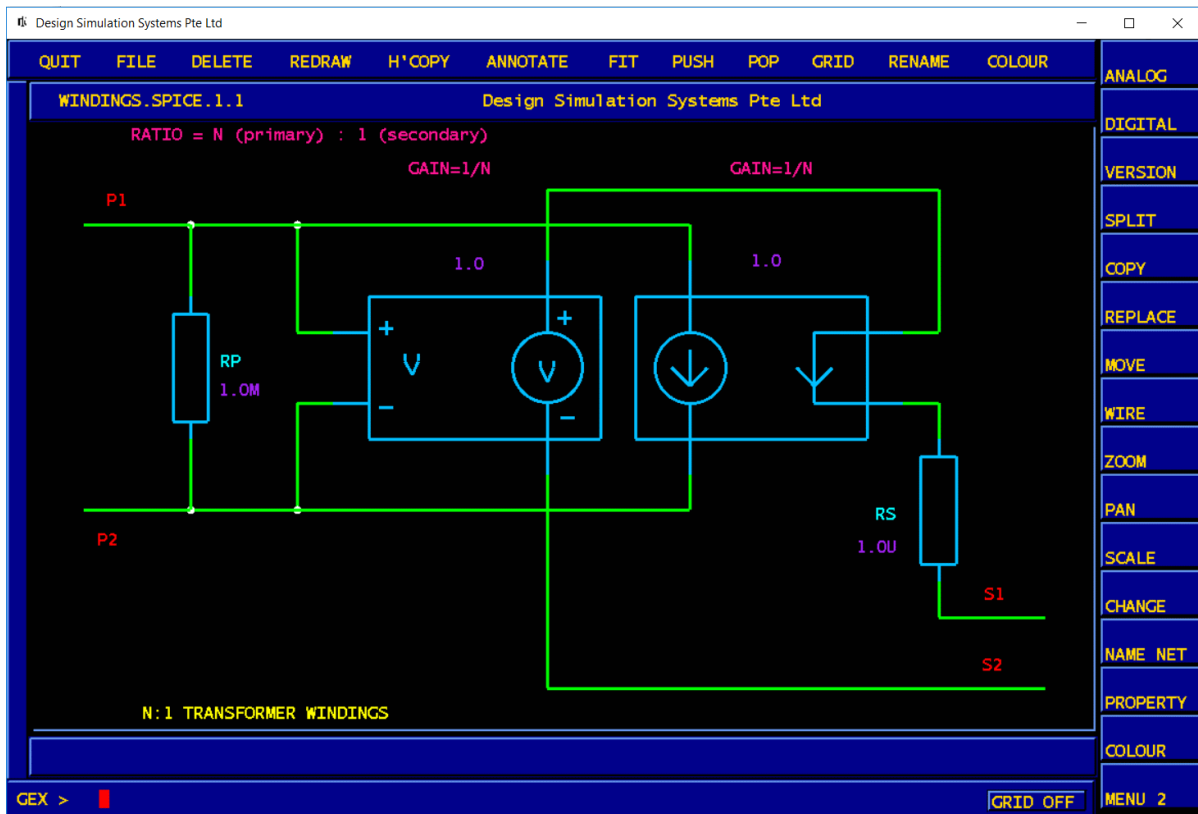
**csh%[6] ls ycore**

**body.1.1 spice.1.1 spice\_cn.1.1**

As may be seen, when Vcores has all the data it needs, it calculates the model parameters for the common core model shown below, and creates a schematic drawing, and a body drawing

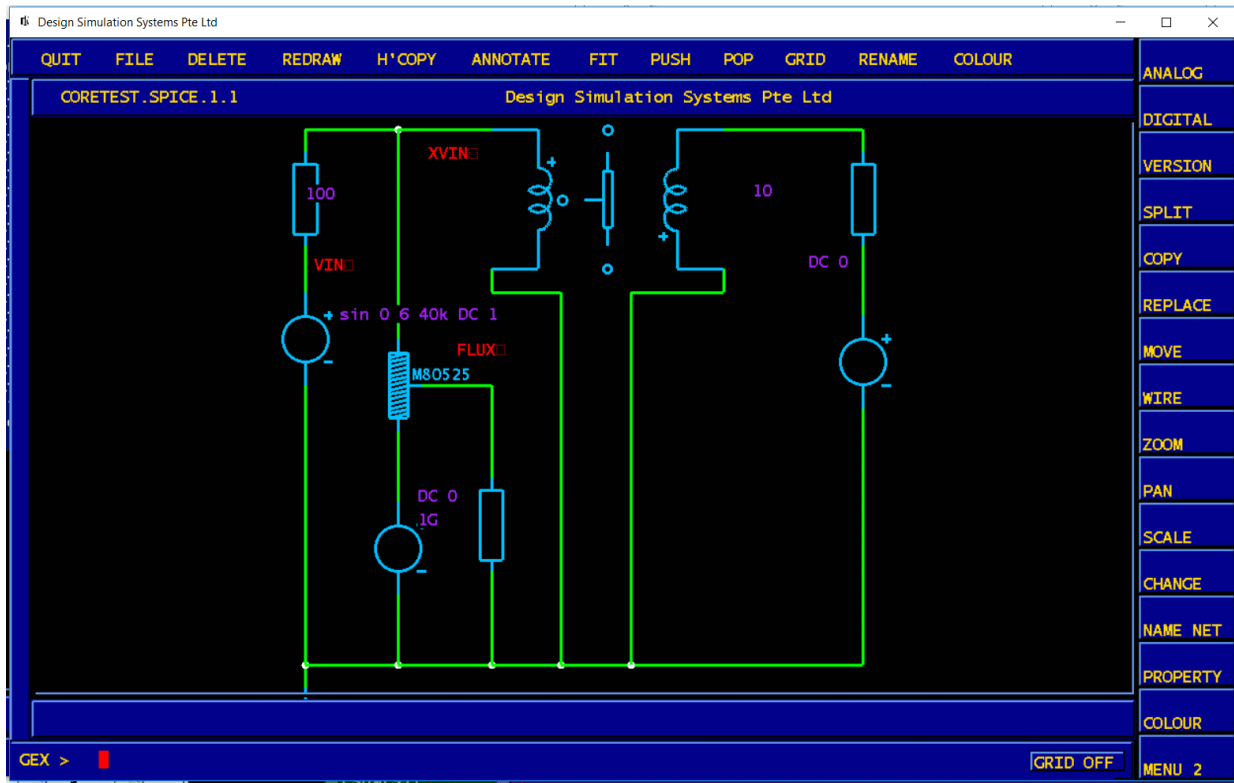


This core is compatible with the transformer model usually ascribed to Middlebrook, and shown below:

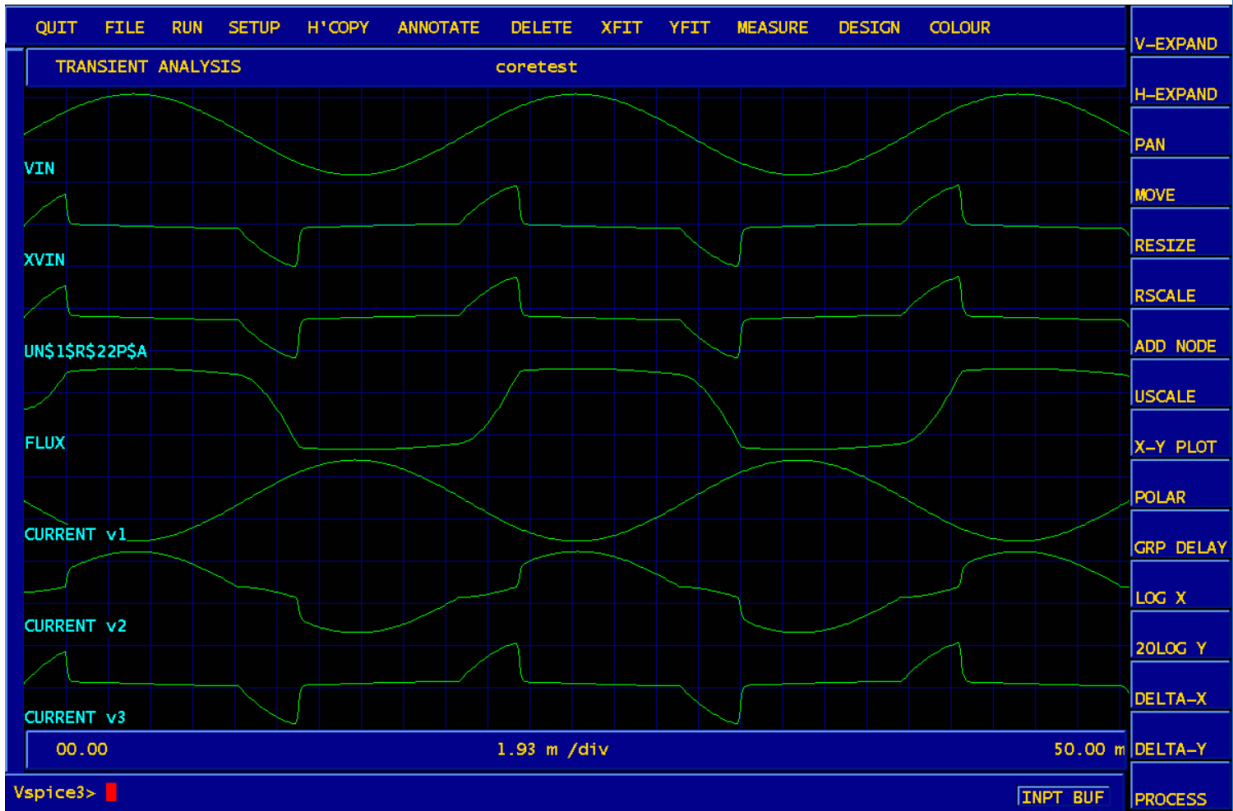


Users are encouraged to create their own multi-winding versions of this model, and to add their favourite leakage inductance model components to it.

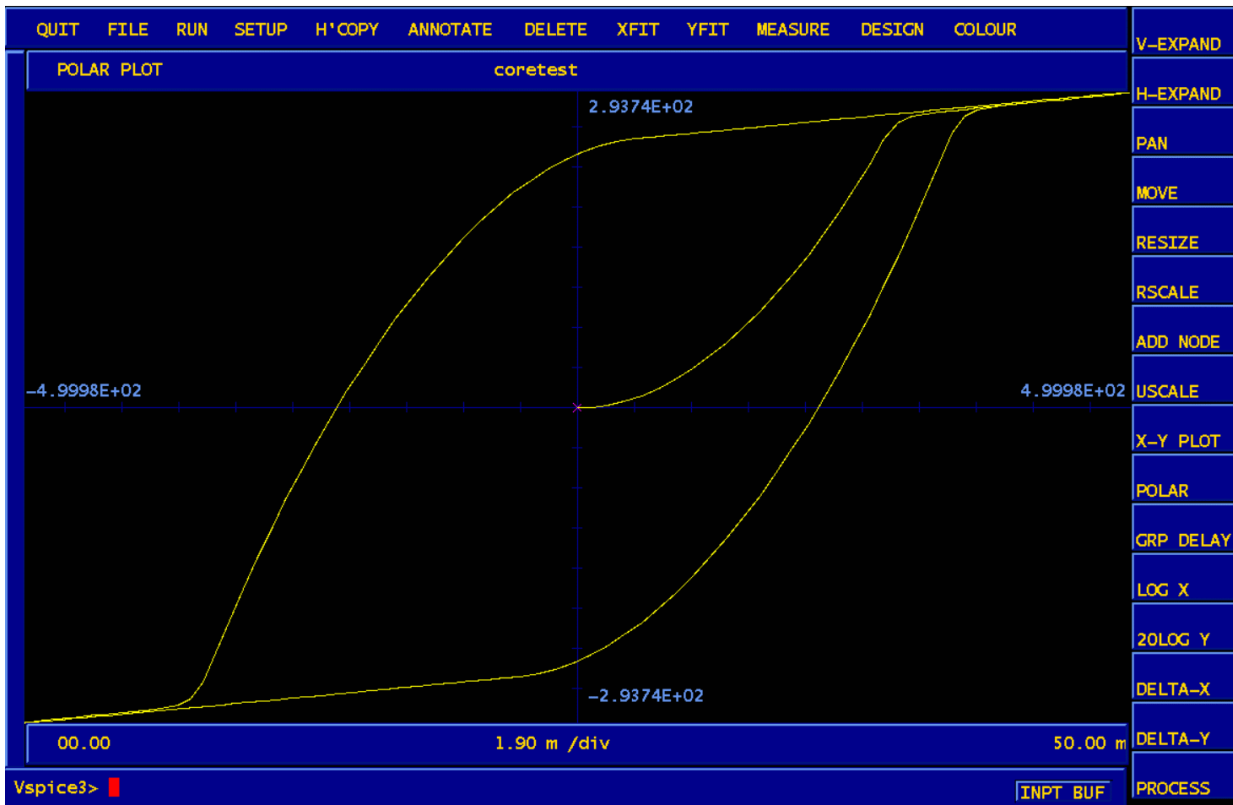
The body drawing created by Vcores allows the new core to be used as a component. For example, the following test circuit shows a transformer created from the above two components.



Compiling and simulating the above circuit gives the results shown below. A useful feature of this core model is that the magnetic flux value is available for plotting, and may be seen as the fourth waveform from the top.



Plotting the input current against the flux gives the following B-H loop.



## Appendix 1

### Supported Ferroxcube F3C8 cores

Ferrite3C8 P1107  
 Ferrite3C8 P1408  
 Ferrite3C8 P1811  
 Ferrite3C8 P2213  
 Ferrite3C8 P2626  
 Ferrite3C8 P3019  
 Ferrite3C8 P3622  
 Ferrite3C8 P4229  
 Ferrite3C8 P6656  
 Ferrite3C8 P704  
 Ferrite3C8 P905

### Supported Orthonol Cores

M52000-1/2A	M52032-2A		M80512-1/2AMA	M80550-1/8AMA
M52000-1A	M52032-4A		M80512-1/4AMA	M80550-1AMA
M52000-2A	M52035-1/2A	M80512-1/8AMA	M80558-1/2AMA	M80613-1/8AMA
M52000-4A	M52035-1A		M80512-1AMA	
M52001-1/2A	M52035-2A		M80516-1/2AMA	M80558-1/8AMA
M52001-1A	M52035-4A		M80516-1/4AMA	M80558-1AMA
M52001-2A	M52038-1/2A	M80516-1/8AMA	M80560-1/2AMA	M80614-1/8AMA
M52001-4A	M52038-1A		M80516-1AMA	
M52002-1/2A	M52038-2A		M80517-1/2AMA	M80560-1/8AMA
M52002-1A	M52038-4A		M80517-1/4AMA	M80560-1AMA
M52002-2A	M52042-1/2A	M80517-1/8AMA	M80581-1/2AMA	M80615-1/8AMA
M52002-4A	M52042-1A		M80517-1AMA	
M52004-1/2A	M52042-2A		M80521-1/2AMA	M80581-1/8AMA
M52004-1A	M52042-4A		M80521-1/4AMA	M80581-1AMA
M52004-2A	M52056-1/2A	M80521-1/8AMA	M80588-1/2AMA	M80616-1/8AMA
M52004-4A	M52056-1A		M80521-1AMA	
M52007-1/2A	M52056-2A		M80523-1/2AMA	M80588-1/8AMA
M52007-1A	M52056-4A		M80523-1/4AMA	M80588-1AMA
M52007-2A	M52061-1/2A	M80523-1/8AMA	M80598-1/2AMA	M80617-1/8AMA
M52007-4A	M52061-1A		M80523-1AMA	
M52011-1/2A	M52061-2A		M80524-1/2AMA	M80598-1/8AMA
M52011-1A	M52061-4A		M80524-1/4AMA	M80598-1AMA
M52011-2A	M52076-1/2A	M80524-1/8AMA	M80600-1/2AMA	M80618-1/8AMA
M52011-4A	M52076-1A		M80524-1AMA	
M52017-1/2A	M52076-2A		M80525-1/2AMA	M80600-1/8AMA
M52017-1A	M52076-4A		M80525-1/4AMA	M80600-1AMA
M52017-2A	M52103-1/2A	M80525-1/8AMA	M80606-1/2AMA	M80619-1/8AMA
M52017-4A	M52103-1A		M80525-1AMA	
M52022-1/2A	M52103-2A		M80529-1/2AMA	M80606-1/8AMA
M52022-1A	M52103-4A		M80529-1/4AMA	M80606-1AMA
M52022-2A	M52106-1/2A	M80529-1/8AMA	M80608-1/2AMA	
M52022-4A	M52106-1A		M80529-1AMA	
M52026-1/2A	M52106-2A		M80530-1/2AMA	M80608-1/8AMA
M52026-1A	M52106-4A		M80530-1/4AMA	M80608-1AMA
M52026-2A	M52128-1/2A	M80530-1/8AMA	M80609-1/2AMA	

M52026-4A	M52128-1A		M80530-1AMA	
M52029-1/2A	M52128-2A		M80531-1/2AMA	M80609-1/8AMA
M52029-1A	M52128-4A		M80531-1/4AMA	M80609-1AMA
M52029-2A	M52168-1/2A	M80531-1/8AMA	M80610-1/2AMA	
M52029-4A	M52168-1A		M80531-1AMA	
M52030-1/2A	M52168-2A		M80539-1/2AMA	M80610-1/8AMA
M52030-1A	M52168-4A		M80539-1/4AMA	M80610-1AMA
M52030-2A	M52425-1/2A	M80539-1/8AMA	M80611-1/2AMA	
M52030-4A	M52425-1A		M80539-1AMA	
M52031-1/2A	M52425-2A		M80544-1/2AMA	M80611-1/8AMA
M52031-1A	M52425-4A		M80544-1/4AMA	M80611-1AMA
M52031-2A	M80505-1/2AMA	M80544-1/8AMA	M80612-1/2AMA	
M52031-4A	M80505-1/4AMA	M80544-1AMA		M80612-1/4AMA
M52032-1/2A	M80505-1/8AMA	M80550-1/2AMA	M80612-1/8AMA	
M52032-1A	M80505-1AMA	M80550-1/4AMA	M80612-1AMA	
M52000-1/2A	M52032-2A		M80512-1/2AMA	M80550-1/8AMA

### Supported Permalloy Cores

M52000-1/2D	M52032-2D		M80512-1/2DMA	M80550-1/8DMA
M52000-1D	M52032-4D		M80512-1/4DMA	M80550-1DMA
M52000-2D	M52035-1/2D	M80512-1/8DMA	M80558-1/2DMA	M80613-1/8DMA
M52000-4D	M52035-1D		M80512-1DMA	
M52001-1/2D	M52035-2D		M80516-1/2DMA	M80558-1/8DMA
M52001-1D	M52035-4D		M80516-1/4DMA	M80558-1DMA
M52001-2D	M52038-1/2D	M80516-1/8DMA	M80560-1/2DMA	M80614-1/8DMA
M52001-4D	M52038-1D		M80516-1DMA	
M52002-1/2D	M52038-2D		M80517-1/2DMA	M80560-1/8DMA
M52002-1D	M52038-4D		M80517-1/4DMA	M80560-1DMA
M52002-2D	M52042-1/2D	M80517-1/8DMA	M80581-1/2DMA	M80615-1/8DMA
M52002-2D	M52042-1D		M80517-1DMA	
M52002-4D	M52042-2D		M80521-1/2DMA	M80581-1/8DMA
M52002-4D	M52042-4D		M80521-1/4DMA	M80581-1DMA
M52004-1/2D	M52056-1/2D	M80521-1/8DMA	M80588-1/2DMA	M80616-1/8DMA
M52004-1D	M52056-1D		M80521-1DMA	
M52004-2D	M52056-2D		M80523-1/2DMA	M80588-1/8DMA
M52004-4D	M52056-4D		M80523-1/4DMA	M80588-1DMA
M52007-1/2D	M52061-1/2D	M80523-1/8DMA	M80598-1/2DMA	M80617-1/8DMA
M52007-1D	M52061-1D		M80523-1DMA	
M52007-2D	M52061-2D		M80524-1/2DMA	M80598-1/8DMA
M52007-4D	M52061-4D		M80524-1/4DMA	M80598-1DMA
M52011-1/2D	M52076-1/2D	M80524-1/8DMA	M80600-1/2DMA	M80618-1/8DMA
M52011-1D	M52076-1D		M80524-1DMA	
M52011-2D	M52076-2D		M80525-1/2DMA	M80600-1/8DMA
M52011-4D	M52076-4D		M80525-1/4DMA	M80600-1DMA
M52017-1/2D	M52103-1/2D	M80525-1/8DMA	M80606-1/2DMA	M80619-1/8DMA
M52017-1D	M52103-1D		M80525-1DMA	
M52017-2D	M52103-2D		M80529-1/2DMA	M80606-1/8DMA
M52017-4D	M52103-4D		M80529-1/4DMA	M80606-1DMA
M52022-1/2D	M52106-1/2D	M80529-1/8DMA	M80608-1/2DMA	
M52022-1D	M52106-1D		M80529-1DMA	
M52026-1/2D	M52106-2D		M80530-1/2DMA	M80608-1/8DMA
M52026-1D	M52106-4D		M80530-1/4DMA	M80608-1DMA



M52026-2D	M52128-1/2D	M80530-1/8DMA	M80609-1/2DMA	
M52026-4D	M52128-1D		M80530-1DMA	
M52029-1/2D	M52128-2D		M80531-1/2DMA	M80609-1/8DMA
M52029-1D	M52128-4D		M80531-1/4DMA	M80609-1DMA
M52029-2D	M52168-1/2D	M80531-1/8DMA	M80610-1/2DMA	
M52029-4D	M52168-1D		M80531-1DMA	
M52030-1/2D	M52168-2D		M80539-1/2DMA	M80610-1/8DMA
M52030-1D	M52168-4D		M80539-1/4DMA	M80610-1DMA
M52030-2D	M52425-1/2D	M80539-1/8DMA	M80611-1/2DMA	
M52030-4D	M52425-1D		M80539-1DMA	
M52031-1/2D	M52425-2D		M80544-1/2DMA	M80611-1/8DMA
M52031-1D	M52425-4D		M80544-1/4DMA	M80611-1DMA
M52031-2D	M80505-1/2DMA	M80544-1/8DMA	M80612-1/2DMA	
M52031-4D	M80505-1/4DMA	M80544-1DMA		M80612-1/4DMA
M52032-1/2D	M80505-1/8DMA	M80550-1/2DMA	M80612-1/8DMA	
M52032-1D	M80505-1DMA	M80550-1/4DMA	M80612-1DMA	
M52000-1/2D	M52032-2D		M80512-1/2DMA	M80550-1/8DMA

