Prototype and Testing

The prototype will be constructed using cylindrical neodymium magnets, a toroidal ferrite core with, 42 AWG enameled magnet wire, and a thin mu-metal sheet for shielding. Neodymium (NdFeB) magnets were chosen because they are stronger than AlNiCo magnets of the same size and are more commonly supplied. Documentation for the magnet and ferrite core can be found below. An alternative to using ferrite for the core would be silicon "electrical" steel, which is often used in AC transformers due to its high field intensity saturation and electrical resistivity. This material is a specialty steel that is usually not sold off the shelf, although several different suppliers exist, for instance AK steel. Use of silicon steel could involve ordering a bar of raw material and machining it into an appropriate shape. The sheet of mu-metal I purchased is on the cheaper end. A more effective and expensive option would be permalloy sheets.

An initial test is to measure the raw output of the pickup with a voltmeter or oscilloscope. The input signal should be generated by an oscillating electric guitar string above the pickup, and an adjacent string will be used to test for isolation. Ideally, the pickup would not have to be embedded inside of a guitar body to perform the test. In other words, the string(s) would be set up outside of a guitar. A designated portion of the adjacent string can be magnetized with two bar magnets. The signal generated from the movement of the adjacent string must be insignificant compared to that of the string directly above the pickup. A benchmark that would indicate ideal isolation is for the amplitude of the signal of the undesired string to be $1/100^{th}$ (-40db) of the amplitude of the desired string. To test the cancellation of noise, any non-shielded power cable carrying 60HZ at residential voltage can placed nearby or held above the pickup. In this case the output signal should be insignificant.

D2H2 Specification Sheet

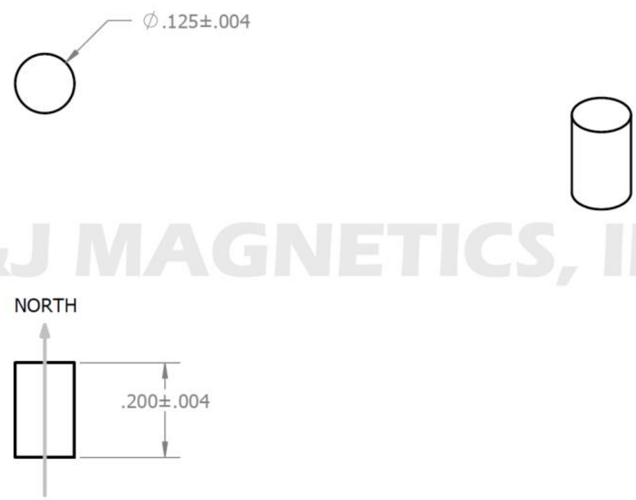
Product Specifications

Type:	DISC
Dimensions:	0.125 dia x 0.2 thk (in)
Tolerance:	All dimensions ± 0.004 in
Material:	NdFeB, Grade N42
Plating:	NiCuNi
Max Op Temp:	176ºF (80ºC)
Br max:	13,200 Gauss
BH max:	42 MGOe

Performance Specifications

Pull Force, Case 1, Magnet to a Steel Plate:	0.79 lb

Surface Field values are derived from calculation and verification with experimental testing. These values are the field values at the surface of the magnet, centered on the axis of magnetization. Measurement of the B field with a magnetometer may yield varying results, depending on the geometry of your sensor. Pull Force values are based on extensive product testing in our laboratory. Different configurations of magnets and surrounding ferromagnetic materials may substantially alter your results.



GRADE:	N42
Br:	13,000-13,200 GAUSS
BHmax:	40-42 MGOe
CURIE TEMP:	310˚C
PLATING:	NICKEL-COPPER-NICKEL PLATING

NOTE: ALL EDGES HAVE A CHAMFER/RADIUS NOT TO EXCEED 1/32"

UNLESS OTHERWISE SPECIFIED, DIMENSIONS ARE IN INCHES

TOLERANCES:
FRACTIONAL: ± 0.030
ANGULAR: ± 1˚
TWO PLACE DECIMAL: ± 0.004
THREE PLACE DECIMAL: ± 0.004

MATERIAL SEE NOTES
FINISH SEE NOTES

K&J Magnetics, Inc.

TITLE: DISC/CYLINDER MAGNET

SIZE	DWG. NO.	REV
A	D2H2	1

SCALE: 4:1 | DO NOT SCALE DRAWING | SHEET 1 OF 1

Fair-Rite Products Corp.
Your Signal Solution®
Ferrite Components for the Electronics Industry

Fair-Rite Products Corp. PO Box J,One Commercial Row, Wallkill, NY 12589-0288
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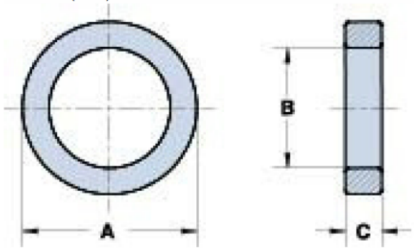
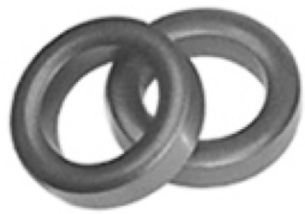
Fair-Rite Product's Catalog
Part Data Sheet, 5977001101
Printed: 2014-06-11

RoHS Material Declaration





Part Number:	5977001101
Frequency Range:	Medium Permeability, 77 (ui=2000) & 78 (ui=2300) materials
Description:	77 TOROID
Application:	Inductive Components
Where Used:	Closed Magnetic Circuit
Part Type:	Toroids

Mechanical Specifications

Weight: 2.400 (g)

Part Type Information

A ring configuration provides the ultimate utilization of the intrinsic ferrite material properties. Toroidal cores are used in a wide variety of applications such as power input filters, ground-fault interrupters, common-mode filters and in pulse and broadband transformers.

-Toroids are listed by initial permeability classes and increasing dimension of the inside diameter.

-All toroidal cores are supplied burnished to break sharp edges.

-Toroids are tested for AL values at 10 kHz.

-Toroids with an outside diameter of 9.5mm (.375") or smaller can be supplied Parylene C coated. The Parylene coating will increase the 'A' and 'C' dimensions and decrease the 'B' dimension a maximum of 0.038mm (.0015"). The ninth digit of a Parylene coated toroid part number is a '1'. See the material characteristics of Parylene C in our online catalog.

-Toroids with an outside diameter of 9.5mm (.375") or larger can be supplied with a uniform coating of thermo-set plastic coating. This coating will increase the 'A' and 'C' dimensions and decrease the 'B' dimension a maximum of 0.5mm (.020"). The 9th digit of the thermo-set plastic coated toroid part number is a '2'. Thermo-set plastic coating is RoHS compliant.

-Thermo-set plastic coated parts can withstand a minimum breakdown voltage of 1000 Vrms, uniformly applied across the 'C' dimension of the toroid.

-The "C" dimension may be modified to suit specific applications.

-For any toroidal core requirement not listed in the catalog, please contact our customer service department for availability and pricing.

-Explaination of Part Numbers: Digits 1&2 = product class, 3&4 = material grade, 9th digit 1 = Parylene coating, 2 = thermo-set plastic coating.

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Mechanical Specifications

Dim	mm	mm tol	nominal inch	inch misc.
A	12.70	±0.25	0.500	-
B	7.90	±0.20	0.312	-
C	6.35	±0.25	0.250	-
D	-	-	-	-
E	-	-	-	-
F	-	-	-	-
G	-	-	-	-
H	-	-	-	-
J	-	-	-	-
K	-	-	-	-

Electrical Specifications

Typical Impedance (Ω)	

Electrical Properties	
A_L (nH)	1300 ±25%
Ae(cm^2)	0.15000
Σl/A(cm^{-1})	20.80
l_e (cm)	3.12
V_e (cm^3)	0.47000

Land Patterns

V	W ref	X	Y	Z
- -	- -	- -	- -	- -

Winding Information

Turns Tested	Wire Size	1st Wire Length	2nd Wire Length
-	-	-	-

Reel Information

Tape Width mm	Pitch mm	Parts 7 " Reel	Parts 13 " Reel	Parts 14 " Reel
-	-	-	-	-

Package Size

Pkg Size
- (-)

Connector Plate

# Holes	# Rows
-	-

Legend

+ Test frequency

Preferred parts, the suggested choice for new designs,have shorter lead times and are more readily available.

The column H(Oe) gives for each bead the calculated dc bias field in oersted for 1 turn and 1 ampere direct current. The actual dc H field in the application is this value of H times the actual NI (ampere-turn) product. For the effect of the dc bias on the impedance of the bead material, see figures 18-23 in the application note How to choose Ferrite Components for EMI Suppression.

A ½ turn is defined as a single pass through a hole.

Σl/A - Core Constant

A_e: Effective Cross-Sectional Area

A_L - Inductance Factor $(\frac{L}{N^2})$

N/AWG - Number of Turns/Wire Size for Test Coil

l_e: Effective Path Length

V_e: Effective Core Volume

NI - Value of dc Ampere-turns

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Ferrite Material Constants

Specific Heat	0.25 cal/g/°C
Thermal Conductivity	**3.5 - 4.5 mW/cm** - °C
Coefficient of Linear Expansion	8 - $10x10^{-6}$/°C
Tensile Strength	4.9 kgf/mm^2
Compressive Strength	42 kgf/mm^2
Young's Modulus	$15x10^3$ kgf/mm^2
Hardness (Knoop)	650
Specific Gravity	≈ 4.7 g/cm^3

The above quoted properties are typical for Fair-Rite MnZn and NiZn ferrites.

See next page for further material specifications.

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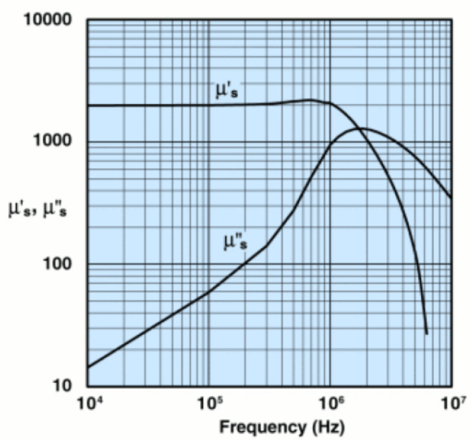
A MnZn ferrite for use in a wide range of high and low flux density inductive designs for frequencies up to 100 kHz.

Pot cores, E&I cores, U cores, rods, toroids, and bobbins are all available in 77 material.

77 Material Characteristics:

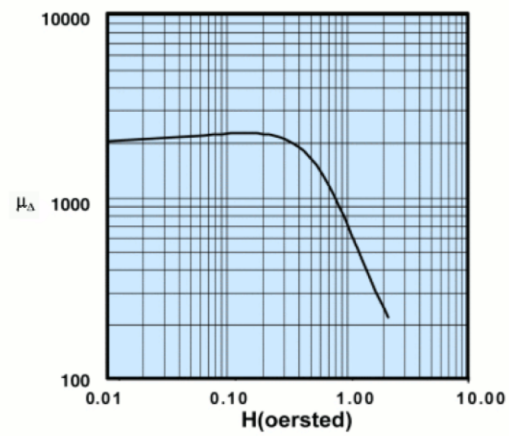
Property	Unit	Symbol	Value
Initial Permeability @ B < 10 gauss		μ_i	2000
Flux Density @ Field Strength	gauss / oersted	B / H	4900 / 5
Residual Flux Density	gauss	B_r	1800
Coercive Force	oersted	H_c	0.30
Loss Factor @ Frequency	10^{-6} / MHz	$\tan\delta/\mu_i$	15 / 0.1
Temperature Coefficient of Initial Permeability (20 -70°C)	%/°C		0.7
Curie Temperature	°C	T_c	>200
Resistivity	Ω cm	ρ	$1x10^2$

Complex Permeability vs. Frequency

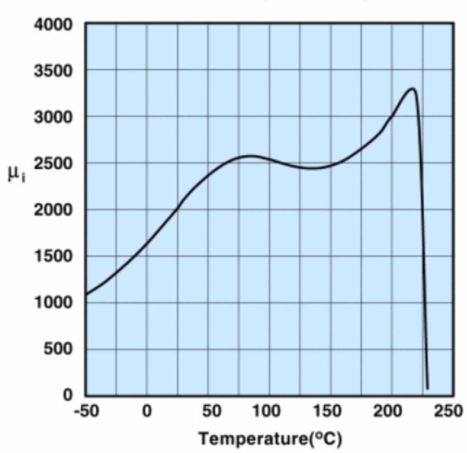


Measured on an 18/10/6mm toroid using the HP 4284A and the HP 4291A.

Incremental Permeability vs. H

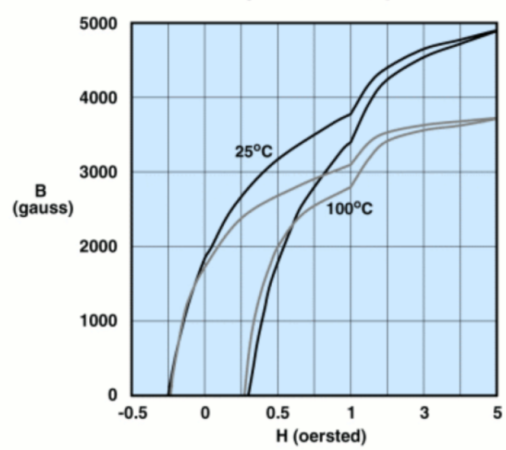


Initial Permeability vs. Temperature



Measured on an 18/10/6mm toroid at 100kHz.

Hysteresis Loop



Measured on an 18/10/6mm toroid at 10kHz.

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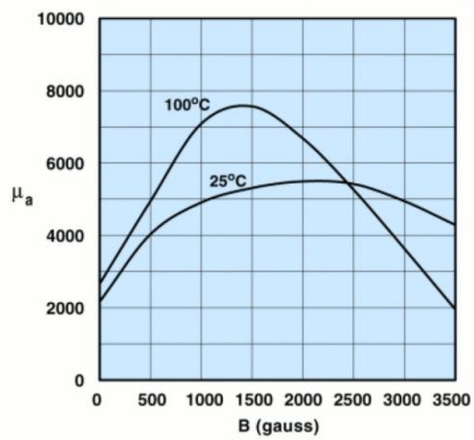
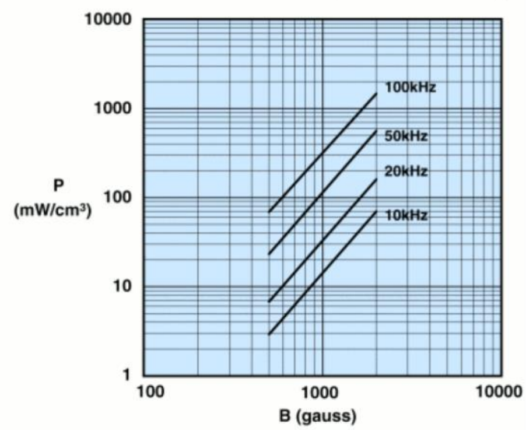
Amplitude Permeability vs. Flux Density



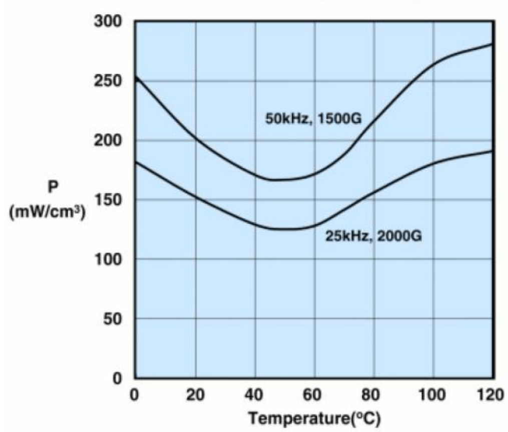
Measured on an 18/10/6mm toroid at 10kHz.

Power Loss Density vs. Flux Density



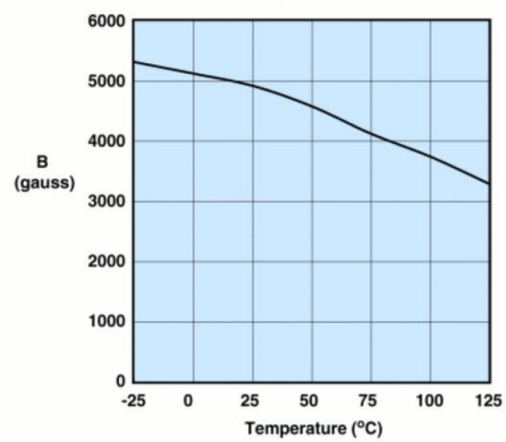
Measured on an 18/10/6mm toroid using the Clarke Hess 258 VAW at 100°C

Power Loss Density vs. Temperature



Measured on an 18/10/6mm toroid using the Clarke Hess 258 VAW.

Flux Density vs. Temperature



Measured on an 18/10/6mm toroid at 10kHz and H=5 oersted.