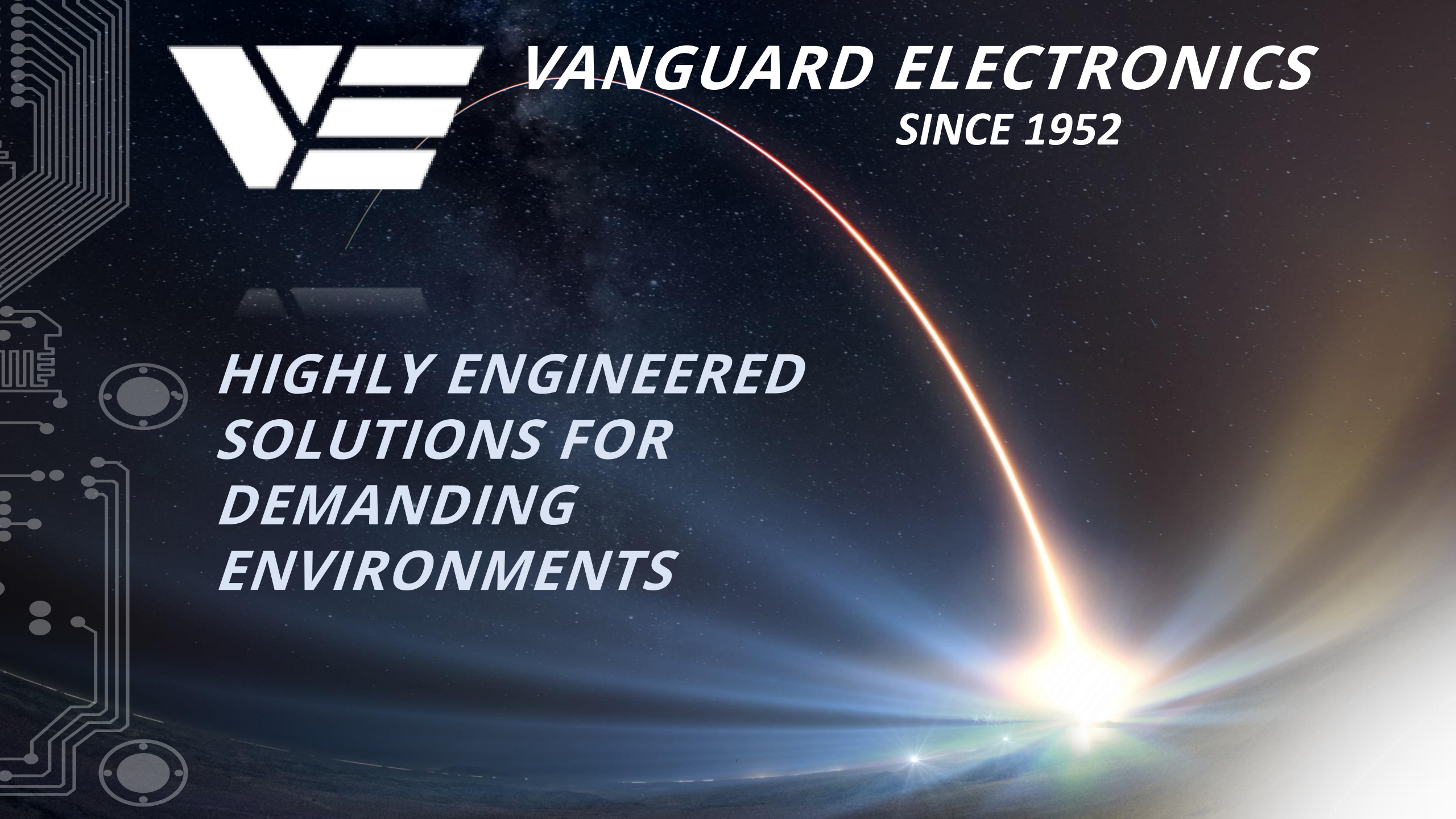

VANGUARD ELECTRONICS
SINCE 1952
HIGHLY ENGINEERED
SOLUTIONS FOR
DEMANDING
ENVIRONMENTS

VANGUARD FACILITIES

HUNTINGTON BEACH, CALIFORNIA

HEADQUARTERS / MANUFACTURING, ENVIRONMENTAL LABORATORY

- Manufacturing
- Qualification Test Laboratory
- AS9100 REV D & ISO 9001:2015 Certified
- ITAR Compliant
- Center of Excellence for Space, Military, and Hi-rel

ENGINEERING, R&D CENTER & MANUFACTURING

- Product Design, Research & Development
- Authorized by DLA to perform Qualification Testing
- Experienced Teams across all departments
- Dedicated Account Managers
- Class 100,000 Cleanroom
- Tool & die fabrication

MEXICALI, BAJA CA MEXICO

ENVIRONMENTAL LABORATORY MANUFACTURING, TESTING

- 400+ employees ; 40,000 square feet
- Cell/Lean manufacturing
- Orders from single pieces to thousands
- In-house tool & die design & fabrication
- AS9100, ITAR, C-TPAT Certified
- Center of Excellence for Space, Military, and Hi-rel
- Authorized by DLA to perform Qualification Testing

GaN Magnetics

Advantages of GaN
Reductions in volume , weight and size
Reduced heat sink requirements
Lower switching losses / increased power output
Maximum current & frequency

GaN Magnetics
Flyback Transformers
Common Mode Chokes
Power Inductors
LLC Transformers
Reduced heat sink requirements
Lower switching losses / increased power output
Maximum current & frequency

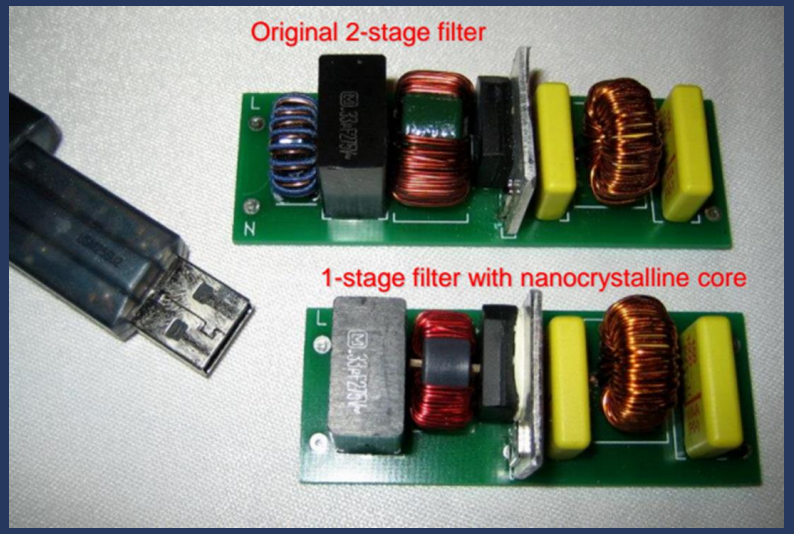
Magnetics Designed to Perform in GaN Applications

Key Design Considerations

- Cores selection is critical
- Wire type selected for maximum operating efficiency in higher switching frequency applications
  - Ex: Litz wire offers minimized AC losses (skin & proximity effect) at higher operating frequencies
- Controlled leakage inductance and reduced parasitic capacitance
  - Reduced loss at switching frequencies
- Higher operating temperatures
  - Increased curie temperatures
  - Improved permeability stability over temperature range
  - Material selection is Key
- Wider ranged operating frequencies
  - Higher saturation magnetization
- Reduced size & weigh

Reduced:

- **Weight**
- **Board size**
- **Number of components necessary**

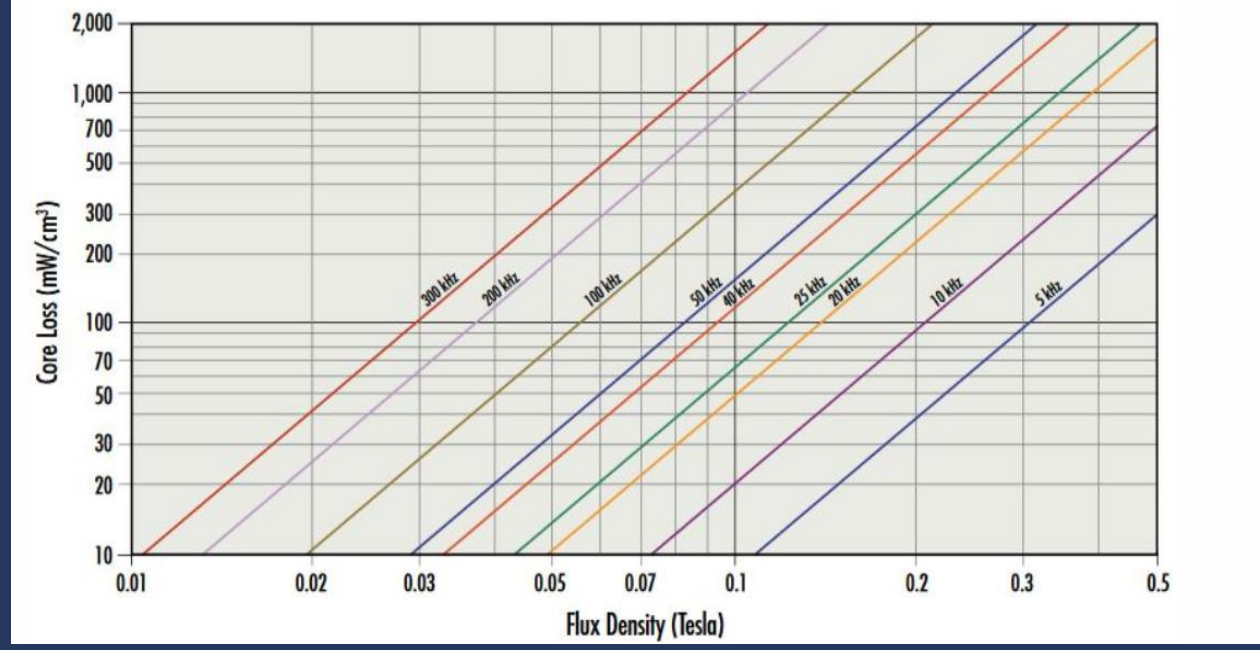


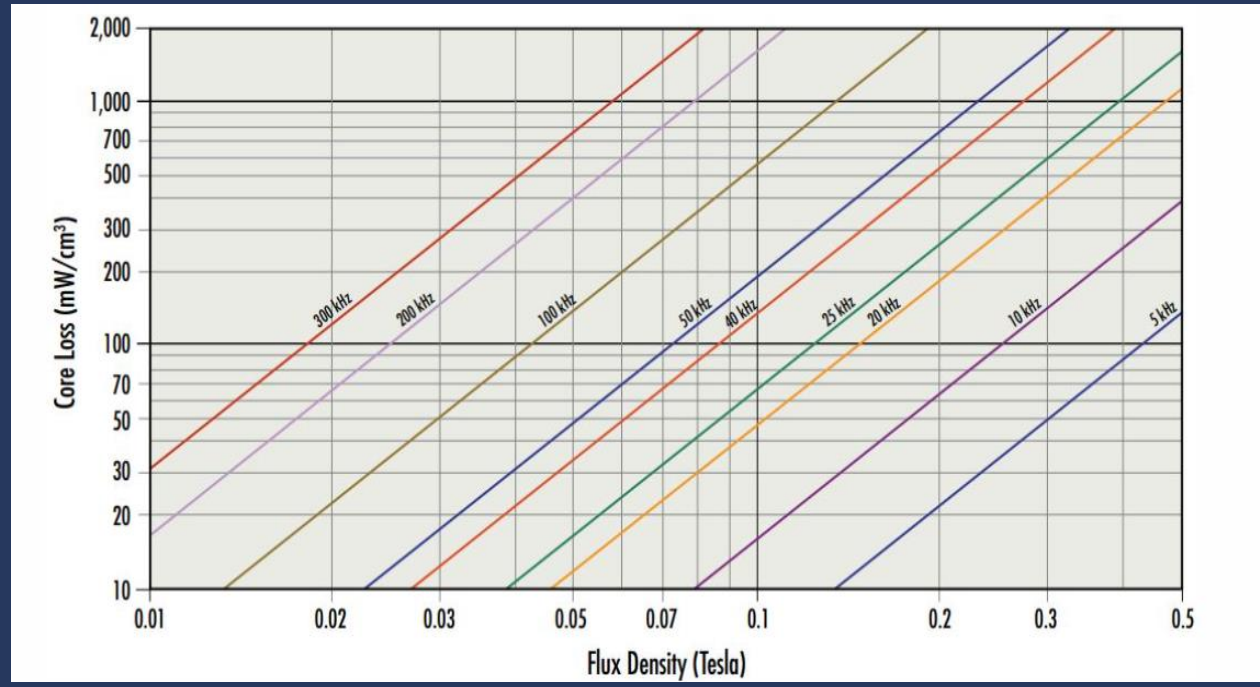
Core Loss

- Top Chart High Frequency toroid @ 60u material
- Bottom Chart Popular toroid @ 60u material

- Typical GaN frequency 250KHz-500KHz+
- “Traditional” frequency 100KHz
- ~2-3X Increase in Core loss due to switching Frequency

- Using the right higher frequency toroid will offer
  - ~ 3X-4X Difference in Core Loss
  - Potential turns count reduction
  - Lower parasitic capacitance





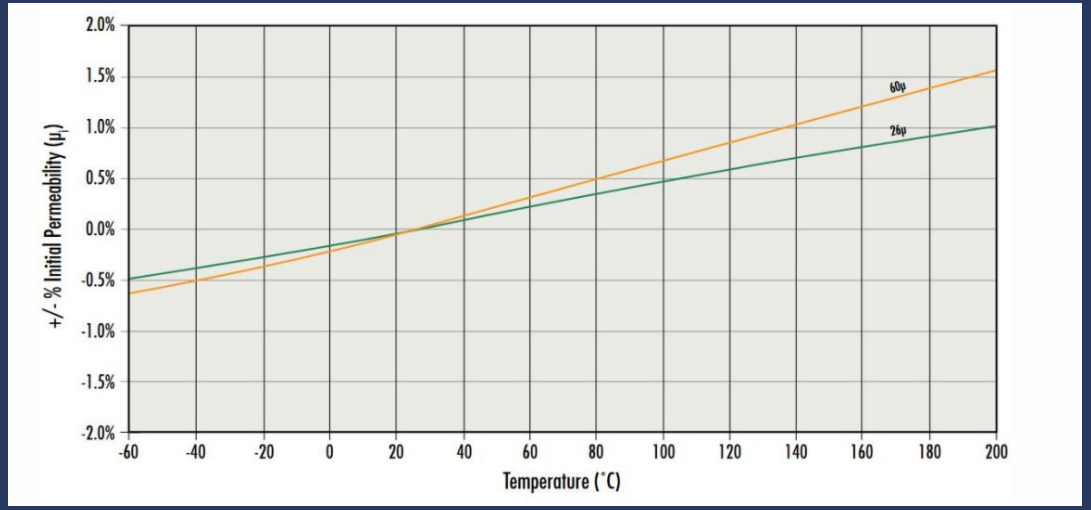
Permeability Over Temperature

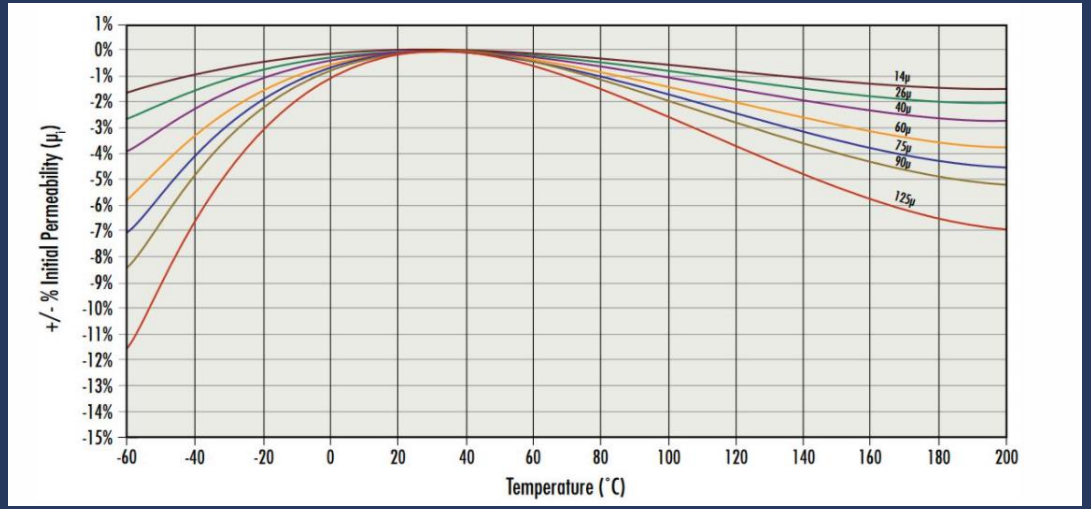
Both parts exhibit good permeability stability over temp

Chart 1 Popular 60u Material designed for HF
Chart 2 Popular 60u Material

Higher Frequency material offers

- Greater u Stability
- Core Loss Less
- Overall better Efficiency





Other Design Considerations

Often taken as an afterthought , becomes dominant as f increases

- Leakage Inductance
  - Goal
    - Lessen or Maintain as you move to higher frequencies
    - 3-5% of total
    - Section winding offer reduced Leakage
    - Critical care on layers , layer stackup and terminations

- Parasitic Capacitance
  - Always present, but at lower frequency it is less of a dominant impact
  - Goal
    - Sectional windings
    - Winding opposing layers in opposing directions
    - Absolute minimum desired.
    - Parasitic capacitance can vary as much as 65% depending on winding patterns

It is possible for stray capacitance and inductance to combine into a resonant circuit!

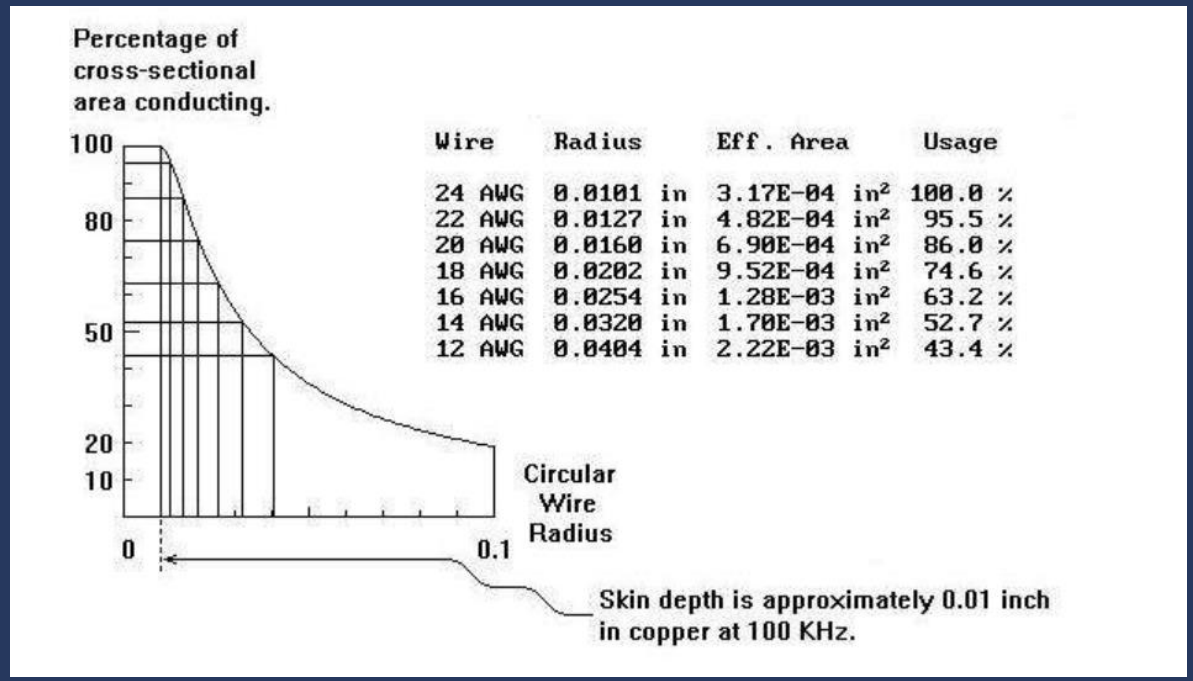
Further Design Considerations – Skin Effect

Choosing the correct wire and wire type is vital
The wrong choice can lead to adverse side effects:

- Increased thermal loss (efficiency)
- Increased labor time (winding and termination)
- Size Impact
- Custom Litz (leadtime)

60 Hz 100KHz 400KHz

$$Skin\ Depth\ (\delta) = \sqrt{\frac{\rho}{\pi f_o \mu_r \mu_o}}; \quad \mu_o = 4\pi * 10^{-7}$$

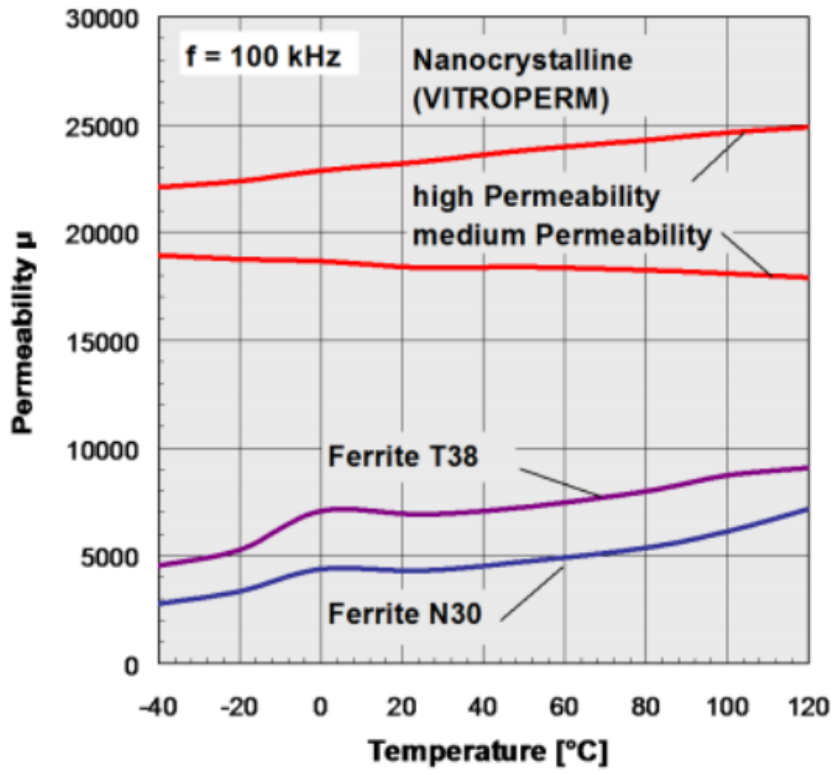


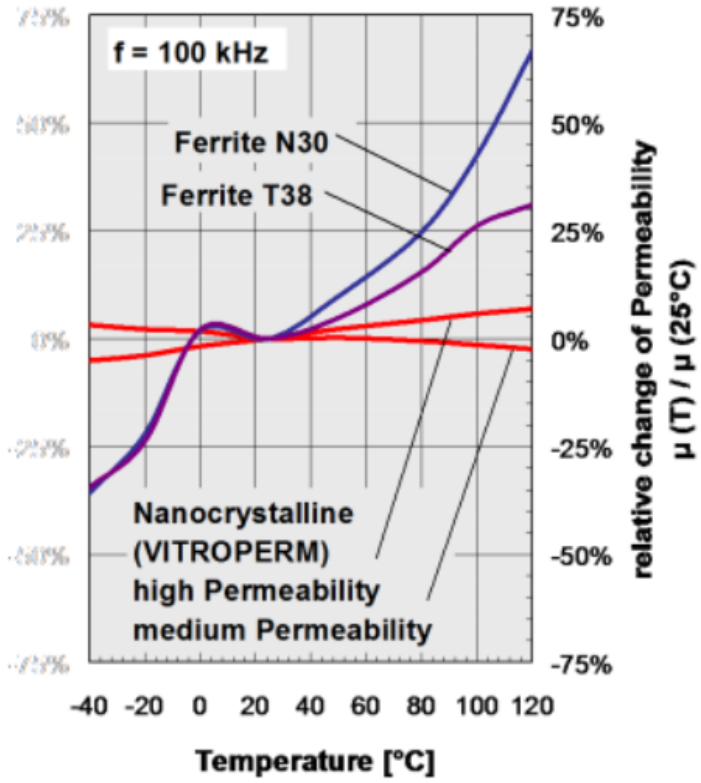
Wire	Radius	Eff. Area	Usage
24 AWG	0.0101 in	3.17E-04 in²	100.0 %
22 AWG	0.0127 in	4.82E-04 in²	95.5 %
20 AWG	0.0160 in	6.90E-04 in²	86.0 %
18 AWG	0.0202 in	9.52E-04 in²	74.6 %
16 AWG	0.0254 in	1.28E-03 in²	63.2 %
14 AWG	0.0320 in	1.70E-03 in²	52.7 %
12 AWG	0.0404 in	2.22E-03 in²	43.4 %

Nanocrystalline: Permeability vs. Temperature

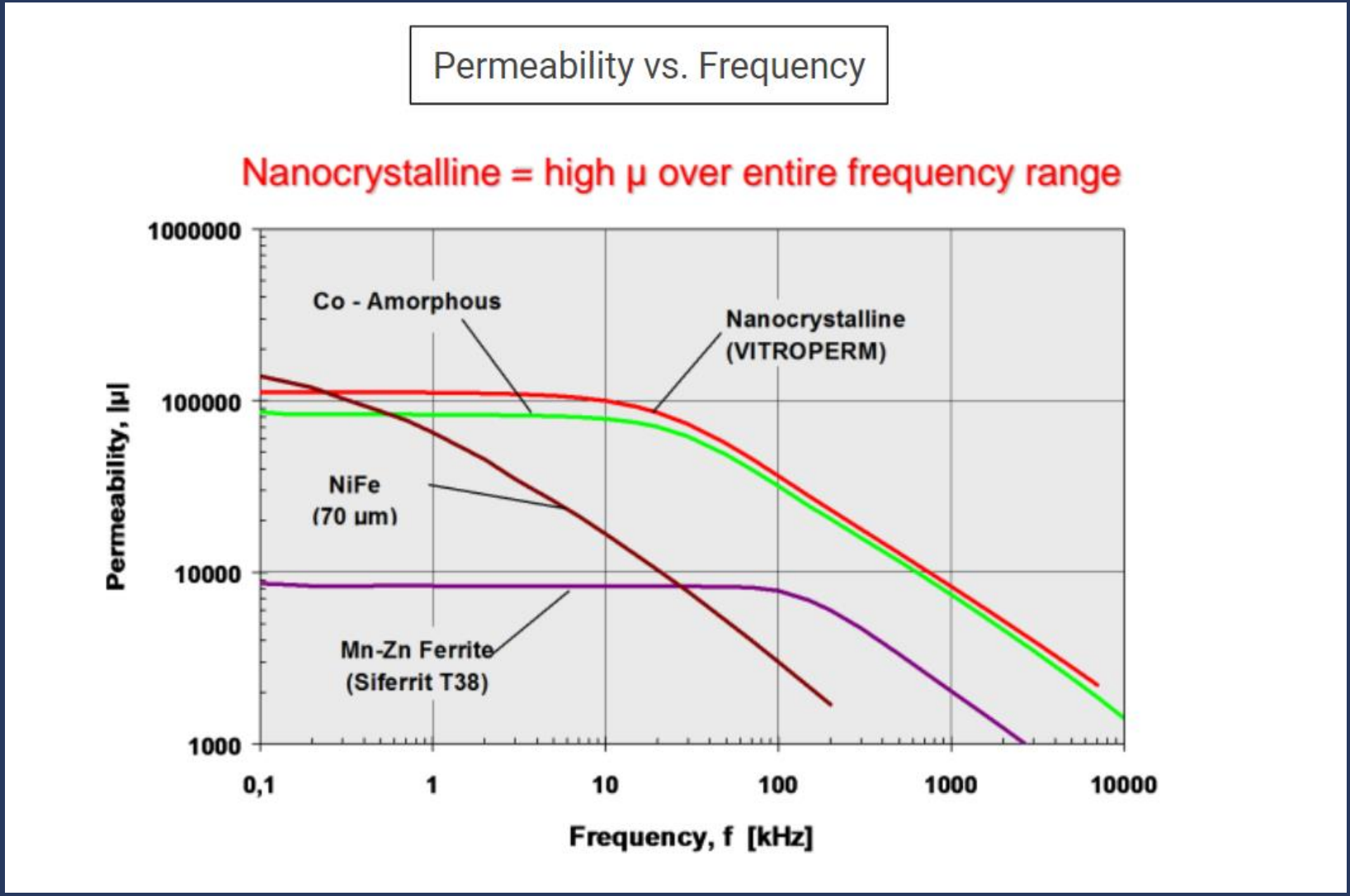
Permeability vs. Temperature

Nanocrystalline = excellent thermal stability





Nanocrystalline: Permeability vs. Frequency



Magnetics Comparison for GaN Applications

Vanguard Products Used in GaN

Power

- Hilo/Shilo
- 60K series (new QPL case size A0 and A5)
- PL33
- CM/SCM Common Mode Series
- 105883AK-1 (Reference Design T1 on Renesas ISL71043MEVAL1Z)
- ~ 87 Custom and Customized Components

RF

- 30K
- 33K
- Air Cores
- ~ 44 Customized RF Chips

New Products Coming

- HCL - High Current Inductors Q2 2021
- Common Modes Designed for 300KHz+ Q2 2021

VANGUARD ELECTRONICS

High Reliability Inductors & Transformers

Contact Vanguard to engineer the solutions to your current and future challenges

Scott Harris - sharris@ve1.com - 714.316.4842

For more information about Vanguard products and capabilities visit us at:

www.VE1.com