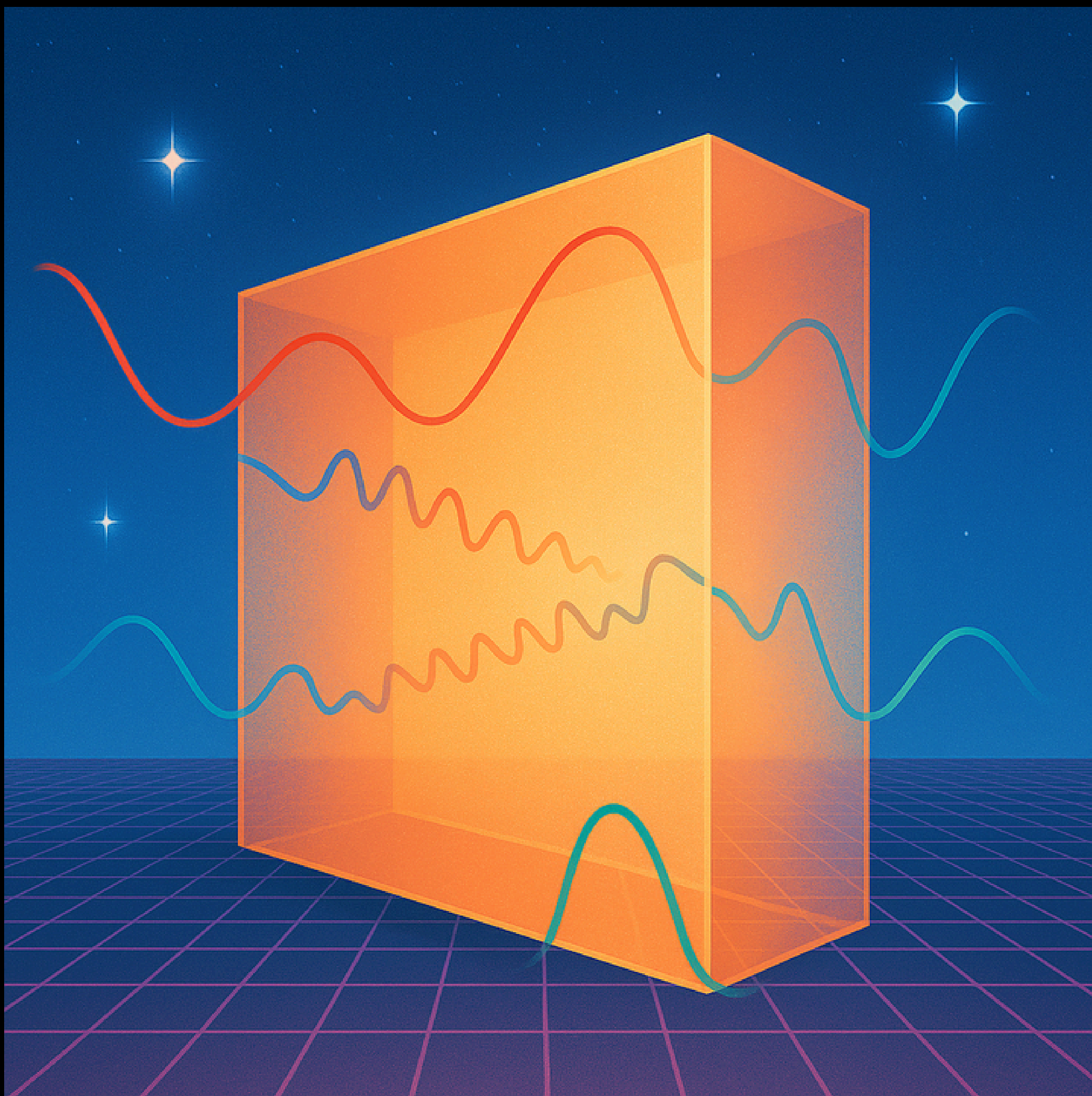
Engineered Materials Solutions

Wickeder Group

# Clad-Shield™ Materials

## Innovative Magnetic and Electric Field Shielding for a Modern World



# Clad-Shield™
# The Total EMI Solution

As electronic systems become more complex, components are increasingly exposed to electromagnetic and radio frequency interference (EMI and RFI). This creates a growing need for effective shielding materials.

### Why Conventional Shielding Falls Short

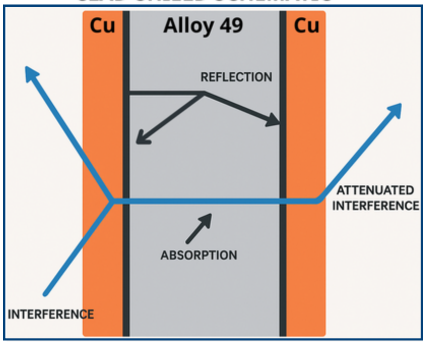
Most traditional shielding materials are strong in either electrical conductivity or magnetic permeability, but not both. Since effective EMI shielding requires both, EMS engineers developed Clad-Shield: a composite material that combines these critical properties in one solution.

### Broad-Spectrum EMI Protection

**Clad-Shield**™ from Engineered Materials Solutions offers a single, versatile solution to EMI challenges. Developed using EMS's expertise in electronics and clad-metal bonding, Clad-Shield delivers:

- High performance across broad frequencies
- Lightweight construction
- Wide dynamic range
- Low sensitivity to stress
- Solderability and formability

**CLAD-SHIELD SCHEMATIC**




This all-metal clad composite outperforms conventional EMI/RFI materials from DC through GHz frequencies.

By combining copper's conductivity with the magnetic permeability of ferromagnetic materials, Clad-Shield can effectively attenuate a broad frequency and dynamic range of EMI. At just 0.010 inches thick, it exceeds NSA 65-6 room shielding specifications while remaining easy to shape and apply.

## CLAD-SHIELD™ PERFORMANCE DATA

| FREQUENCY | FIELD | dB ATTENUATION |
|---|---|---|
| 1 KHz | H | 35 |
| 3 KHz | H | 55 |
| 10 KHz | H | 78 |
| 30 KHz | H | 95 |
| 100 KHz | H | 114 |
| 200 KHz | E | >130 |
| 1 MHz | E | >130 |
| 18 MHz | E | >130 |
| 400 MHz | PW | >120 |
| 1 GHz | PW | >120 |
| 10 GHz | PW | >110 |

INDEPENDENT LAB DATA (0.014" THICKNESS CLAD-SHIELD)

### Lower Costs by Design

Because Clad-Shield attenuates both magnetic and electric fields, it reduces the need for complex or costly post-installation fixes. You can specify it early in the design process, eliminating extra engineering hours and reducing development costs caused by overspecification.

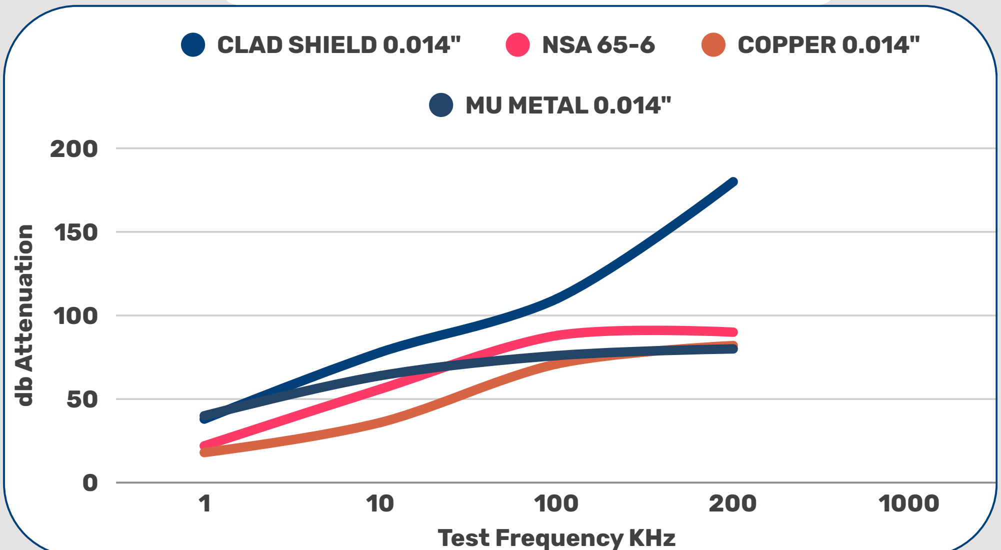
It also simplifies compliance testing, taking much of the guesswork out of EMI control.

### Lightweight, Space-Saving Shielding

Clad-Shield delivers a superior performance-to-weight ratio. Thin sections (just 0.010 inches thick) offer better protection than many bulkier traditional materials; an advantage in compact, lightweight designs.

Smaller, lighter shielding enclosures free up space for more complex systems and offer greater design flexibility.

## Comparative Data
## Magnetic Field Attenuation





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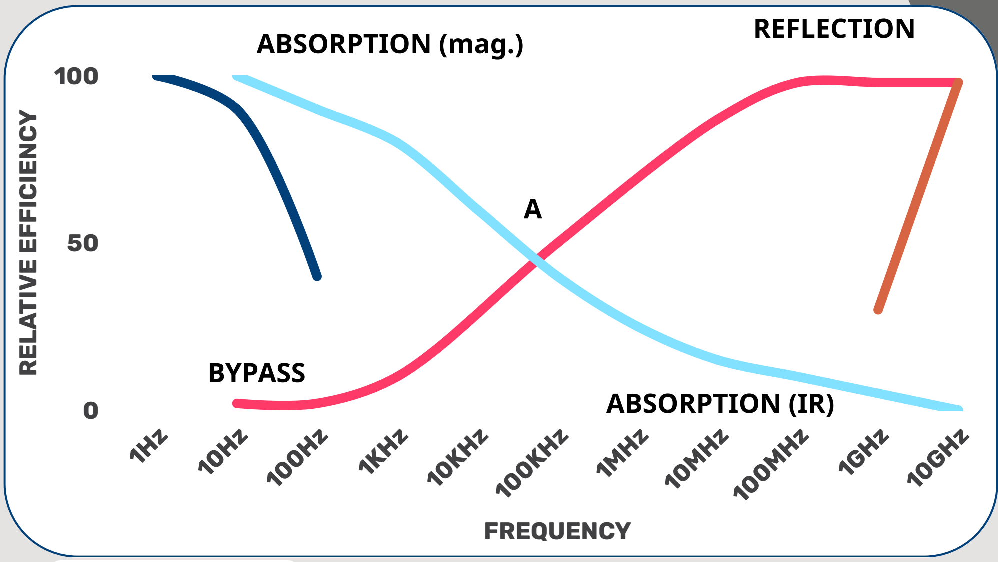
# Understanding EMI Shielding

## MEANS FOR EFFECTIVE EMI SHIELDING




**Mechanism Summary**

This diagram illustrates the five regions of the EMI frequency spectrum and the most efficient mechanism for shielding in each region. **Point A** indicates the frequency region where the magnetic absorption mechanism starts to decline in efficiency and the reflection mechanism efficiency increases. This point is arbitrarily chosen and pertains to the conductivity of copper and the permeability of 50% nickel, 50% iron alloy.
This figure not only illustrates the frequency regions of shielding mechanisms but also indicates the problems if broadband EMI shielding is attempted with monometals: High conductivity or magnetically soft materials only. Monometals do not perform satisfactorily over the whole frequency range.

Effective EMI control relies on three primary methods:

- **Conduct** the interference around a protected space
- **Absorb** and dissipate its energy
- **Reflect** it away

The best method depends on these 3 factors:

**1. Frequency Range** – Determines how waves interact with materials

EMI spans frequencies from direct current (DC) to high-frequency electromagnetic radiation. The frequency characteristics and behavior of the EMI determine the type and extent of shielding material required. Electromagnetic shielding typically must cover broad frequency ranges rather than narrow, isolated bands.

Most EMI sources exhibit a wide frequency distribution, including carrier signals, harmonics, and modulation products.

**2. Field Strength** – Affects magnetic saturation

The energy level of EMI at a given point in space is important, especially if magnetic-shielding is used. These materials can only handle limited energy densities before they saturate.

**3. Wave Impedance** – Based on Source, Distance, and Frequency

Wave impedance at a given point in space depends on the characteristics of the EMI source, the distance the wave has traveled, and its frequency. Shielding strategies can be selected based on the physical principles governing electromagnetic wave propagation and interaction with materials.

The EMI frequency band can be divided into defined ranges, within which generalizations about effective shielding methods can be made.

***Note:*** *Changes in shielding behavior across frequency bands occur gradually, not abruptly. The specific transition frequencies depend on material properties, particularly electrical resistivity and magnetic permeability.*

### Very Low Frequency (DC to ~60 Hz)

In this region, $\partial\varphi/\partial\tau$ is nearly zero. Even in highly conductive materials, the EMI induces only minimal eddy currents. As a result, electromagnetic energy penetrates the shielding material with little attenuation.

The depth of this penetration, defined by $\Delta = K\sqrt{\rho/\mu F}$, may be substantial.

At these frequencies, reflection and absorption mechanisms are largely inactive. Shielding effectiveness depends primarily on magnetic rerouting, where EMI is diverted around the protected region via a magnetic circuit formed by the shielding material. The efficiency of this path is determined by the material's magnetic resistance, as described by $\varphi = F/R_m$

The resulting magnetic flux depends on the magnetic reluctance of the shielding path. According to Kirchhoff's law, in parallel branches of a magnetic circuit, the majority of flux will follow the path of least magnetic resistance. Materials effective in this frequency range should be magnetically soft and exhibit high electrical resistivity, allowing EMI to penetrate and be redirected through the magnetic circuit.

Very Low Frequency Material Characteristics

- Magnetically soft
- High resistivity
- High permeability

### Low Frequency (~60 Hz to 2 kHz)

As the disturbance frequency increases, EMI penetration depth into the material decreases. This results in a larger portion of the shielding material becoming electromagnetically inactive, raising the apparent magnetic resistance and reducing the effectiveness of magnetic rerouting.

$\partial\varphi/\partial\tau$ remains small, meaning induced eddy currents are still negligible. Under these conditions, absorption becomes the dominant attenuation mechanism.

Effective shielding in this range depends on efficiently coupling the interfering magnetic field into the material.

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# Understanding EMI Shielding

As the magnetic field penetrates, it displaces Bloch walls; with increasing energy, it rotates and aligns magnetic domains at the frequency of the interfering wave. This energy transfer is most efficient when load resistance equals generator resistance.

By definition, the generator impedance is given by:

λ/2π

($Z_{gen} = V_{gen} / I_{gen} = E / H$)

This impedance matching condition defines optimal energy transfer in the near-field region.

Materials that are magnetically soft, with high permeability and a narrow hysteresis loop, are best suited for EMI absorption in this frequency band.

Low Frequency Material Characteristics

- Magnetically soft
- Narrow hysteresis loop
- High resistivity
- High permeability

**Medium Frequency (~2 kHz to 50 kHz)**

At these frequencies, Bloch walls and magnetic domains, each with finite mass and inertia, begin to lose their ability to respond effectively to the time-varying field. EMI penetration depth continues to decrease, reducing the coupling efficiency to the magnetic material.

In this range, reflection becomes an active attenuation mechanism.

The value of ∂φ/∂τ is now large enough to induce eddy currents within conductive materials. These currents generate opposing magnetic fields, as described by Lenz's law, which counteract the incoming EMI.

Both absorption and reflection mechanisms contribute to attenuation at these frequencies. Shielding materials should therefore combine ferromagnetic properties with good electrical conductivity.

**High Frequency (~50 kHz to 1 GHz)**

At high frequencies, ∂φ/∂τ reaches a level that effectively prevents coupling of the EMI into magnetic materials. In contrast, the reflection mechanism becomes increasingly efficient.

Shielding materials should emphasize high electrical conductivity to maximize eddy current induction and reflection of incident EMI.

High Frequency Material Characteristics

- Low Resistivity
- Nonmagnetic

**MATERIAL CHARACTERISTICS OF COMMON SHIELDING MATERIALS**

| | Resistivity (FORMULA) | Permeability (relative) | Maximum Permeability (relative) | Hysteresis Width (oersteds) |
|---|---|---|---|---|
| Silver | 1.52 | 1.0 | - | NA |
| Copper | 1.72 | 1.0 | - | NA |
| Monel | 42.50 | | Temperature suppressed Curie point | |
| Nickel | 8.70 | 200 | 600 | .8 |
| Aluminum | 2.78 | 1.0 | - | NA |
| Zinc | 6.10 | 1.0 | - | NA |
| Iron | 10.00 | 150 | 1,5000 | .35 |
| Invar | 80.00 | 300 | 1,600 | .35 |
| Mu Metal | 62.00 | 20,000 | 100,000 | .002 |
| 42 Alloy | 50.00 | 2,000 | 30,000 | .02 |
| 49 Alloy | 48.00 | 2,500 | 90,000 | .005 |
| Hiperco50 | 26.00 | 600 | 6,000 | .2 |
| 79 Permalloy | 58.00 | 50,000 | 250,000 | .002 |
| 430 SS | 60.00 | 300 | 1,600 | .45 |
| 1% So Orpm | 23.00 | 400 | 2,700 | .25 |
| 50 Ni 50 Fe (oriented) | 45.00 | 4,000 | 70,000 | .003 |

The table above compares the resistivities and magnetic characteristics of many popular shielding materials.

This table illustrates that no single material possesses both good high-frequency and low-frequency shielding characteristics.

**Very High Frequency (Above 1 GHz)**

As frequency increases beyond 1 GHz, shielding efficiency tends to decline due to the skin effect, where EMI penetration depth decreases to the point that less of the material actively contributes to attenuation.

In this range, traditional magnetic or conductive shielding becomes less effective. To maintain high shielding performance, specialized materials such as 377-ohm space cloth, absorber pyramids, or graded-resistance composites are commonly employed.

# Clad-Shield™
# A World of Applications

Clad-Shield material is used across a wide range of applications thanks to its superior protection against magnetic and electric-field EMI, while also reducing product size, weight, and cost.

These advantages help designers meet the growing demand for more complex systems without increasing overall system size.

### Aerospace & Aviation

Clad-Shield material addresses the critical challenge of meeting broadband EMI shielding requirements within the strict weight and space constraints of aerospace and aviation systems. Its multi-layer construction enables attenuation across a broad frequency range while minimizing added mass and bulk.

This makes it suitable for use in densely packed electronic assemblies, such as avionics, radar, flight control units, communication systems, and navigation modules. Clad-Shield material meets MIL-STD-461c shielding requirements, ensuring reliable performance in high-altitude, high-vibration, and thermally variable environments.

### Military & Government

Military and government systems require materials that deliver high shielding effectiveness while maintaining low weight and long-term durability.

Clad-Shield is engineered to meet the needs of environments with concentrated electronic payloads, compact form factors, and exposure to harsh operational conditions.

Its thin-gauge construction enables effective magnetic and electric field attenuation at reduced weight compared to conventional steel shielding, making it suitable for portable systems, hardened enclosures, and mobile command centers. Shielded structures and enclosures fabricated with Clad-Shield can achieve significant weight savings, supporting greater mobility and deployment flexibility without sacrificing electromagnetic protection. Its layered metal composition ensures performance across a broad spectrum of frequencies, supporting mission-critical operations that rely on clean signal environments.

### Computers

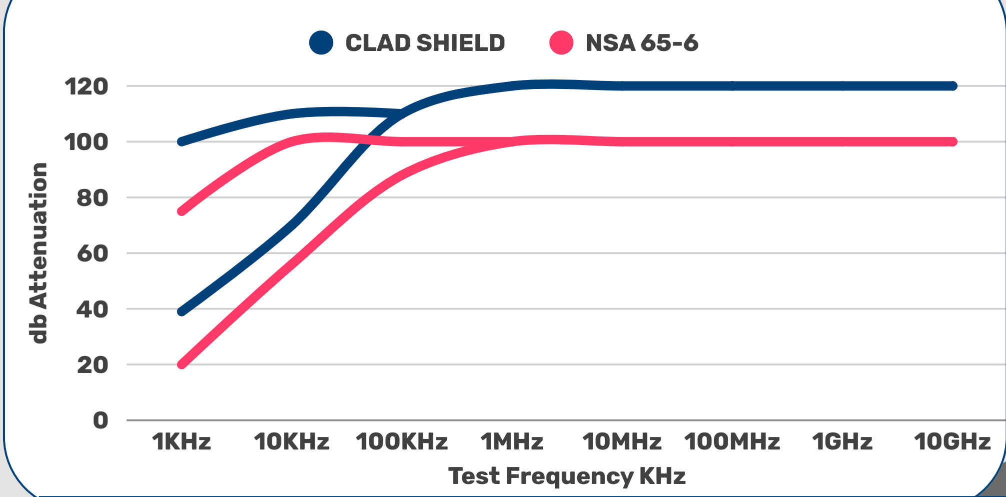
Clad-Shield provides broadband attenuation of both magnetic and electric fields, making it well suited for shielding computers, peripherals, and communications systems. Its performance characteristics align with the requirements for secure information environments and can support designs aiming to meet government-level TEMPEST specifications. Clad-Shield's thin profile and formability allow for integration into compact system enclosures without compromising signal integrity or thermal management.

## CLAD-SHIELD SIZES AND PROPERTIES

| Sizes and Properties | | |
|---|---|---|
| Width | Up to 24.5" | (622 mm) |
| Thickness | Min .008" | (0.2 mm) |
| Density | .306 lb/in$^3$ | (8.3 g/cc) |
| Thermal Expansion | 4.5 to 6.0 x $10^6$/F | (8.1 to 10.8 ppm°C) |
| Formability | Similar to annealed nickel/iron alloys<br>Materials can be deep drawn with postanneal | |
| Solderability | Same as copper (do not heat over 650°F, 350°C) | |

Stress Sensitivity: EMS-Shield material does not display as much reduction in magnetic properties with increased stress as in other ferromagnetic materials. EMS-Shield material is not produced to the maximum parameters of its magnetic core. The thermomechanical processing for EMS-Shield material is optimized to produce minimum deterioration of the magnetic properties under stress. The performance data enclosed is achieved by "underannealed" material, not perfectly magnetic annealed material, which is highly stress sensitive.

## CLAD-SHIELD PERFORMANCE
## Shielding Effectiveness




### Other Industries

Clad-Shield is engineered for broad applicability across industries where high-density electronics and EMI susceptibility intersect. It is used in automotive control systems, medical diagnostics and monitoring equipment, industrial automation systems, and commercial electronics.

Its mechanical flexibility, low weight, and consistent shielding effectiveness make it suitable for use as a single shielding solution across complex assemblies, reducing the need for multiple material types in product design.

### What Clad-Shield Can Do For You

Clad-Shield is specifically designed to meet the demands of environments with concentrated electronic payloads, compact system architectures, and harsh operational conditions.

### Reach Out to EMS Today

EMS engineers can provide samples, collaborate on prototypes, and assist with EMI shielding applications by reaching out here:

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www.emsclad.com

## References

For a more in-depth technical discussion of EMS-Shield materials, refer to the following articles:


1. George Trenkler and Lyle McBride, "Characteristics of Metals and EMC Shields," *IEEE Transactions on Instrumentation and Measurement*, 1986, Boulder, CO.

2. George Trenkler and Lyle McBridge, "Composite Metal Shields for Electromagnetic Interference," *ITEM* 1987.

3. George Trenkler and Richard Delagi, "The Application of Clad Metals for EMI Room Shielding," *ITEM* 1988.

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5. George Trenkler, "Testing with a Near-Field Tabletop Tester," *ITEM* 1989



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