MEDICAL IMAGING:
Capacitor Solutions for MRI, CT, and X-Ray Systems

Medical imaging systems demand an uncommon combination of patient safety, long-term reliability, high-voltage/high-power capability, and—in MRI—ultra-low-loss, non-magnetic RF performance. Capacitor selection directly impacts regulatory compliance (IEC 60601), image quality (signal-to-noise ratio), system uptime, and total cost of ownership across 10–15-year product lifecycles.

Capacitor Roles in Medical Imaging

EMI FILTERING AND PATIENT SAFETY (ALL MODALITIES)

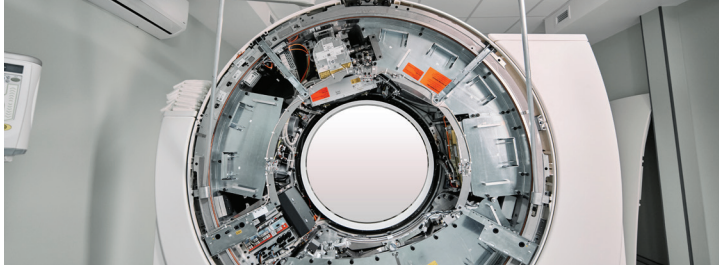
The challenge: Meet IEC 60601-1 conducted emissions limits while also meeting extremely low patient leakage current requirements—down to 10 µA for CF-rated equipment. This constrains Y-capacitor values and forces designers to maximize EMI attenuation per picofarad.

KEY REQUIREMENTS

- X1/Y2 safety certification (IEC 60384-14)
- Open-circuit failure mode, TUV and UL listed
- 5 kV impulse withstand
- Precise values from 100 pF to 4.7 nF, up to 500 Vrms

RECOMMENDED SOLUTIONS

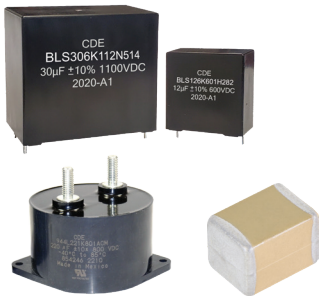
- **X1/Y2 Safety MLCCs (SYX/SYS)** – Optimized value range for leakage-vs-EMI tradeoffs
- **2720 Case Size MLCCs** – Increased creepage distance for higher-voltage medical designs



DC-LINK ENERGY STORAGE

MRI Gradient Amplifiers, CT & X-Ray HV Generators

The challenge: DC link energy storage is pushed to its limits in gradient amplifiers and high voltage generators, where massive pulsed energy, intense ripple currents, and harsh thermal and mechanical forces threaten stability.



Design note: Best-in-class DC-links combine bulk film capacitors with close-in MLCC decoupling for broadband ripple suppression.

KEY REQUIREMENTS

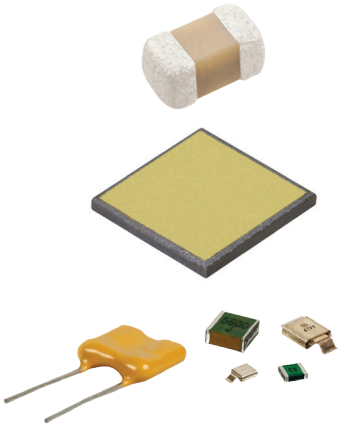
- 800–1400 Vdc ratings
- High ripple current capability
- Low ESR and low ESL for IGBT and SiC switching
- Long life and self-healing construction

RECOMMENDED SOLUTIONS

- **944L Series DC-Link Film Capacitors –** Bulk energy storage for gradient amps and HV inverters
- **BLS Series Film Capacitors –** High-temperature, vibration-tolerant designs
- **StackiCap MLCCs –** Ultra-low ESL decoupling close to power switches

RF TUNING AND MATCHING (MRI COILS)

The challenge: MRI RF coils are resonant LC circuits tuned to the Larmor frequency, which varies with magnetic field strength. Capacitor loss and magnetic properties directly impact Q factor and image SNR. Nickel-barrier terminations are unacceptable due to magnetic artifacts.



KEY REQUIREMENTS

- Non-magnetic terminations
- Very high Q factor at RF
- Stable dielectric (C0G/NP0)
- High dielectric withstand voltage

RECOMMENDED SOLUTIONS

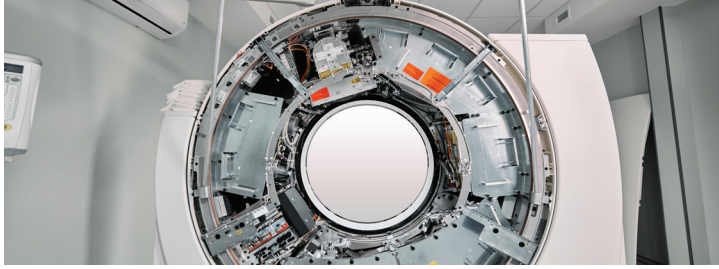
- **C0G Non-Magnetic High-Voltage MLCCs –** Ultra-stable, high-Q tuning and matching
- **FM2 Non-Magnetic X7R Low-Loss MLCCs –** Lower ESR than standard X7R for RF-adjacent decoupling
- **Single Layer Capacitors (SLCs) –** Lowest parasitic inductance for high-field MRI
- **RF Mica Capacitors –** Exceptional stability for coil arrays and baluns

RX COIL PROTECTION – REJECT TX, PRESERVE SIGNAL

The challenge: Receive coils must detect extremely weak RF signals while rejecting powerful transmit pulses. Integrated passive networks prevent overload and protect downstream electronics inside a non-magnetic environment.

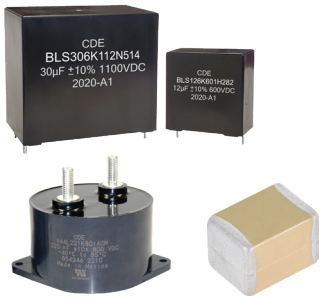
RECOMMENDED SOLUTIONS

- **C0G Non-Magnetic MLCCs –** tuning and protection networks
- **FM2 Low-Loss X7R MLCCs –** non-magnetic local decoupling



COIL-TO-LNA MATCHING, DETUNING, AND DECOUPLING

The challenge: Between the coil and the low-noise amplifier, matching and detuning networks block unwanted currents, filter DC bias paths, and maintain low noise across frequencies from MHz to hundreds of MHz.



TYPICAL CAPACITOR ROLES

- RF matching and detuning (pF range)
- DC path filtering to prevent noise injection

RECOMMENDED SOLUTIONS

- **C0G Non-Magnetic MLCCs –** High-precision RF functions
- **FM2 Low-Loss X7R MLCCs –** Bias and decoupling where X7R is appropriate

LNA / PREAMP BIASING, STABILITY, AND DC BLOCKING

The challenge: LNA and preamp circuits operate at the edge of the noise floor, where biasing, DC blocking, and stability must be carefully controlled without introducing noise or degrading overall performance.

TYPICAL CAPACITOR ROLES

- DC blocking
- Supply bypass and decoupling
- Stability and feedback shaping

RECOMMENDED SOLUTIONS

- **FM2 Non-Magnetic X7R Low-Loss MLCCs –** Bias and bypass networks
- **C0G Precision MLCCs –** Critical low-noise signal paths

BALUN / CABLE TRAP FOR PATIENT SAFETY

The challenge: Prevent RF currents from traveling on the outside of coaxial cables, which can cause heating and patient injury.

RECOMMENDED SOLUTIONS

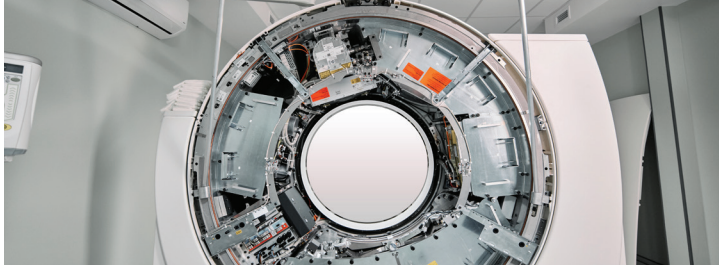
- **RF Mica Capacitors –** Stable RF trap circuits
- **C0G Non-Magnetic MLCCs –** Where ceramic solutions are preferred

RESONANT TANK CAPACITORS (LLC CONVERTERS – CT & X-RAY)

The challenge: LLC resonant converters require stable, low-loss capacitance across voltage and temperature.

RECOMMENDED SOLUTIONS

- **C0G High-Voltage MLCCs –** Low loss, stable capacitance
- **Power Film Capacitors –** Higher capacitance for resonant tanks



OUTPUT FILTERING AND DETECTOR POWER

The challenge: Imaging detectors and digital processing electronics require ultra-clean power; noise directly degrades image quality.

RECOMMENDED SOLUTIONS

- **Aluminum Polymer Capacitors –** Very low ESR for fast transient response
- **C0G Precision MLCCs –** Reference and feedback filtering
- **Aluminum Electrolytics –** Bulk filtering for high-power rails

SNUBBER PROTECTION (POWER SWITCHING STAGES)

The challenge: Protect IGBT and SiC devices from voltage spikes during switching.

RECOMMENDED SOLUTIONS

- **High-Voltage MLCCs –** Fast transient suppression
- **Power Film Capacitors –** Repetitive energy absorption

BACKUP ENERGY FOR GRADIENT COIL CURRENT AMPLIFIERS

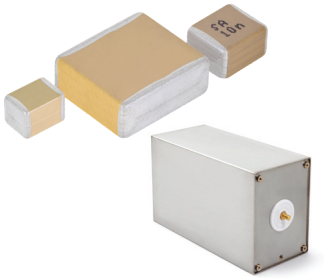
The challenge: Gradient coils demand extremely stable current delivery; backup energy storage helps maintain precision during dynamic operation.

RECOMMENDED SOLUTIONS

- **Supercapacitor modules –** Short-term energy buffering

TX RF POWER AMPLIFIER ENERGY STORAGE AND BIASING

The challenge: Transmit amplifiers require local energy storage and stable bias networks, often in space-constrained designs.



RECOMMENDED SOLUTIONS

- **Compact film capacitors –** Pulse energy storage
- **MLCCs –** Biasing and local decoupling