

Application Note

5G Equipment EMC Testing

New Challenges in EMC Compliance

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Applicable Standards: EN 301 489-1, ETSI EN 301 489-52, FCC Part 15/27



1. Introduction to 5G EMC Challenges

Fifth-generation (5G) wireless technology introduces significant EMC challenges due to higher frequencies (up to 52.6 GHz for FR2), massive MIMO antenna arrays, beamforming technology, and increased power levels. Traditional EMC test methods require adaptation to address 5G-specific characteristics including millimeter-wave propagation, beam steering, and dynamic power control.

This application note provides guidance on EMC testing for 5G equipment including base stations, user equipment, and small cells. Understanding these unique requirements is essential for manufacturers developing 5G infrastructure and devices.

1.1 5G Frequency Ranges

5G operates in two main frequency ranges (FR1 and FR2) with different propagation characteristics and EMC considerations.

Range	Frequency	Characteristics
FR1 (Sub-6 GHz)	450 MHz - 6 GHz	Better coverage, building penetration
FR2 (mmWave)	24.25 - 52.6 GHz	Higher bandwidth, shorter range



2. Emissions Testing for 5G Equipment

5G emissions testing must address conducted and radiated emissions up to 52.6 GHz for FR2 equipment. Traditional test methods are extended with new measurement techniques for beamforming and dynamic power allocation.

2.1 Conducted Emissions

Conducted emissions testing uses Line Impedance Stabilization Networks (LISNs) on AC and DC power ports. 5G base stations with high power requirements need special consideration for high-current LISNs and cable loading effects.

Test Parameters:

- **Frequency range:** 9 kHz - 30 MHz (EN 55032 limits)
 - **Measurement types:** Quasi-peak and average detection
 - [Com-Power Spectrum Analyzers](#) - SPA-900 Series with appropriate detectors for EMC testing
 - **LISN:** 50 μ H + 50 Ω for 16A capability, higher current for macro base stations
 - [Com-Power Three-Phase LISN 3P Series](#) - 16A to 100A current ratings for high-power 5G base stations
 - [Com-Power LI-550C LISN](#) - 50A AC / 35A DC, CISPR 25 and CISPR 16-1-2 compliant
 - **Transient Protection:**
 - [Com-Power LIT-930A Transient Limiter](#) - protects analyzer during conducted emissions testing
 - **Test modes:** All operational states including maximum power transmission
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2.2 Radiated Emissions - Extended Frequency Range

Radiated emissions testing extends to 52.6 GHz for FR2 equipment. Measurements use specialized horn antennas and test receivers capable of millimeter-wave measurements. Beamforming must be considered during testing.

Test Requirements:

- **Frequency range:** 30 MHz - 52.6 GHz
- **Test distance:** 3m or 10m depending on equipment size
- **Antennas for 5G Radiated Emissions:**

Low Band (30 MHz - 1 GHz):

- [Com-Power AB-300M-F Biconical Antenna](#) - Fixed standard elements, 25-300 MHz
- [Com-Power AB-300M-C Biconical Antenna](#) - Collapsible elements, 25-300 MHz
- [Com-Power AL-100 Log Periodic Antenna](#) - 300 MHz to 1 GHz
- [Com-Power AC-220 Combilog Antenna](#) - 20 MHz to 2 GHz (reduces testing time by 30%)

Mid Band (1-18 GHz):

- [Com-Power AH-118 Double Ridge Horn Antenna](#) - 700 MHz to 18 GHz, excellent for 1-18 GHz
- [Com-Power AHA-118 Active Horn Antenna](#) - 700 MHz to 18 GHz with built-in 40 dB preamplifier for enhanced sensitivity
- [Com-Power AH-8055 High Power Horn Antenna](#) - 800 MHz to 5 GHz, usable to 6.5 GHz

High Band / mmWave (18-40 GHz):

- [Com-Power AH-826 Standard Gain Horn Antenna](#) - 18-26.5 GHz, K-Band, WR-42 equivalent frequency coverage
- [Com-Power AH-640 Standard Gain Horn Antenna](#) - 26.5-40 GHz, Ka-Band, WR-28 equivalent frequency coverage
- [Com-Power AH-840 Double Ridge Horn Antenna](#) - 18-40 GHz, combines AH-826 and AH-640 frequency ranges
- [Com-Power AHA-840 Active Horn Antenna](#) - 18-40 GHz with integrated preamplifier

Ultra-Broadband Solutions:

- [Com-Power ACL-6000 Combilog Antenna](#) - 30 MHz to 6 GHz (receive), reduces antenna switching
- **Preamplifiers for Low-Level Measurements:**
 - [Com-Power PAM-118A Preamplifier](#) - 500 MHz to 18 GHz for enhanced sensitivity
 - [Com-Power Preamplifier Product Line](#)
- **Beam direction:** Multiple beam positions to capture maximum emissions
- **Exclusion zones:** Intentional transmissions excluded per ETSI EN 301 489-52
- **Spurious emissions:** Measured at full transmit power
- **Near-Field Probes for Debugging:**
 - [Com-Power PS-400 Near Field Probe Set](#) - E-field and H-field probes for EMI source identification
 - [Com-Power PS-500 Near Field Probe Set](#) - includes contact tip probe

2.3 Massive MIMO Considerations

5G base stations with massive MIMO (64T64R, 128T128R, 256T256R) require special test considerations. Multiple antenna elements operating simultaneously create complex radiation patterns and emission profiles.

Test Challenges:

- **Beamforming Effects:** Dynamic beam steering creates time-varying emission patterns
- **Spatial Coverage:** Must measure emissions across full azimuth and elevation angles
- **Peak vs. Average Power:** RMS power may be significantly lower than peak power
- **Measurement Time:** Extended measurement times to capture all beam states

Recommended Test Approach:

- Use spectrum analyzers with sufficient dynamic range and speed
 - Implement automated turntable systems for spatial scanning
 - Consider max-hold measurements to capture peak emissions
 - Test with all transmit chains active at maximum rated power
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3. Immunity Testing for 5G Equipment

5G equipment must demonstrate immunity to electromagnetic disturbances while maintaining communication performance. Testing includes traditional immunity tests plus 5G-specific performance criteria.

3.1 Radiated RF Immunity

Radiated immunity testing exposes equipment to amplitude-modulated RF fields. Test frequency range extends to cover 5G operating bands. Field strengths typically 3-10 V/m depending on installation environment.

Test Parameters:

- **Frequency range:** 80 MHz - 6 GHz (extended for mmWave testing)
- **Field strength:** 3-10 V/m depending on environment
- **Modulation:** 1 kHz sine wave, 80% AM
- **Performance criteria:** Bit error rate, throughput, latency

Immunity Test Antennas:

- **80 MHz - 1 GHz:**
 - [Com-Power AB-300M-F Biconical Antenna](#) - Fixed elements, for transmit applications up to 50W
 - [Com-Power AB-300M-C Biconical Antenna](#) - Collapsible elements, portable option
 - [Com-Power AC-220 Combilog Antenna](#) - 20 MHz to 2 GHz, handles up to 500W for immunity testing
 - **1-6 GHz:**
 - [Com-Power AH-118 Horn Antenna](#) - 1-18 GHz, handles 300W for radiated immunity
 - [Com-Power AH-8055 Horn Antenna](#) - 800 MHz to 6.5 GHz
 - **Power Amplifiers** (external, not Com-Power products) required for generating field strengths
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3.2 Electrostatic Discharge (ESD)

ESD testing applies to user-accessible surfaces including antenna connectors, control interfaces, and mounting hardware.

Test levels: ±4 kV contact, ±8 kV air discharge typical.

3.3 Electrical Fast Transients and Surge

Power supply immunity critical for outdoor installations exposed to lightning and switching transients. Testing per IEC 61000-4-4 (EFT) and IEC 61000-4-5 (Surge) with enhanced levels for industrial environments.

Test Equipment:

- **LISNs for Immunity Testing:**
 - [Com-Power LISN Product Line](#) - provides stable impedance during immunity tests
 - **Current Injection for Conducted Immunity:**
 - [Com-Power CLCI-100 Bulk Current Injection Probe](#) - 10 kHz to 100 MHz, IEC 61000-4-6 compliant
 - [Com-Power CLCI-400 Bulk Current Injection Probe](#) - 10 kHz to 400 MHz, MIL-STD-461 compliant
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4. mmWave Test Challenges

Millimeter-wave frequencies (24-52 GHz) present unique EMC test challenges including higher path loss, atmospheric absorption, and specialized test equipment requirements. Traditional EMC test methods require adaptation for mmWave.

4.1 Test Equipment Requirements

mmWave Test Equipment:

- **Spectrum analyzers:** 50 GHz+ frequency range
 - [Com-Power SPA-900TG Series Spectrum Analyzers](#) - up to 3.2 GHz for sub-6 GHz 5G testing
 - **Note:** For FR2 mmWave (24-52 GHz), external specialized spectrum analyzers required beyond Com-Power's current range
- **Horn antennas for mmWave:**

18-26.5 GHz (K-Band / WR-42 equivalent):

- [Com-Power AH-826 Standard Gain Horn](#) - 18-26.5 GHz, covers n258 (24.25-27.5 GHz) 5G band

26.5-40 GHz (Ka-Band / WR-28 equivalent):

- [Com-Power AH-640 Standard Gain Horn](#) - 26.5-40 GHz, covers n257 (26.5-29.5 GHz) and n261 (27.5-28.35 GHz) 5G bands

18-40 GHz (Combined Range):

- [Com-Power AH-840 Double Ridge Horn](#) - 18-40 GHz, single antenna for K and Ka bands

- [Com-Power AHA-840 Active Horn](#) - 18-40 GHz with integrated preamplifier for improved sensitivity at mmWave frequencies

Note: For higher FR2 frequencies (40-52.6 GHz / WR-19 equivalent covering n260 band), specialized waveguide horn antennas from other manufacturers required

- **RF amplifiers** with sufficient output power at mmWave (external specialized equipment required)
- **Waveguide components and low-loss RF cables**
- **Field probes** calibrated for mmWave frequencies

4.2 Chamber Requirements

Anechoic chambers for mmWave testing require specialized absorber materials effective at high frequencies. Absorber performance critical above 18 GHz where traditional ferrite-loaded absorbers become less effective.

Chamber Specifications for 5G mmWave:

- **Absorber Material:** Pyramidal foam absorbers with performance extending to 60 GHz or higher
- **Chamber Size:** Sufficient for 3m or 10m test distance plus antenna separation
- **RF Shielding:** Effective shielding to at least 60 GHz
- **Quiet Zone:** Uniform field area sized appropriately for equipment under test
- **Validation:** Site VSWR or NSA measurements extending to FR2 frequencies

Additional Resources for 5G EMC Testing

Pre-Compliance Test Systems:

- [Com-Power PC-114 Pre-Compliance Test System](#) - complete system for sub-6 GHz 5G testing
- [Com-Power PC-114H Pre-Compliance Test System](#) - extended frequency range with 3.2 GHz spectrum analyzer

Complete Antenna Line:

- [Com-Power Antenna Products](#) - comprehensive selection from 9 kHz to 40 GHz

LISNs and Conducted Test Equipment:

- [Com-Power LISN Product Line](#) - single-phase and three-phase options for all power levels
- [Com-Power Current Probes](#) - emissions and immunity current measurement

Near-Field Probes:

- [Com-Power Near Field Probes](#) - for 5G base station EMI debugging and source identification
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Key 5G EMC Standards

- **ETSI EN 301 489-1:** General EMC requirements for radio equipment
- **ETSI EN 301 489-50:** EMC requirements for 5G base stations
- **ETSI EN 301 489-52:** EMC requirements for 5G user equipment
- **EN 55032:** Multimedia equipment emissions requirements
- **IEC 61000-4 series:** Immunity test standards (ESD, radiated immunity, conducted immunity, surge, EFT)
- **3GPP TS 38.104:** 5G NR base station radio transmission and reception
- **3GPP TS 38.101:** 5G NR user equipment radio transmission and reception

Test Frequency Bands for 5G:

- **FR1 (Sub-6 GHz):** 410 MHz - 7.125 GHz
 - Com-Power equipment covers full FR1 range
- **FR2 (mmWave):** 24.25 GHz - 52.6 GHz
 - Com-Power horn antennas cover 18-40 GHz (partial FR2 coverage)
 - Specialized equipment required for 40-52.6 GHz



5. Design Guidelines for 5G EMC

Achieving EMC compliance for 5G equipment requires proactive design addressing high-frequency effects, power integrity, and thermal management alongside EMI mitigation.

5.1 PCB Design for mmWave

Critical Design Practices:

- Use specialized RF laminates (Rogers, Taconic) for mmWave circuitry
- Implement controlled impedance design with tight tolerances
- Minimize via stubs - use back-drilling for high-frequency signals
- Partition RF, mixed-signal, and digital sections with isolation barriers
- Use ground vias extensively around RF traces

5.2 Shielding and Enclosure Design

5G equipment enclosures must provide electromagnetic shielding while allowing antenna radiation and thermal management. Careful aperture design, gasket selection, and conductive coatings essential.

Shielding Techniques:

- Compartmentalize RF sections with internal shielding
- Use conductive EMI gaskets at all enclosure seams
- Filter all cables entering/exiting enclosure
- Design ventilation openings as waveguide-below-cutoff
- Apply conductive coatings to plastic enclosures

6. Conclusion

5G technology introduces significant EMC challenges requiring new test methods, specialized equipment, and innovative design approaches. Manufacturers must adapt traditional EMC practices to address millimeter-wave frequencies, massive MIMO, and beamforming technology.

Key Recommendations:

1. Understand applicable 5G EMC standards (ETSI EN 301 489-52, FCC)
2. Invest in mmWave test equipment and qualified test facilities
3. Address EMC in early design phases for FR2 equipment
4. Conduct pre-compliance testing with beamforming active
5. Consider massive MIMO effects on emissions and immunity

7. References

6. ETSI EN 301 489-1: EMC standard for radio equipment - Common requirements
7. ETSI EN 301 489-52: EMC standard for 5G base stations and user equipment
8. FCC Part 27: Wireless Communications Services including 5G bands
9. 3GPP TS 38.104: NR Base Station radio transmission and reception

For 5G EMC test equipment and technical support,
contact Com-Power Corporation

www.com-power.com

