03.10

Analysis of Shielding Effectiveness at ...

Executive Summary –

A General Electric MRI Test Room initially measured -55 dB isolation. Although damage was found to the door frame and RF fingerstock around the door, it was also found that the main RF leakage at 100.5 MHz was occurring due to improperly secured shield panels and hardware for cable pass-through between the MRI test room and the MRI equipment room. After replacing damaged finger stock around the door and shimming where the door frame had been damaged, re-installing cable pass-through shield panels properly, and replacing missing hardware on the shield panels, the leakage was reduced to a worst case of -101.1 dB, meeting the MRI Test Room's required leakage specification of greater than -100 dB.

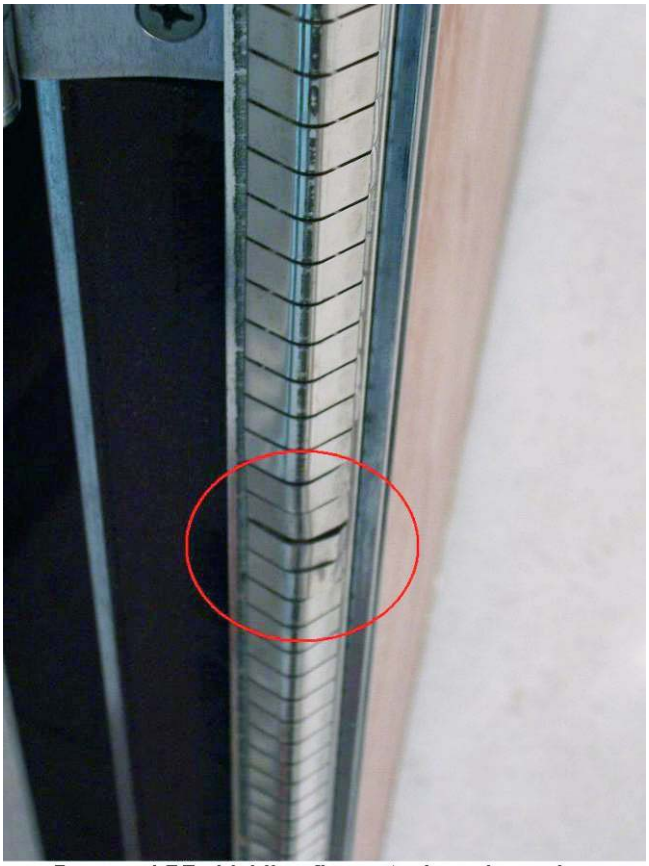
Initial Inspection and Measurements –

Initial inspection of the room found that fingerstock on the RF-tight door had been damaged in three places.

The photo to the right shows damaged fingerstock, apparently caused by a patient gurney striking the door. Although not shown in the photo, the door frame itself was also found to be dented, most likely from being struck by another patient gurney, resulting in a visible gap between the door frame and the fingerstock.

An initial measurement of the RF isolation of the MRI Test Room was -55 dB, or about 400,000 times beyond the >-100 dB specification.

Cleaning the door frame and fingerstock (see the photo below), replacing the finger stock in several areas, and shimming the finger stock where the door frame had been bent, helped; but it was found that the door, itself, was not the main leakage source.



Damaged RF-shielding fingerstock on door edge.

Dirty fingerstock on inside of door

Engineer replacing damaged fingerstock

Above: Precision equipment and calibrated antennas used for MRI Room measurements

Above: Calibrated EMC Test Antenna in MRI Test Room

Corrective Actions –

The main source of RF leakage, measured at 100.5 MHz, was found to be around the cable feed-through panel in the equipment room. The inner shield in the MRI room was missing two of four grounding fasteners, and the bottom shield was loose. The top and bottom shields in the equipment room had been completely removed and many of the securing bolts were found to be loose; see the photos on the following page.

Above: Precision test equipment installed for measurements within the equipment room

Engineer examining removed shield panel in equipment room

Two of four shield panel fasteners were found missing in the MRI room (red circles).

The cable pass-through and shield panels were reinstalled, missing hardware was purchased and installed, and loose hardware was properly tightened. Further measurements now found the shielding had improved to better than -100 dB.

Final Readings –

The RF output power level from the signal generator and power amplifier was measured to be +30.8 dBm. The antenna coupling factor at 6 feet spacing was measured at -19.5 dBm; thus, the power level measured by the spectrum analyzer with the antennas spaced 6 feet apart was +11.3 dBm.

Test Signal Power Level: +30.8 dBm
Antenna-to-Antenna Coupling at 6 feet spacing: -19.5 dB
Resulting Power Level at Spectrum Analyzer: +30.8 dBm - 19.5 dB = +11.3 dBm

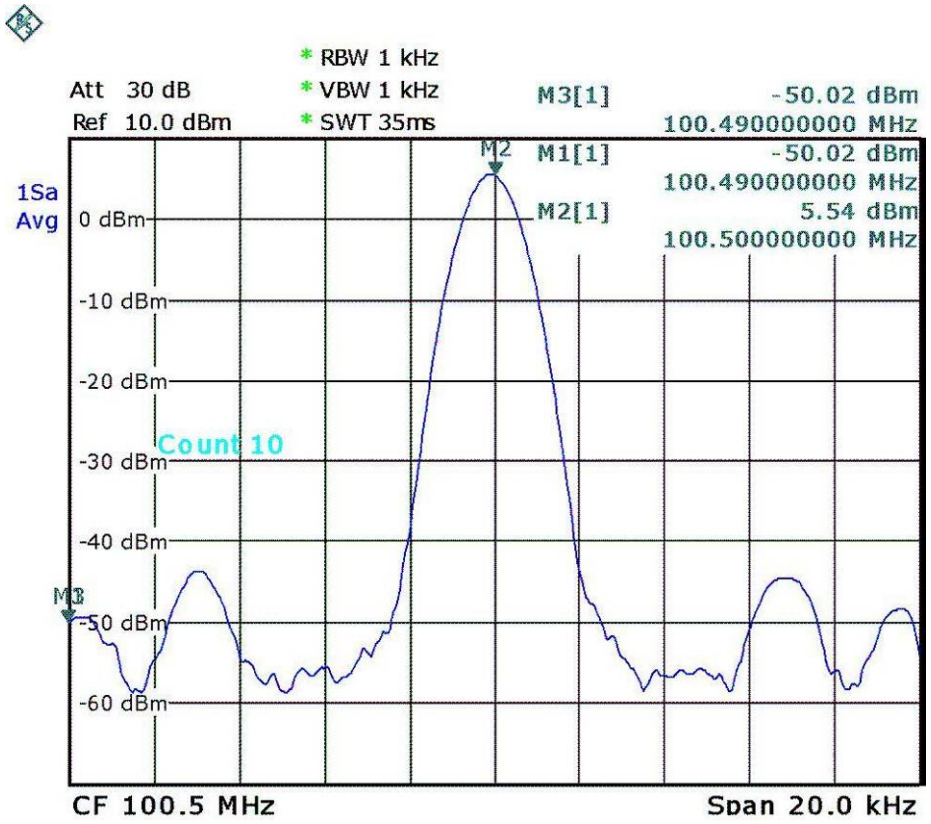
Final RF Power Measurements after Repairs to MRI Room Shielding and Door:

Location	Measured Signal Level (100.5 MHz)
Initial Measurement	- 43.7 dBm (+11.3 dB) = - 55 dB leakage
Door	- 89.8 dBm (+11.3 dB) = - 101.1 dB leakage
Equipment Room	- 91.1 dBm (+11.3 dB) = - 102.4 dB leakage
Observation Window	-101.2 dBm (+11.3 dB) = - 112.5 dB leakage
East Wall	-110.6 dBm (+11.3 dB) = - 121.9 dB leakage
North Wall	-105.0 dBm (+11.3 dB) = - 116.3 dB leakage

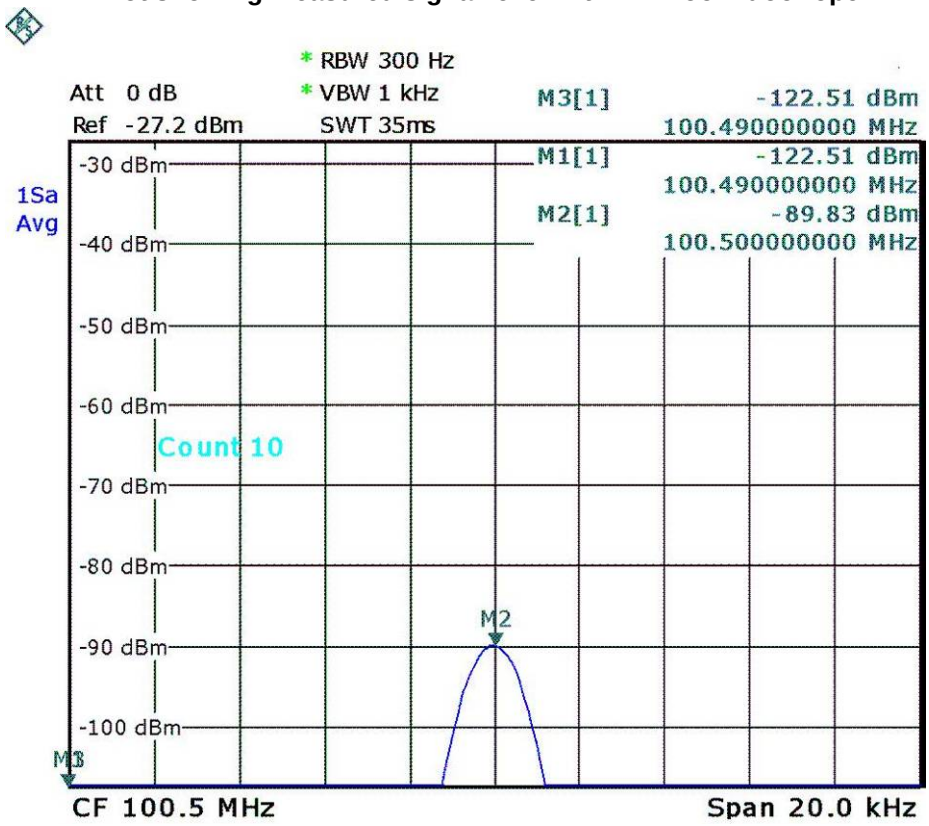
The repaired room now exceeds the required 100 dB of shielding at 100.5 MHz.

The following plots show the RF leakage as displayed on the spectrum analyzer for each of the areas above.

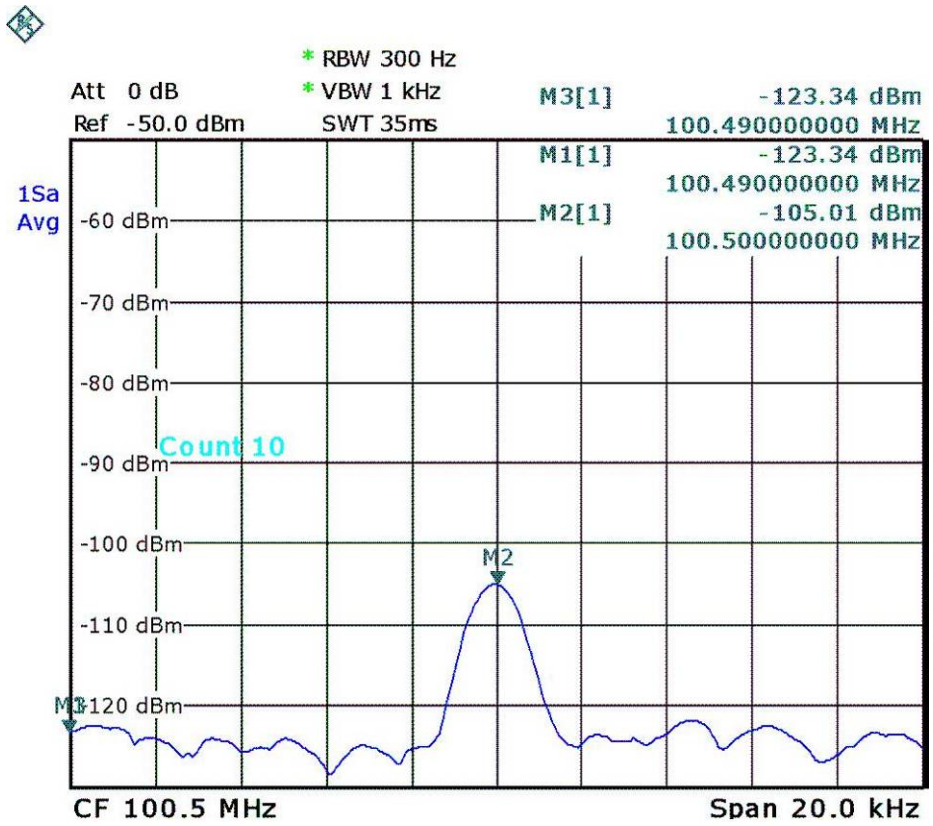
Spectrum Analyzer Plots –



Plot showing measured signal level with MRI room door open

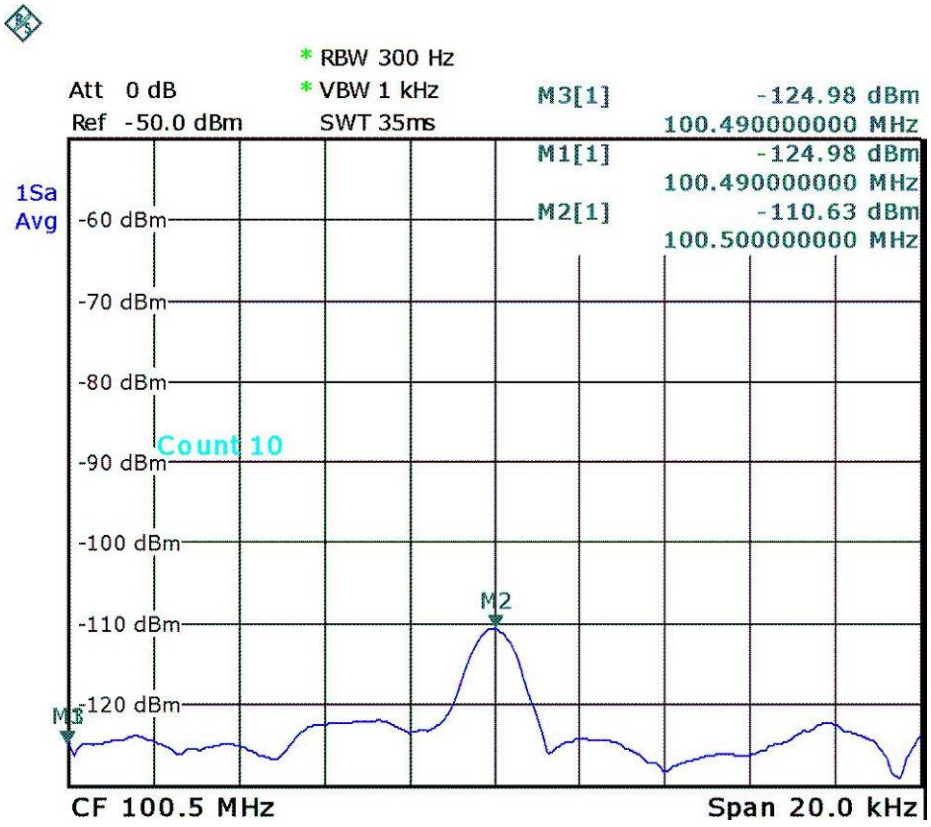


Plot showing measured signal level with MRI room door closed

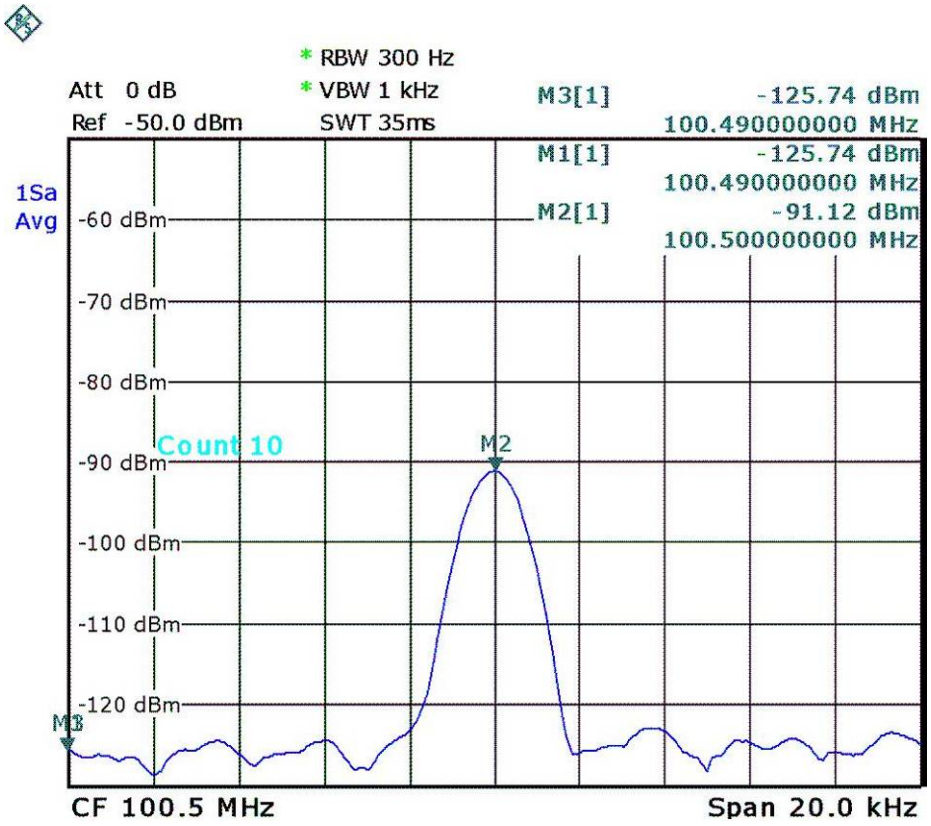


Plot showing measured signal level outside building along North wall (see photo below)

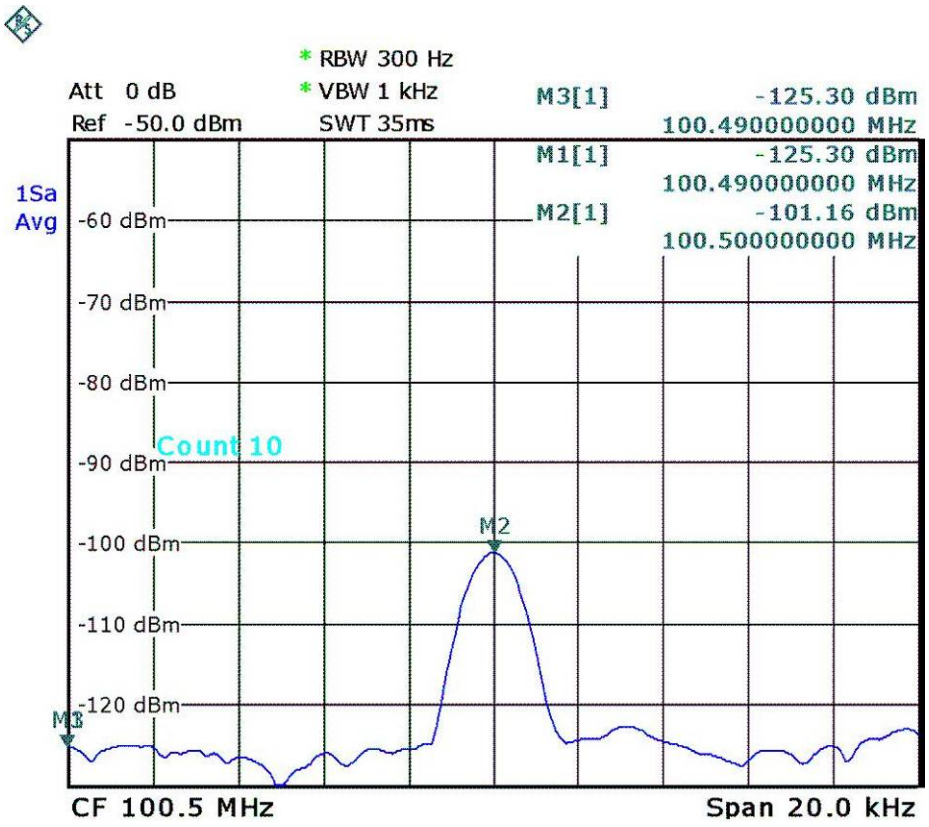
The signal level was measured outside the building along the North wall



Plot showing measured signal level outside the building along the East wall



Plot showing measured signal level inside the equipment room



Plot showing measured signal level inside the equipment room at the observation window

Signal level measured inside the equipment room at the observation window

Conclusions –

The initial RF leakage measured at 100.5 MHz was -55 dB, significantly worse than the specified -100 dB. The majority of the leakage was found to be caused by the removal and improper installation of shields covering the cable pass-through locations, although the RF-tight door's integrity had also been compromised. 360°RF directed and performed repairs on the door by replacing damaged fingerstock material, and also reinstalled the shields covering the cable pass-through area. This effort reduced the worst RF leakage (at the door area) to an acceptable -101.1 dB.

Recommendations –

We found that the fingerstock on the edges of the door was damaged in three locations, as well as being dirty, preventing a good, low-resistance contact with the metal doorframe. The doorframe itself was also found dented, apparently as a result of being hit by a patient's gurney (at least one of the fingerstock damage is also suspected to be resulted from contact with a gurney). Thus, 360°RF recommends that greater care be taken when moving a gurney or other object through the doorway to prevent damage.

The attending RF engineer also found shield panels both missing as well as improperly reinstalled, perhaps while work was performed on cables. These shield panels are essential to obtaining high RF isolation of the MRI Test Room and should always be reinstalled properly, with all fasteners properly secured and tightened.