Isolation Requirements in Diplexed MF Antenna Systems

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The vast majority of diplexed medium wave antenna system installations are retro-fits; installation of a second frequency on an existing antenna system.

In most cases if the original antenna feed system was of good quality and has been well maintained, it is retained, and the only modification to the geometry of the feed system for the original frequency is the installation of series and possibly shunt filters for isolation.

The advent of modern solid state transmitters, which have relatively wide band output networks, can make the filtering problem much more intractable than was the case with the high-Q output circuits of tube transmitters. And, a considerable percentage of existing antenna feed systems use panel and shelf mounted networks, particularly for ACU installations.

New system installations with solid state transmitters, however, now almost always use cabinet mounted antenna feed system equipment, even if the cabinets themselves are located in ACU buildings. The tendency of the equipment vendors (Kintronic, Harris, and Phasetek are the only significant suppliers) is to supply equipment in stand-alone boxes. Sometimes these contain both an ACU network and filter, and sometimes, particularly for the filters on the existing frequency, the filters are in separate boxes. Occasionally, when there is "pre-matching" common to both feeds, there will be common tower feed from one of the cabinets.

In cases where the frequency spacing is less than about 200 kHz and filters and ACUs were mounted in separate enclosures, we have encountered substantial difficulty in reducing intermodulation components -80 dB below carrier, as required by the FCC rule. *(47CFR73.44)* In each instance we have investigated, the difficulty was the result of circulating RF current in ground loops created by the cabinetry or panel layout and interconnection practices.

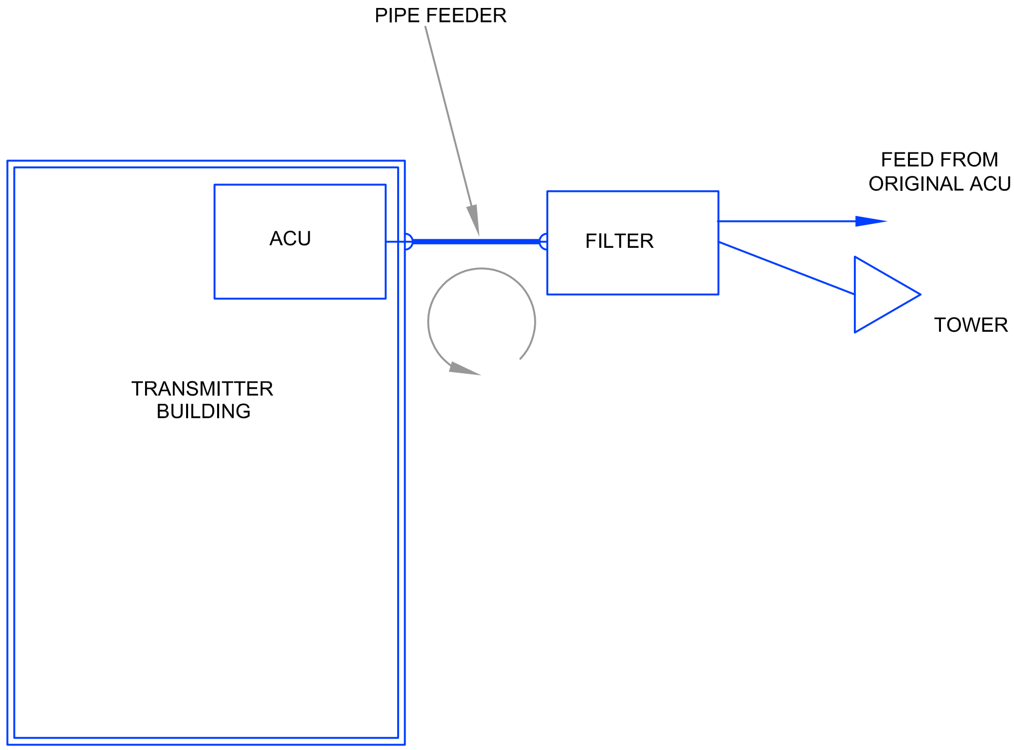
A recent example is illustrated in the attached drawings.

Drawing 1 shows the "retro-fit" installation with the original ACU in a transmitter building to the right, a new ACU in the new transmitter building on the left, and a cabinet with filters for each frequency and a common pre-match reactance between the new building and the tower.

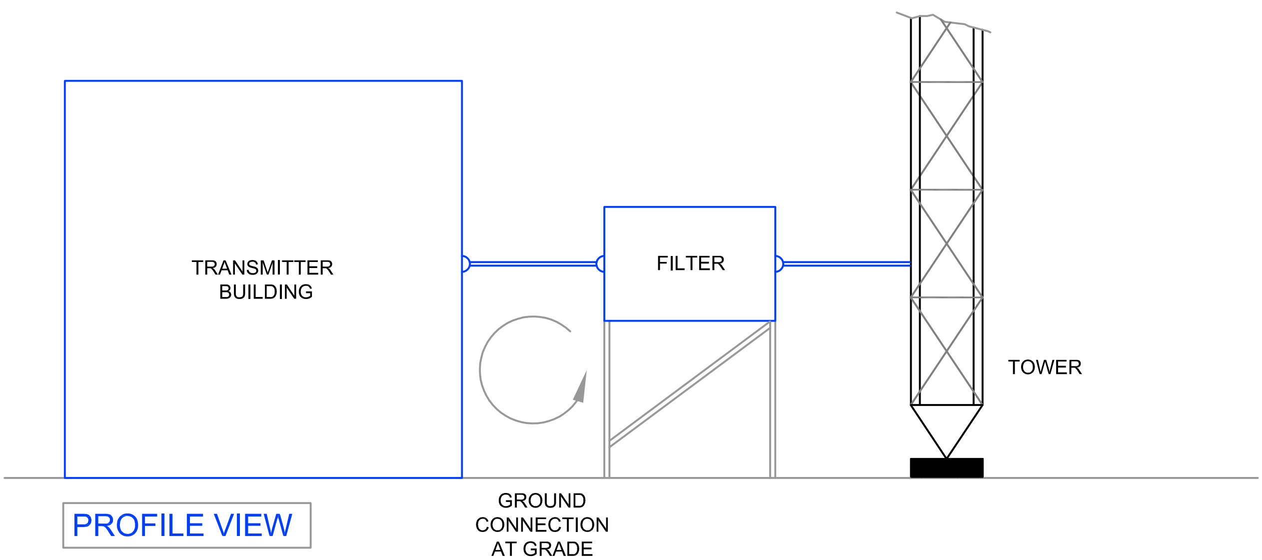
The 2x-y intermodulation product from the new transmitter was found to be down only about -65 dB, although the similar product from the original transmitter on the site was nearly undetectable, well below -80 dB. The filter, pretuned by the manufacturer, was found to be optimally adjusted when checked. However, a substantial amount of undesired carrier could be observed on the common-point bus of the second, newly installed, feed system equipment.

A visual inspection disclosed that the ground connections between the cabinet and the transmitter buildings were at grade, although they were made with multiple parallel straps as was recommended. As noted by the "arrow circle" on Drawing 1, however, there was a large loop consisting of the ACU box, the ground strap, the filter box, and the feeder. At the filter end, the feeder-ground connection was essentially zero impedance due to the shunt filter network. At the ACU end, the impedance was modest but not high at the undesired frequency. The orientation of the equipment with respect to the tower and its magnetic ("H") field characteristics near the tower base resulted in substantial current flow at the undesired frequency, and "current loop" was on the input side of the filter.

Drawing 2 shows an effective amelioration method. If the feed itself is paralleled with a ground strap or, better yet, enclosed in coax or a "quasi-coax" arrangement, the current will flow in the ground or the outer of the "quasi-coax" and the induced current into the feed system can be minimized. In low power installations a short piece of foam Heliax or Foamflex can be used, as long as care is taken not to exceed its voltage breakdown ratings. In higher power installations, an "outer conductor" can be fashioned from 1-inch or 2-inch (2.5 or 5 cm) strap of appropriate thickness.



PLAN VIEW



PROFILE VIEW

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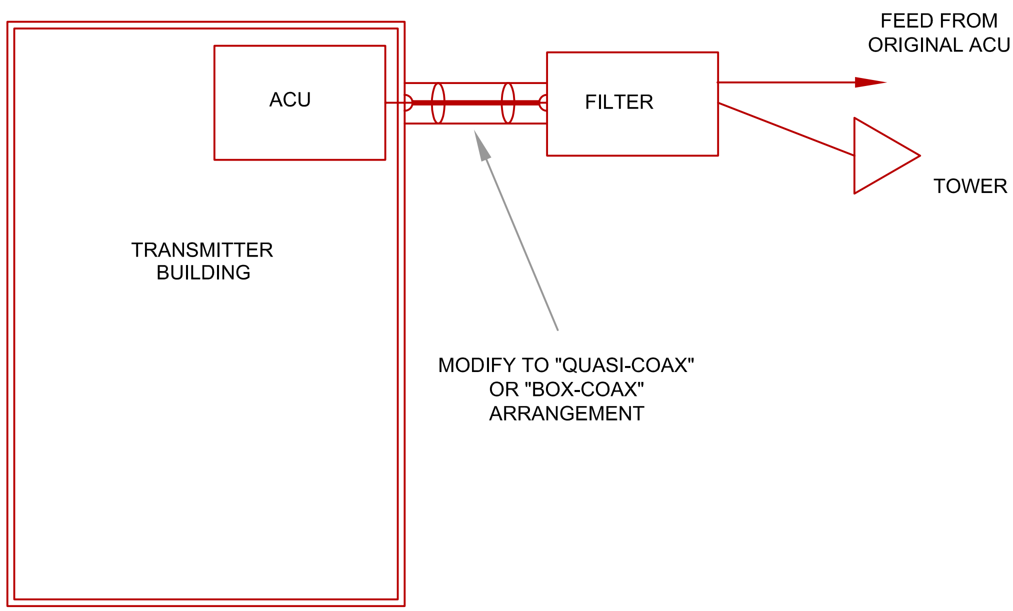
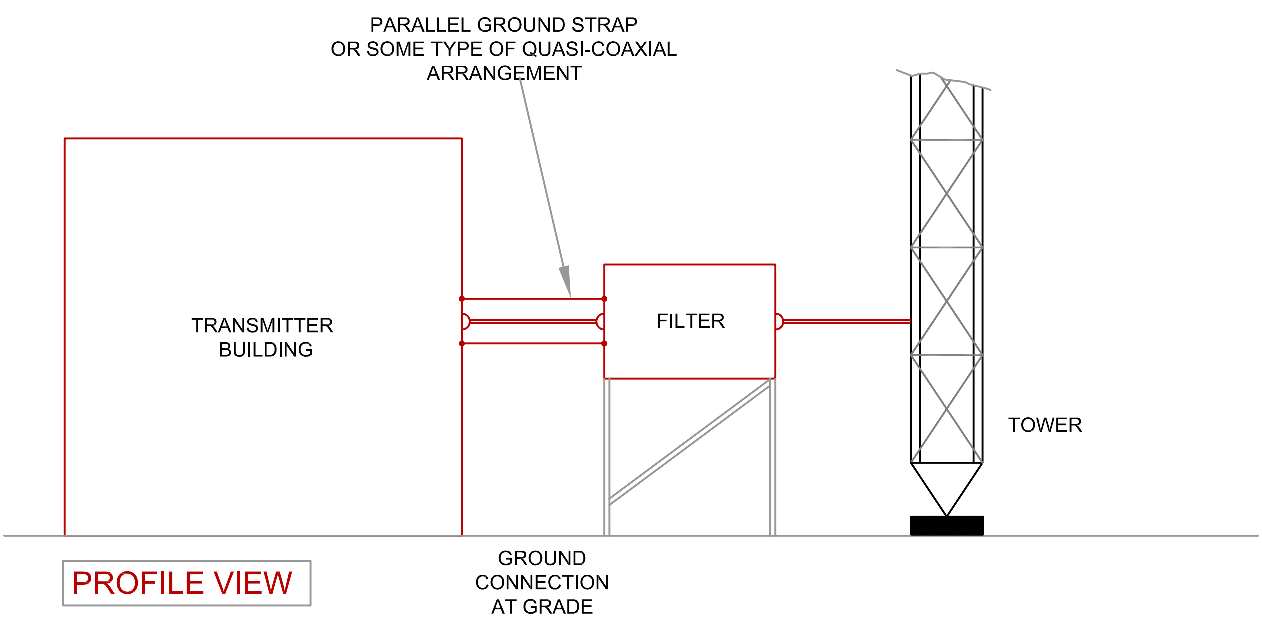
RETRO FIT DIPLEXER INSTALLATION

DRAWING 1



PLAN VIEW



PROFILE VIEW

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RETRO FIT DIPLEXER INSTALLATION
MODIFIED TO REDUCE INDUCED CURRENT FROM TOWER

DRAWING 2

Of interest is why the 2x-y product from the original transmitter did not occur at a high level as well. In the geometry of this installation, the feed from the filter to the original ACU is at such an angle to the tower that it is not well coupled to the displacement current generated H field, and has approximately equal segments extending each direction from the point closest to the tower, resulting in minimum coupling.

When the pipe feeder was shielded with a new set of coaxial arranged ground bus straps (see photographs), after the ACU was retuned to compensate for its effects, the 2x-y product from the second frequency transmitter also fell well below -80 dB from carrier.

It's important to pay attention to the magnetic field coupling among the various portions of this type of interconnected system. In at least one instance a diplexing filter that was on an open panel on the inside of a wood frame ACU building located about 1 meter from a tower had enough current from the magnetic field of the tower induced into an inductor to cause an arc and damage to it, even though the induced energy was picked up from another transmitter site a kilometer or so distant. The diplexing equipment at this installation, which had well over 200 kHz spacing, had only series filters, and very short multiple ground strap connections between adjacent panels, so the filtering wasn't compromised by the geometry of the equipment. In general, systems with wide frequency spacing don't usually suffer from unintended coupling since the transmitters themselves offer better discrimination against the unwanted signal. Systems with wide spacing and favorable impedance bandwidth situations are often constructed with only series filters. The high impedance of series filters, when no shunt filter is present, substantially reduces pickup at the unwanted frequency because the high impedance is a part of the unintended loop.

In another retro-fit installation, the equipment manufacturer located the two sets of filters and the newly installed ACU network in a single cabinet with appropriate internal dividers to minimize coupling, but then ran the unshielded combined feed from the output side of the filters back through one of the filter cubicles to an output feed-through to the tower. This system had unacceptable intermodulation when first installed. Because the system power was low, short sections of foam coaxial line were installed to shield the feeders, minimizing the coupling and bringing the intermodulation below the required value.

Similarly, at a site where a new owner replaced the equipment of the original station with new equipment, the interconnection between the newly installed ACUs and the previously installed filter cabinets, which were integral with the ACUs for the second frequency, ran close to the tower base and enough coupling was present to produce unacceptable intermodulation. It was necessary to add cabinet grounding from all corners of all of the equipment cabinets to the tower base grounding and to add coaxial cable for the interconnections to bring the intermodulation down below the required value.

Completely new installations don't often suffer from these problems, but it's generally because they most often employ a single cabinet for each ACU/filter combination.

“Quasi-coaxial” shielding for outdoor buswork

Shielding inside transmitter/feed system building