Transmitter replacement considerations beyond Repack

Introduction

The major components of a transmitter system include; control system, exciter(s), high power amplifier(s), cooling system(s), and a high-power RF filtering and switching system. All these subsystems are designed to ensure that when they are integrated together, FCC requirements are met, and the system provides the most redundancy and reliability possible. Advances in exciter and amplifier technology have been occurring rapidly, making systems built as little as ten years ago obsolete. Although these older systems may still be functional, efficiency and long-term support issues may prompt broadcasters to consider replacing them. The significant changes in technology that impact efficiency and parts obsolescence primarily involve the exciter and high-power amplifiers in a system. Since transmitter control systems and cooling systems are closely integrated with the high-power amplifiers, they are often included in any upgrade plans. Although the RF system was also originally designed as an integral component of the overall transmission system, it often gets looked at as a separate system independent of the transmitter. It usually makes up about 10% of the cost of a new transmission system. It only makes sense that, after repack, broadcasters looking to replace, for example, IOT transmitters, would look to re-use all or part of the existing RF system. However, it is certain that some components of the system will need to be replaced. There may also be a number of potentially serious issues that arise making the integration of new transmitter with old RF system more complex than expected – eroding any potential savings on such a significant capital investment. The compatibility of the older components with the new system, condition and level of support that still exist for the older components, ATSC 3.0 readiness, and the impact on the installation, proof and system documentation must all be part of the decision.

Compatibility

The compatibility of the components in the existing RF system need to be looked at closely to confirm that they will interface properly with the new transmitter. Potential issues can arise with the RF connections, cooling systems, control systems and the monitoring points.

- Before confirming physical compatibility, it is important to ensure that the actual level of filtering provided by the system is acceptable. The newer systems typically will have higher performance, it is unlikely that additional filtering will be required however there may be too much filtering. Higher levels of filtering will impact system efficiency and may result in unnecessary components being left in the RF system.
    - Harmonic filtering needs close attention. Older systems would often have multiple levels of harmonic filtering with both coaxial and waveguide filters used to meet FCC requirements. Many of the current transmitter systems have all necessary harmonic filtering integral to the cabinet or use newer external designs that eliminate the need for the waveguide harmonic filters.
    - There are also a large variety of mask filters. Bandwidth, power handling and rejection are typically the parameters reviewed. However, the impact of frequency drift should also be understood. A popular filter design for digital IOT systems had several hundreds of kilohertz of drift between cold start and normal operation.

- Most of the coaxial and waveguide connections in a high-power RF system conform to an EIA standard that ensures compatibility. The exception is 4 -1/16" coaxial line which is now widely used. Without a universal industry standard, two different versions exist. These are commonly referred to as "thin wall" and "thick wall" based on the difference in wall thickness of their inner conductor. These are not compatible with each other and adapters between the standards must be used if they will be mated to each other. Failure to identify and use appropriate adapters can have catastrophic consequences.
- As new transmitters were introduced, some manufacturers changed the coolant used in their cooling systems. New RF components were redesigned to ensure materials that were in contact with the new coolants are compatible with these new coolants. If any of the old RF components are liquid cooled, compatibility with the coolant to be used in the new system must be confirmed.
- High power RF systems are primarily passive systems however RF switches, magic tee combiners and air-cooled filters will often be integrated with, and controlled by, the transmitter's control system. Ensuring that these interface and control provisions are integrated in the new transmitter could be problematic, requiring development of custom interfaces. Simply bypassing interlocks is very risky.
    - It is also important to confirm that voltage and impedance of the RF components is compatible with the new control system. Most of the control systems used either 12 or 24 VDC. Relays may need to be changed in the RF switches or fan control boxes if the voltage has changed. Some of the new transmitters have also taken advantage of the high impedance solid state inputs on switch actuators. The approach being used to control new switches may not work with the older low impedance, relay commanded switches.
- RF systems provide interlocks and RF monitoring points to be used by the transmitters control, metering and exciter correction circuits. It should be confirmed that the necessary interlocks exist. The quantity, location and coupling level of the existing directional couplers should be reviewed. Confirm that there are enough for not only the transmitter but also any ancillary monitoring or test equipment. Plans to adjust coupling levels or attenuate levels may be needed. It should be noted that not all directional couplers are field adjustable, and some require shims to be changed in value.

Current RF System Condition - VSWR

The condition of an existing RF system should be looked at very closely if it will be incorporated into a new transmitter system. High power combining, filtering and switching systems are designed to need little maintenance. Little maintenance is not the same as no maintenance. An RF sweep of the system should be performed on a regular basis to provide early detection of any component drift or damage. If no recent sweep information is available, a new RF sweep should be carried out prior to determining the final configuration and before a new system is energized. During the RF sweep, switch movement and contacts should be checked, and any manufacturer recommended cleaning or lubrication of components should be carried out. Overall system VSWR should be optimized. A high VSWR level will quickly degrade the voltage safety margin of all the components between the mismatch and the transmitter. The level of support that is still provided by the system manufacturer should also be investigated. Special attention and specific questions should be asked about motorized components or any system components with integral PCBs or PLC systems. These components are harder to support over long periods, often causing manufacturers to end all support for that product line or series.

Transmissions sites have undergone a considerable amount of change in the last decade. Many sites have decommissioned systems as result of the repack or even the analog sunset. If any of these decommissioned systems have components in the active RF path of the current system, it would be a good time to consider removing these. This would be especially true for channel combiners that may still be in place with unused channel ports now terminated or capped off. The safety margin of these unused components would also need to be confirmed. A breakdown or high VSWR level in any RF component stresses all the components between it and the transmitter. It would be unfortunate if a component that had no current purpose in a system resulted in the damage of an expensive component required to remain on air. Many of the newer RF systems designs are also more space efficient. Would a new system layout free up space that may serve another purpose or make servicing the transmitter easier?

Considering ATSC 3.0?

A potential format change from ATSC 1.0 to ATSC 3.0 may also influence the decision to re-use an RF system, with a major factor being the increased peak power of the OFDM based format. Most of the components in a typical high-power RF system are limited by the average power and have ample peak power headroom to accommodate the format change. Filter components may be the exception. Physical constraints and localized high peak voltages will often limit the amount of peak headroom that can be designed into these components. Filters will typically be designed to a voltage safety factor that was based upon the peak to average power ratio expected at the time the filter was purchased. Older filters were not designed anticipating the higher peak levels of ATSC 3.0. This applies primarily to the channel bandpass filter but should be confirmed for the system's low pass filters. Keep in mind that it is not uncommon to have multiple levels of low pass filtering. Many systems had a primary coaxial low pass filter and a supplemental waveguide low pass filter installed. The safety factor of all these components should be understood. If the safety factor is less than the manufacturer recommends, the components should be replaced.

The other significant change when transitioning to ATSC 3.0 is the increase in occupied bandwidth. ATSC 1.0 used approximately 5.38 MHz of the allocated channel, ATSC 3.0 will use up to 5.83 MHz. It does not sound like a significant difference and many of the channel bandpass filters do have the required bandwidth to pass the full ATSC 3.0 band. The exception may be adjacent channel combiners and some highly selective, sharp tuned filters. Early adjacent channel combiners used the channel guard band at the edge of the channel to improve the isolation between the combined channels. Sharp tuned filters were widely used as channel filters and were designed to provide a considerable amount of rejection of the shoulder energy. Prior to the development of the ATSC 3.0 standard, these also used part of the guard band on the channel edge as the filter transitioned from the passband to the rejection band of the filter. Original data if available should be reviewed. If significant roll-off in the ATSC 3.0 band is seen, carrier reduction may help but replacement of the filter is recommended to ensure adequate safety margin and to minimize loss of channel data capacity. It is important to note that filter roll off on the edge of the band may have little impact on reception but could lower the safety factor of the filter significantly. The skirts of the filter are the most susceptible to voltage breakdown.

Logistics

If an auxiliary site exists that allows a broadcaster to maintain coverage as a system is being replaced, the extra off-air time needed to identify issues and integrate the new transmitter to the old RF system should not be a problem. Additional challenges will be experienced if the system must remain on air, with minimal down time during the upgrade.

- Connections to the high-power RF system should never be made while any portion of the system is under power. RF switch or combiner isolation should not be trusted to bring levels to safe levels on parts of the system that are not active. Ports should never be left open during any transitional phases of an upgrade.
- If any liquid cooled loads or filters will be reused, they should be flushed and cleaned before being connected to a new cooling system. Old coolant should not be allowed to contaminate a new system.
- If the transition will be phased with a portion of the old system removed as either part or all the new system is being installed, a plan that includes maintaining functionality of critical system interlocks is important. During these periods there is a higher likelihood of a fault occurring. Bypassing interlocks could prevent a shutdown that leads to significant damage.
- AC power for the RF system cooling fans and switches may be coming through the existing transmitter or its dedicated service panels. A clear plan for transition of any AC requirements is needed.

Summary

In some cases, reusing the existing RF system may save time and installation costs. In other cases, savings may only be evident in initial proposals and those may quickly be eroded as the project starts. Cost comparisons should be done capturing all the costs associated with using a new system verse an existing system. Time to modify, clean and test the existing system, necessary adapters and multi-stage installation costs if the system must remain on air during the upgrade. With the newer transmitter systems, the FCC proof of performance should proceed smoothly. However, for RF systems that have not been proven with a specific transmitter, issues may come up. Is the transmitter supplier accepting this risk? Lastly system documentation is something that is often overlooked. Standard new RF systems will typically be well documented in the transmitter suppliers' manuals. How will the existing RF system and its interface to the rest of the overall system be documented? Lack of attention to this at the time of installation may lead to considerable frustration years later while attempting to troubleshoot a fault, especially as the number of experienced RF personnel available to be employed by broadcasters continues to fall.

This bulletin has attempted to draw attention to some of the issues that need to be carefully considered when a partial replacement of a transmission system is being contemplated. These additional, potentially hidden, costs along with the age of the RF system may make the purchase of a completely new system the more logical choice.

Dielectric recognizes the attractiveness of the proposition to re-use RF components and will work with broadcasters and transmitter manufacturers to identify when this is practical and cost effective.