

OPERATIONAL CHALLENGES OF 85MHz DEPLOYMENT



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Changing an HFC network from a 42 MHz split to an 85 MHz split, or an even higher frequency split such as 200 MHz, presents significant operational challenges in the home and local access networks. These challenges result from the dramatic change in level experienced in the home and local access network as the frequencies shift from downstream usage to upstream usage as well as long-held assumptions about the frequencies used for downstream transmission.

This paper will discuss upfront considerations for set-top box out-of-band (OOB) communication frequencies as well as the results of the higher power levels in the home and in the local network. Finally, some coping strategies will be presented to allow the network upgrade to proceed without requiring a wholesale upgrade of in-home equipment.

SET-TOP OOB CONSIDERATIONS

Most Operators have a large existing population of set-tops and digital television adapters (DTAs) that use the old proprietary OOB communications channel in the downstream. The exact frequencies used vary with different setups, but they are generally below 85 MHz. This OOB channel is required to keep set-tops operational – it provides everything from encryption keys to firmware updates. When a network moves the downstream/upstream split to 85 MHz, changing the OOB channel must also be addressed.

The simplest path is to move it above 85 MHz, but it is important to note that not all set-tops support higher OOB frequencies. For set-tops or DTAs that cannot move to an OOB channel above 85 MHz, upgrade plans must address their removal from the network before the upgrade can proceed. Most recent set-tops can accept a higher downstream OOB channel, though a firmware upgrade may be required.

If the network upgrade is pursuing a 200 MHz split, then most OOB set-tops will not support a high enough OOB frequency. An operator pursuing a 200 MHz upgrade may consider moving video delivery to all IP, which can eliminate the need for a legacy OOB channel. Another option for that Operator is to use a DOCSIS set-top gateway (DSG) for OOB communications. The DSG places the same communications normally in the OOB channel into a DOCSIS IP communication. If deployed set-tops support DSG, then a 200 MHz upgrade can proceed without a massive investment in new equipment or new methods of video delivery.

WHY IS THERE AN ISSUE WITH LEVELS?

Ideally the change in frequency of the HFC split point would not cause any issues. In-home equipment, though capable of tuning to the new upstream frequencies, would have no reason to tune to that band once the downstream channels are removed. But, the tuners within set-top boxes, cable modems and cable-ready TVs are not perfect. The presence of significant energy in their reception band even outside of the nominal tuned channel can cause distortions due to the automatic gain control (AGC) circuitry being fooled by that excess energy.

An AGC circuit exists to protect the tuner from too much energy and to boost the signal, if needed, to stay in the tuner's linear region. Many AGC circuits integrate the power received over a wide bandwidth, not just the narrow channel currently to be received, and adjust the level into the tuner accordingly. When the signal power is too high, the AGC circuit will lower it to protect the tuner. Harmonic distortion or similar issues caused by a powerful upstream signal above 54 MHz in the tuner may also contribute to the problem, but AGC effects appear to account for most of the issue.

The upstream transmit signal from an 85 MHz cable modem is potentially quite powerful. As an example, in DOCSIS 3.1, the transmit level of a minimally sized 24 MHz signal can be up to 56dBmV relative to 6 MHz. As is shown in Figure 1, the transmitted signal will leak to other ports within each splitter that the signal crosses.

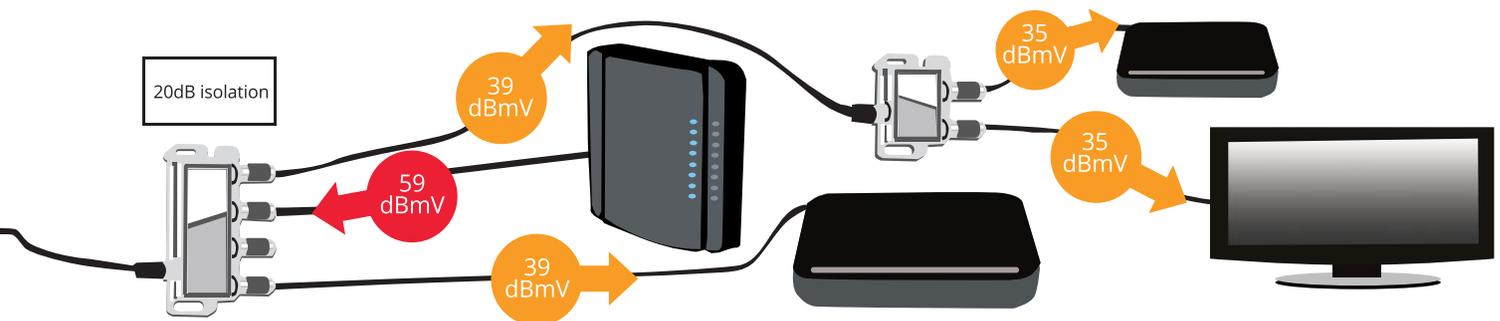


Figure 1

The isolation of the ports in the splitter sets the amount of leakage that will be seen on the other ports. Common inexpensive splitters may have isolation as low as 20dB from port to port. Better quality splitters may have more loss, or less leaked energy, but at the DOCSIS3.0 or 3.1 power levels, some energy will leak through. That energy, as is shown in the diagram, travels back through the rest of the home network.

When the leaked signal reaches a device, the AGC may react. For example, if the leaked signal has a loss of 30dB, it could reach a directly connected set-top box at 26dBmV, a much higher level than the typical 0dBmV downstream video signal within the home. When the AGC detects the higher power level, it will attenuate the entire downstream signal. If the attenuation is too high, the desired downstream video signal will be degraded or lost. The amount of additional attenuation present between the leakage signal and the affected device will vary depending upon the splitter arrangement within the home.

ARRIS tested a collection of set-top boxes to determine what level of signal leakage tended to cause problems. Results of the testing are shown in Figure 2.

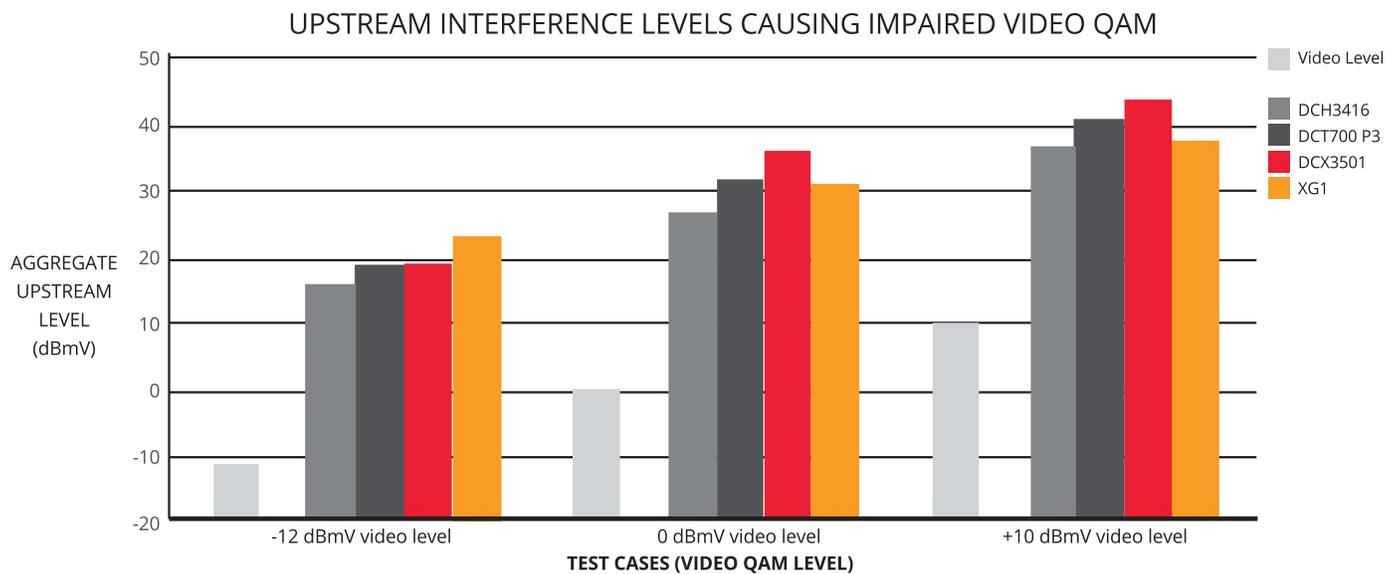


Figure 2

The devices under test were tuned to a 256 QAM video channel at 111 MHz, with a full video channel load present up to 945 MHz. A block of upstream signals was added between 54.3 MHz and 74.5 MHz. The block was varied in level to discover at what level video degradation occurred. As would be expected, the level of the video signal as well as the level of the upstream signal both influenced the problem. One way to describe the result is that the difference between downstream video level and the 85 MHz upstream level must be less than 25dB to avoid problems in the majority of set-top boxes.

The problem of unexpected reflected energy in the downstream tuner's receive band is not limited to the home where a new 85 MHz cable modem is deployed. ARRIS also tested the performance of some taps. The test setup annotated with sample test results is shown in Figure 3.

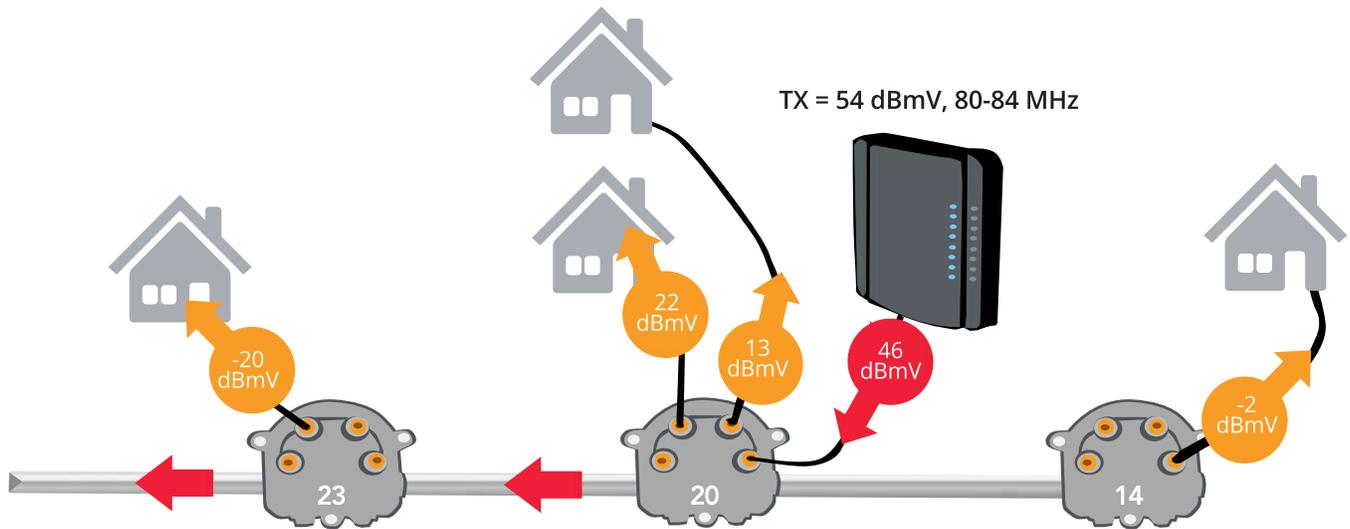


Figure 3

The internal circuitry of a tap is equivalent to a directional coupler tapping the trunk line with a splitter dividing that tapped energy to the tap's F-connector ports. When a signal is sent from one home into a port on a tap, reflections or leakage are generated in the splitter circuitry within the tap. Another home that shares a tap's internal splitter can receive the leaked signal at a relatively high level. In testing, as little as 24dB of loss was seen from port to port of a standard tap. Since a set-top box in another home will still have drop cable loss as well as in-home splitter loss to reduce the reflected signal's power, the possibility of degraded performance is not as high as it is in the original home, but if the incoming video level is low, the stray signal could still cause problems. Many tap specs have higher isolation levels, but it is advisable to actually test representative examples of equipment found in the plant to see how the equipment performs.

CAN THE PROBLEMS BE EASILY DIAGNOSED?

Operationally, the most difficult problems to troubleshoot are the intermittent ones. Problems caused by AGC overload due to upstream transmissions below 85 MHz will be intermittent, showing up only when the new modem is transmitting. A report of video breaking up

occasionally can have many possible causes, and 85 MHz leakage is just another possible cause. As noted above, it is even possible that the subscriber reporting the problem does not have a DOCSIS 3.1 modem themselves; it could be the neighbor's new modem that is affecting the home through low isolation at a shared tap. Aside from the splitter contributions, the hysteresis timing of the set-top's AGC circuit can also affect whether or not a problem is seen. If the AGC circuit has a slow hysteresis, then the shorter cable modem bursts may not even be detected by the AGC. But if the AGC is triggered, a slow release may cause the problem to be visible to the affected customer even after the cable modem has ceased transmissions.

Because of the overlap in the use of video services with high-speed data (HSD) services that has been shown in other studies, subscribers are likely to be watching television at the same time that other people in their home or their neighbors are most likely to also be using HSD services. If there is a 85 MHz upstream signal issue, it may be seen and reported in the evening, but probably not investigated until the following day. A technician who arrives at the home the following day may not see any video degradations and, unless trained to also look for 85 MHz modem issues, he may dismiss the problem as a temporary interruption in the plant.

HOW CAN THE ISSUE BE PREVENTED IN THE HOME?

Many alternatives exist to remediate a home where a new 85 MHz modem has been installed; the sensitive home equipment can be protected individually or addressed by remediating the home overall.

One approach to preventing in-home issues is to use a two-port cable modem for 85 MHz deployments as shown in Figure 4.

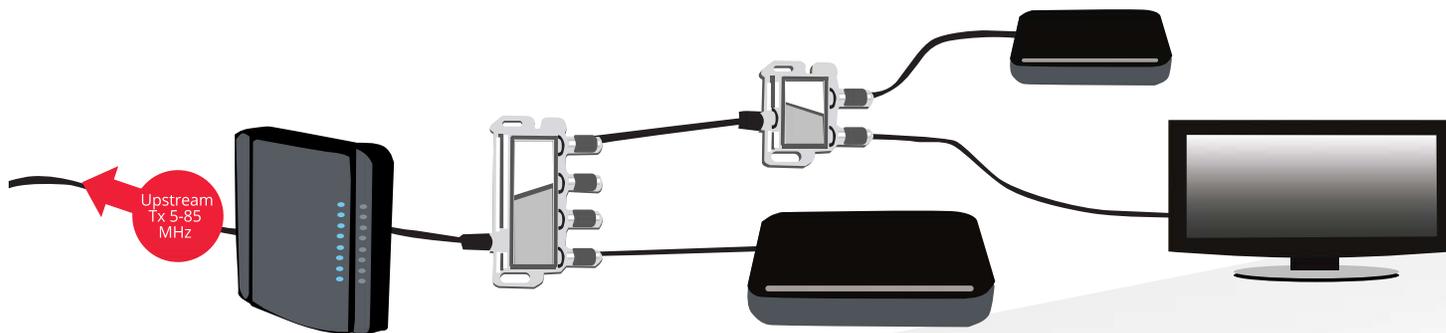


Figure 4

One port addresses the hybrid fiber coax (HFC) network and the other port addresses the home network. Using this device eliminates the possibility of interference in the home by directing all upstream transmissions directly onto the HFC network.

Alternatively, if a traditional cable modem configuration with a single port is used, filters that block signals between 42 MHz and 85 MHz can be added to each set-top box or other cable receiving device or alternatively to a leg to protect multiple device.

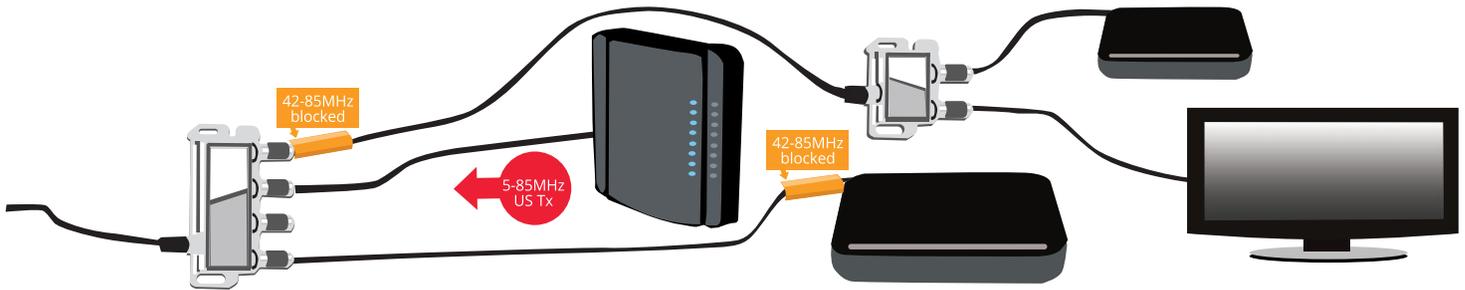


Figure 5

Note that a simple high pass filter is probably not sufficient, since most set-top boxes have internal DOCSIS modems or other OOB means to transmit upstream. A simple high pass filter can change those two-way devices into one-way devices. A bandpass filter can be used to just block the offending transmissions between 42 MHz and 85 MHz while still allowing upstream transmission in the original upstream band.

Alternatively, a new splitter with internal filtering could be placed at the top of the home network, similar to common practice with EMTAs today as shown in Figure 6.

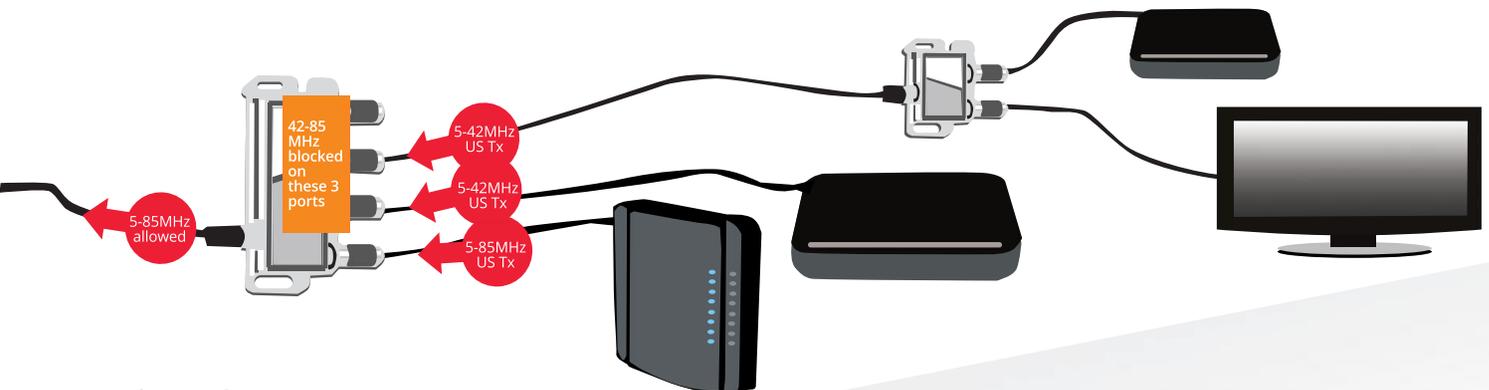


Figure 6

The new splitter could have a port with additional filtering appropriate for an 85 MHz cable modem. The additional filtering can prevent reflections in the 42-85 MHz band from reaching the other ports used for the home.

HOW CAN THE ISSUE BE PREVENTED IN THE LOCAL ACCESS NETWORK?

A more challenging situation is present if testing has shown that some tap ports do not have enough isolation from each other and will tend to pass 85MHz energy from one port to another. One option is for direct installers to place bandpass filters on other ports of a tap potentially affected when the new modem is installed. A possible drawback to this approach is that if a neighbor attempts a self-install of an 85MHz modem at a later time, it will fail unless the filter in the tap port is removed.

Another possible approach is to replace the tap faceplate or even the entire tap as a part of the 85 MHz plant upgrade. This solution makes the most sense if the tap is to be replaced for example to enable 1.2 GHz downstream service. Some MSOs are considering expanding their downstream services above 1 GHz. The current taps in the field generally do not provide good performance in this band. If the tap is planned to be replaced, also upgrading the isolation to prevent 85 MHz crosstalk would be an ideal combination.

WHAT IF AN 85MHZ MODEM ONLY TRANSMITS IN THE 42MHZ BAND?

Some MSOs are considering deploying 85 MHz modems now in advance of a plant upgrade. They would like to continue using the 54-85 MHz frequency band for downstream services, but also want to ensure that their new modems will be intact after a 85 MHz plant upgrade down the road.

Unfortunately, problems can be caused by an 85 MHz modem even when it is operating below 42 MHz if it does not have a built-in switchable filter. Testing has shown that at least some DACs used for cable modem transmitters have a noise floor that pops up during transmissions. The levels will be fairly low, for example -16dBmV, because the device must still pass the specification for noise in the 85 MHz band, but it is higher than the noise

specification for the 54 MHz downstream band. Because this noise would have to pass through the same port-to-port isolation loss discussed earlier, it is unlikely to affect digital carriers, but it may cause distortion to analog video signals in the 54-85 MHz band. Analog video signals can begin to show distortion with signal-to-noise ratio (SNR) of less than 40dB. If the incoming video signal is at 0dBmV, then the reflected jump in the noise floor could be around -36dBmV. For lower video levels, the likelihood of problems would increase.

To avoid this problem, deploying a device with a built-in switchable filter is preferable. The solution proposed above for 85 MHz deployments of improved port-to-port isolation could also solve this issue.

CONCLUSION

Consumer demand for increased downstream bandwidth is also driving increases in the demand for upstream bandwidth. The latest DOCSIS standards allow or require support for upstream operation above the current operating 5 to 42 MHz or 5 to 65 MHz upstream bands. Successful operation in this band requires that actions be taken to prevent problems in the legacy equipment already deployed in the field.

A two-port cable modem or gateway provides the most operationally friendly option, but other options can also provide acceptable performance. Improving the port-to-port loss in splitters in the home as well as within taps supporting homes with new 85 MHz modems can prevent problems from showing up after the new modems are deployed.

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