

## OPERATIONAL CHALLENGES OF 85MHZ DEPLOYMENT

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### *Abstract*

*Upstream expansion past the current 45MHz or 65MHz to increase available upstream bandwidth has been discussed for many years, but now it's about to become a reality. The standards are all finished and hardware is becoming available. But before a successful real world deployment can happen, a plethora of operational challenges must be assessed.*

*This paper gives an overview of the causes for concern, presenting set top box sensitivity testing results, as well as other characterization tests. Results from testing of existing taps are used to explain potential neighborhood effects of expanded upstream deployment that could pose operational headaches if not addressed proactively.*

### OPERATIONAL CHALLENGES OF 85MHZ DEPLOYMENT

Changing an HFC network from a 42MHz split to an 85MHz split, or an even higher frequency split such as 200MHz, presents significant challenges in the home and local access networks. These challenges result from the dramatic change in RF level experienced in the home and local access network at the frequency band shifting from downstream usage to upstream usage. This paper discusses the effects of the higher power levels in the home as well as in the local network, and presents some coping strategies to allow the network upgrade to proceed without requiring a wholesale upgrade of in-home equipment.

#### Why is there an issue?

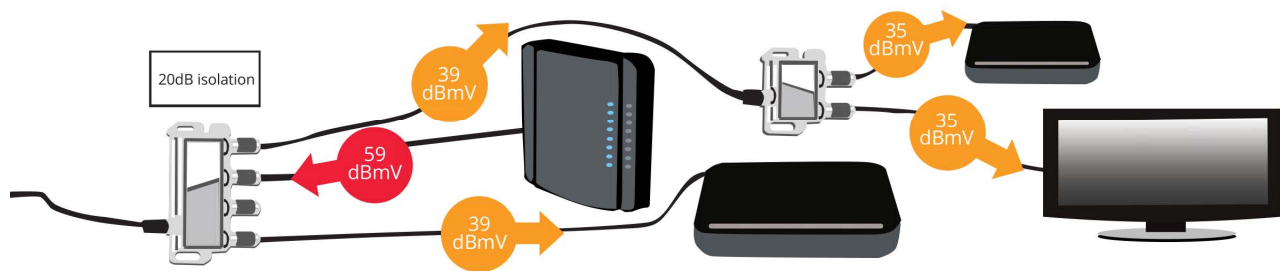
Ideally, the change of the HFC frequency split would not cause any issues. In-home

equipment, though capable of tuning to the frequencies now dedicated to upstream use, would have no reason to tune to that band once the downstream channels are removed. But, the tuners within settop boxes, cable modems, and cable-ready televisions are not perfect. The presence of significant energy in their originally designed reception band even outside of the nominal tuned channel can cause distortions due to automatic gain control (AGC) circuitry.

An AGC circuit exists to protect a device's internal tuner from too much energy in the incoming signal and to boost the signal when it is too low. Many AGC circuits integrate the power received over a wide bandwidth, not just the narrow channel currently desired, and adjust the level into the tuner accordingly. When the AGC circuit detects that the incoming signal power is too high, it will attenuate the signal to protect the tuner. Harmonic distortion or similar issues caused by a powerful upstream signal above 54MHz 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 85MHz cable modem (CM) is potentially quite powerful. As an example, in DOCSIS 3.1, the transmit level of a minimally sized 24MHz signal can be up to 56dBmV relative to 6MHz. As is shown in the figure below, the transmitted signal will generate reflections within each splitter that the signal crosses.

The isolation of the ports in the splitter sets the amount of reflection that will be seen on the other ports. Common inexpensive splitters may have as little as 20dB of isolation from port to port. Better quality splitters may have more loss, resulting in less reflected energy, but at the DOCSIS3.0 or 3.1 power levels, some reflected energy is to be expected. That reflected energy, as is shown



**Figure 1 - Showing Reflected Signal in the Home**

in the diagram, travels back through the rest of the home network.

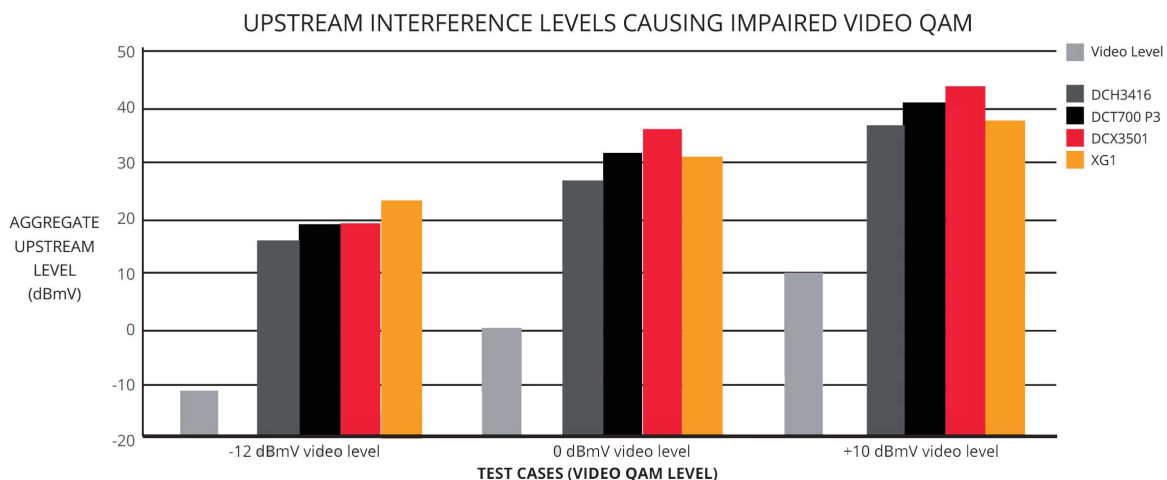
When the reflected signal reaches a device, its internal AGC may react. Using the earlier example of a 56dBmV signal reflected with a loss of 30dB, the reflected signal could reach a directly connected set top box at 26dBmV, a much higher level than the typical 0dBmV downstream video signal within the home. When an AGC detects a high power level, it may attenuate the entire downstream signal. If the attenuation is too high due to 85MHz US reflections, the desired downstream video signal will be degraded or lost. The amount of additional attenuation present between the reflected 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 reflected signal

tended to cause problems. Results of the testing are shown in the figure below.

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 results. The resulting rule of thumb is that the difference between downstream video level and the 85 MHz upstream level must be less than 25 dB at the F-connector of the legacy device to avoid problems in the majority of set top boxes.

The problem of unexpected reflected energy



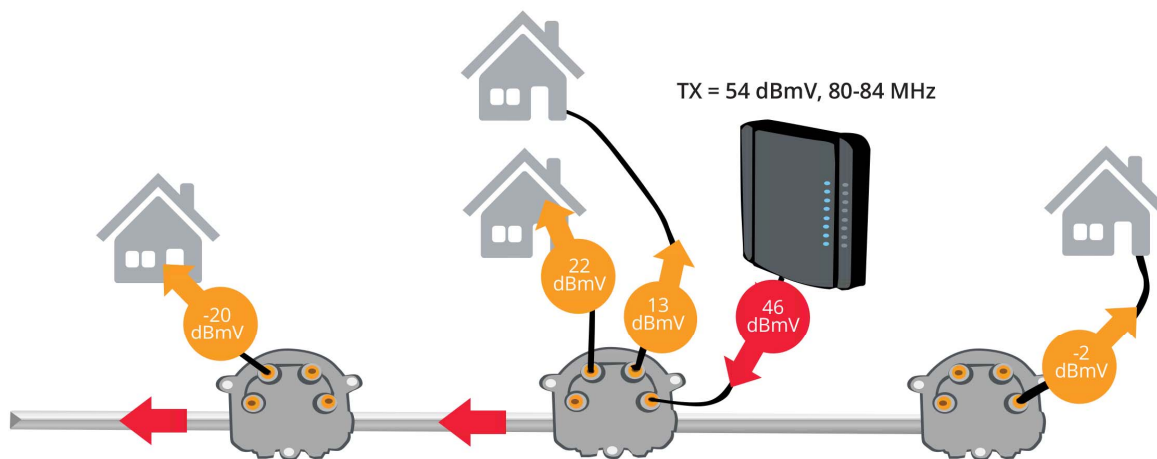
**Figure 2 - Interference Testing Results**

in the downstream tuner's receive band is not limited to the home where a new 85MHz CM is deployed. ARRIS also tested the performance of some taps. The test setup annotated with sample test results is shown below.

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 are generated in the splitter circuitry within the tap. Another home that shares a tap's internal splitter can receive a high level of reflected energy. In testing, reflections with as little as 24dB of loss were seen. 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 reflected signal could still cause problems.

### Diagnosing 85MHz Related Issues in the Field

Operationally, the worst problems to troubleshoot are the intermittent ones. Problems caused by AGC overload due to upstream transmissions below 85MHz will be intermittent, showing up only when the new CM is transmitting. A report of occasional video break ups can have many possible causes, and 85MHz reflections add another possible cause. As noted above, it is even possible that the subscriber reporting the problem does not have a D3.1 modem themselves; it could be their neighbor's new modem that is affecting their home through reflections at a shared tap. Aside from the splitter contributions, the hysteresis timing of the set top box's AGC circuit can also affect whether or not a problem is seen. If the AGC circuit has a slow hysteresis, then the shorter CM bursts may not even be detected by the AGC. But if the AGC is triggered, a slow



**Figure 3 - Example Levels Seen Across Tap Ports**

release may cause the problem to be visible to the affected customer even after the CM has ceased transmissions.

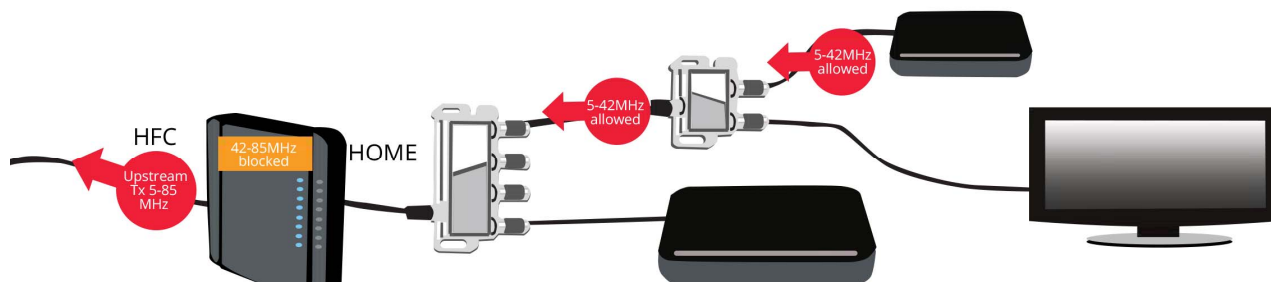
Because of the overlap in the use of video services with High Speed Data (HSD) services that has been shown in other studies, subscribers are likely to be watching

television at the same time that other people in their home or their neighbors are likely to also be using HSD services. If a reflected signal issue exists, it may be seen during prime time in the evening, but may disappear the following morning. A technician who arrives at the home may not see any video degradations and, unless trained to also look for 85MHz modem issues, may dismiss the problem as a temporary interruption in the plant.

### Preventing 85MHz Related Issues

Several alternatives exist to remediate a home where a new 85MHz 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 85MHz deployments as shown below.



**Figure 4 - Two Port Gateway Solution**

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 85MHz upstream transmissions directly onto the HFC network. Upstream transmissions in the legacy US band from within the home must pass through the CM from the home port to the HFC port.

Alternatively, if a traditional single port CM configuration is used, then filters that block signals between 42MHz and 85MHz should be added to each set top box or other cable

receiving device or alternatively to a splitter port leg to protect multiple devices.

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

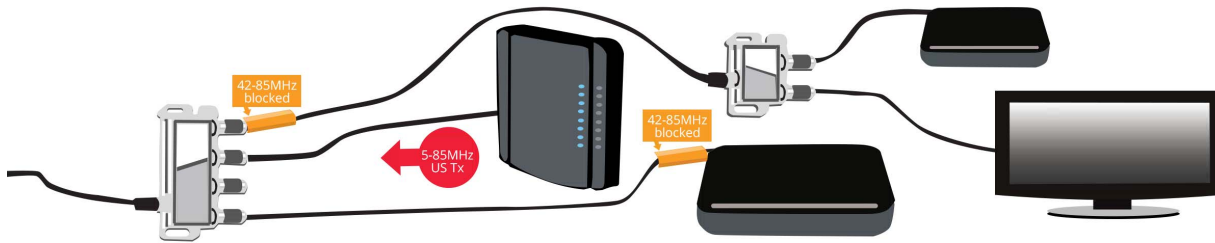
Alternatively, a new splitter with internal filtering could be placed at the top of the home network, similar to common practice with EMTAs today as shown in the figure below.

The new splitter could have a port with additional filtering appropriate for an 85MHz CM. The additional filtering would prevent

reflections in the 42-85MHz band from reaching the other ports used for the home.

### Preventing Issues in the Local Access Network

A more challenging situation is present if Operations determines some tap ports do not have limited port-to-port isolation and will tend to pass 85MHz energy from one port to another. One option is to direct installers to place bandpass filters on other ports of a tap potentially affected when the new modem is installed. A potential drawback to this approach is that if a neighbor attempts a self



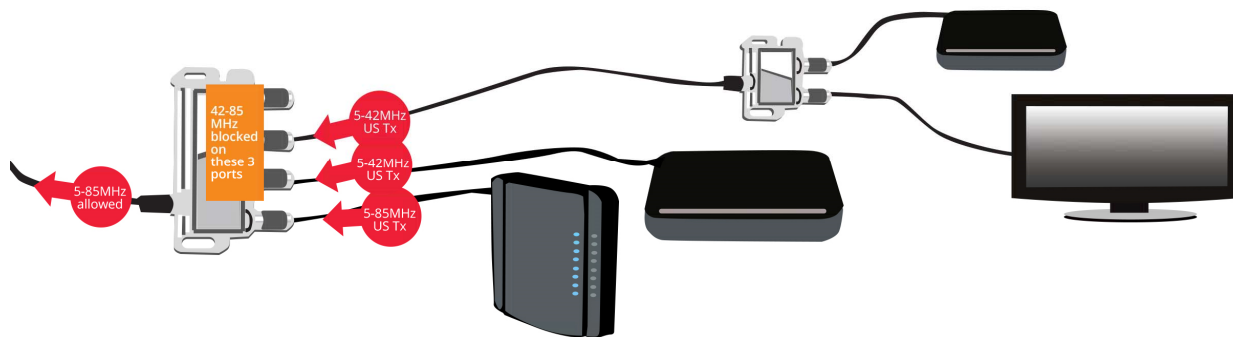
**Figure 5 - Filter Placement to Prevent 85MHz Feedback**

install of an 85MHz modem at a later time, it will fail unless the filter in the tap port is removed.

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

continue using the 54-85MHz frequency band for downstream services, but ensure that their new modems will be future proof against a later 85MHz plant upgrade.

Unfortunately, problems can be caused by an 85MHz modem even when it operates below 42MHz if it does not have a built-in switchable filter. Testing has shown that at least some DACs used for CM transmitters have a noise floor that pops up during transmissions. The levels seen were fairly low, for example -16dBmV. Because this noise would have to pass through the same port-to-port isolation loss discussed earlier that is seen, it is unlikely to affect digital



**Figure 5 - Splitter with Embedded Filters to Prevent 85MHz Feedback**

#### Advance Deployment of 85MHz Modems before Plant Upgrades

Some MSOs are considering deploying 85MHz modems now in advance of later 85MHz plant upgrades. They would like to

carriers, but it may cause distortion to analog video signals in the 54-85MHz band. Analog video signals can begin to show distortion with 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.

### Conclusion

Consumer demand for increased downstream bandwidth is also driving increased demand for upstream bandwidth. The latest DOCSIS standards allow or require support for upstream operation above the current operating 5 to 42MHz or 5 to 65MHz upstream bands. Successful expansion of the upstream band requires that actions be taken to prevent problems with 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 85MHz modems can prevent problems from showing up after the new modems are deployed.