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The Case Against A Proposed Relaxation Of Out-Of-Band Noise And Spurious Specifications For DOCSIS Edge-QAM RF Devices

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Submitted by Broadband Innovations, Inc.

1. Executive Summary

In this memo, Broadband Innovations, Inc. ("BI") provides support and explanations to its recommendation against certain relaxing provisions in Out-of-Band Noise and Spurious specifications for QAM downstream transmission of Edge-QAM ("EQAM") devices. These specifications are included in the draft Downstream RF Interface specifications ("DRFI") of CableLabs® intended to replace the RF specifications in its current DOCSIS RF Interface Specifications [1] ("DOCSIS RFI"). The out-of-band noise and spurious specifications of the draft DRFI are provided in Table 6-5, which is attached hereto as Appendix A for reference. The exemption in Item 5(d) of that table effectively replaces Item 5 with Item 8 and it is a relaxation of the broadband noise and spurious specification of up to 10 dB in certain instances. This relaxation was proposed and sponsored jointly by some vendor members of the DRFI Working Group. Their proposal is referred to herein as the Joint Proposal for Self-Aggregate noise and spurious ("JPSA"). BI urged the DRFI Working Group not to adopt the JPSA exemption, and to remove the provisions in Item 5(d) and Item 8 shown in color in Table 6-5 (Appendix A). Nevertheless, the majority of vendors in the DRFI Working Group have aligned themselves with the JPSA. This note explains in more detail why we recommend that Items 5(d) and 8 of Table 6-5 be removed from the DRFI specifications.

Item 8 of Table 6-5 does not count *all noise and spurious* on a given channel but rather, it is a novel obscure notion of a threshold based selective self-aggregated spurious measure. Thus, the use of the term "Spurious Signals" for only a fraction of the actual spurious and noise power on a channel is misleading. Evidently, this novel concept of partial noise power counting in Item 8 is not easily explained and all implications of its constructs are not fully appreciated, even by some JPSA proponents themselves. This is evident from the fact that they do not acknowledge that Item 5 is made moot and irrelevant by the exemption in 5(d), rendering Item 8 *a full replacement* of Item 5. It can be easily appreciated that *no* device that *meets* the requirements of Item 8 can independently *fail* the requirements of Item 5. Thus, as Table 6-5 currently stands, *there are no requirements* in Item 5. Moreover, the JPSA proponents inserted the current language in Sections 6.3.5.1.3 and 6.3.5.1.4 of the DRFI draft, explaining the concept of Self-Aggregated Spurious measure, where the language erroneously characterizes Item 8 as providing the required guarantees for CNR protection of other non-adjacent channels. It also erroneously claims to provide such protection from up to 7 distinct "types" of new EQAM makes. As shown below, compliance with Item 8 ensures nothing of the sort.

The deficiency of the proposed relaxation is that unlike the exemption for harmonics in Item 6, it permits the exemption of *any other* spurious components of up to –63 dBc that are *not* Universally Non-Aggregating (as defined below). Because QAM sources combined for RF transmission to a certain serving zone are tuned to distinct channels, one is assured that their harmonics do not coincide in frequency and therefore the spurious harmonic components do not spectrally aggregate. This non-alignment property is guaranteed regardless of the design or make (*type*) of the EQAM device and therefore such spurious components are called *Universally Non-Aggregating* components. We believe this universal non-alignment property to be essential for any exemption from Item 5 of Table 6-5 to be favorably considered.

Thus, BI's proposal (just as the current DOCSIS RFI spec) does not permit the exemption in Item 5(d). It is our contention that the limited protection features vested in Item 8 are insufficient to provide the assurances cable operators now have based on the legacy DOCSIS RFI. These are required in order to limit broadband noise aggregation in head-ends.

A most problematic aspect of the JPSA is its implication that spurious and noise aggregation would come only from a single EQAM device "type" that meets the requirements of Table 6-5 and that other existing devices already installed in head-ends (that comply with the legacy DOCSIS RFI specifications) somehow irrelevant because they may be removed or replaced by the new type of EQAM devices. The implication that these new EQAMs *are not designed* to operate *side by side* with existing RF modulators is troubling because their deployments may require untimely wholesale replacements of the installed RF modulators base. The cross-type aggregation features of the JPSA are non-existent and claims to the contrary in Section 6.3.5.1.4 are in error (especially in the example of Figure 1). Proponents of the JPSA now claim that such protection claims may be true for fewer than 7 types under certain assumptions of EQAM RF filtering characteristics. These filtering assumptions require certain bands to be filtered in a predetermined manner. However, because implementations differ widely among EQAM designs, there is no basis to assume such characteristics without *specifically requiring them* within the DRFI specifications and no such additional filtering noise-mask over the operating frequency range are included in the DRFI. Moreover, future RF technologies that are yet unknown may achieve the requirements of Items 6 and 7 and meet the literal specification in Item 8 without meeting filter noise masks assumed by the JPSA proponents, therefore not providing the implied protection they claim. It is important to recognize that in order for the DRFI to be meaningfully protective of cable operators' lineups for years to come, it must contain all technical specifications on which one relies to offer the promised protections.

We further show below that many instances of cross-type spurious aggregation can take place under the JPSA exemption in Item 5(d). An example of modulated distortion spurious alignment due to mixer distortions is shown to meet the exemptions listed in Item 8 of the JPSA but provide operators with insufficient protection – *not even the protection they enjoy today under the current DOCSIS RFI*. Hence, the JPSA exemption is a step back to inferior protection and a regression in specifications. Cable operators have not adequately evaluated the full impact of this regression and no hardware deployment proofs of its protection adequacy have been established. At the very minimum, caution is called for, because one can always relax the DOCSIS specification later, if the record and experience with such devices proves that it can be done. At this juncture, however, it would be ill advised to embark on this broadband noise specification relaxation for DOCSIS in a manner that promotes deployment of EQAM devices having relaxed specifications with an irreversible adverse impact on head-end spurious and noise aggregation.

It is important to recognize that a very vibrant and competitive Edge-QAM supply market exists for products that are designed to meet or exceed the out-of band spurious and noise specifications of Table 6-5 *without* having to invoke an exemption such as that in Item 5(d). The disadvantages to cable operators in permitting such relaxation is that their head-end operations would have to change radically and their actual aggregated broadband noise margin would shrink. We therefore urge the rejection of the proposed relaxation embodied in Item 5(d) of Table 6-5. This concludes the Executive Summary.

2. The deficiencies in the JPSA noise and spurious specification proposal.

Item 8 of Table 6-5 calls for employing self-aggregation measurements of spurious and noise. As a pioneer in proposing self-aggregation measures for RF modulators and upconverters, and having coined the term "Self-Aggregate" noise [2], we at BI are aware of the advantages of such measures in some instances. In this instance, however, the manner in which Item 8 uses self-aggregated measures is counterintuitive and confusing. Item 5(d) in Table 6-5 constitutes an exemption for EQAMs from having to meet the $-73+10\cdot\log_{10}(N)$ dBc noise and spurious specification by permitting an EQAM RF signal to have noise and spurious levels in accordance with Item 8 of up to –63 dBc on *any* other channel (other than the three adjacent channels on each side of the desired channel block). In contrast, no such exemption is provided in BI's proposal.

The actual method for applying the JPSA provisions in Item 8 is shown in detail in Appendix B, where the Self-Aggregated Spurious measures (a defined term in the footnote to Item 8) are derived. It is clear from this analysis and from the definitions in the footnotes to Item 8, that the confusing aspect of the Self-Aggregated Spurious power measure as defined, is that (contrary to the erroneous statements in Sections 6.3.5.1.3 and 6.3.5.1.4 of the current draft DRFI), it *does not* guarantee any protection for more than one type beyond that provided by Item 7 because it does not express the *total* noise and spurious power on a given channel that would aggregate from EQAM devices covering 119 digital channels. Rather, it expresses only an arbitrary *fraction* of that total aggregated power – only that fraction coming from channels that *fail* to meet the $-73+10*\log_{10}(N)$ dBc limit. Noise and spurious power from channel settings otherwise meeting that limit is by definition excluded from the Self-Aggregated Spurious power tally, *making it a measure that exists only in some spreadsheet* but not on actual channels and therefore it is not a correct account of the *total actual* noise power from combined EQAM devices. Actual self-aggregated spurious and noise on channels from combined EQAM devices is only guaranteed by Item 7, which provides for the –55 dBc limit and not –63 dBc. The latter limit in Item 8 is *not an additional requirement* to Item 7 but rather *only a relaxation* replacing Item 5 with Item 8.

2.1. No margins for multiple product types.

Contrary to the JPSA's proponents' assertion, the strict worst-case impact on the analog channels under the JPSA proposal can theoretically reach levels of approximately –48 dBc if all combined sources are of a distinct type and the spurious and noise allowed by Item 5(d) aggregates on the same frequency. In fact, the proponents calculation that with 7 different vendors or types of the new EQAM, the analog protection level in the combined system will reach –60 dBc is wrong because not all possible spurious power on a given channel was taken into account in their calculation so the cross type aggregation features of the JPSA are non-existent. The fact is that for the stated protection sought by MSO's, *only one EQAM device type can be used on a channel lineup*. Any assurances to the contrary cannot be made without further specifications on broadband filtering noise masks. Thus, a problematic aspect of the JPSA is its implication that spurious and noise aggregation would come only from a single EQAM type that meets the requirements of Table 6-5 and that other types or existing devices already installed in head-ends that comply with the legacy DOCSIS RFI specifications would somehow be removed or replaced by the new type of EQAM devices. This is important because the JPSA would apply only to *new* RF modulators and upconverters that are introduced to a channel lineup while the majority of the channels are already installed and must be presumed to emit noise and spurious on all other channels at levels that may reach –73 dBc, as provided by legacy DOCSIS RFI specifications. The broadband noise and spurious spectral shape aggregated from, say, 100 channels inserted by such legacy modulator devices would not necessarily match favorably the aggregating broadband noise and spurious shape of the new EQAM devices. Hence, cable operators would not be able to add these new EQAM devices that may have excellent aggregate noise and spurious levels on some channels but have –63 dBc levels on other channels because their head-end noise budget would permit only a limited number of –73 dBc per channel degraders. Stated another way, *every addition to their channel lineup of a new EQAM type having the exemption of Item 5(d), constitutes a broadband aggregation noise budget loss equivalent to 10 legacy DOCSIS channels*.

In general, satisfactory Self-Aggregation of noise and spurious from a *single* product type provides no assurance of a satisfactory protection across *different* product types. In fact, Self-Aggregation of spurious and noise has very little bearing on potential Cross-Type spurious aggregation. We show below that spurious component's frequency movement with channel assignment is *exactly* the nature of certain mixer cross-terms for which the JPSA proponents actually sought specification relief in suggesting Item 5(d).

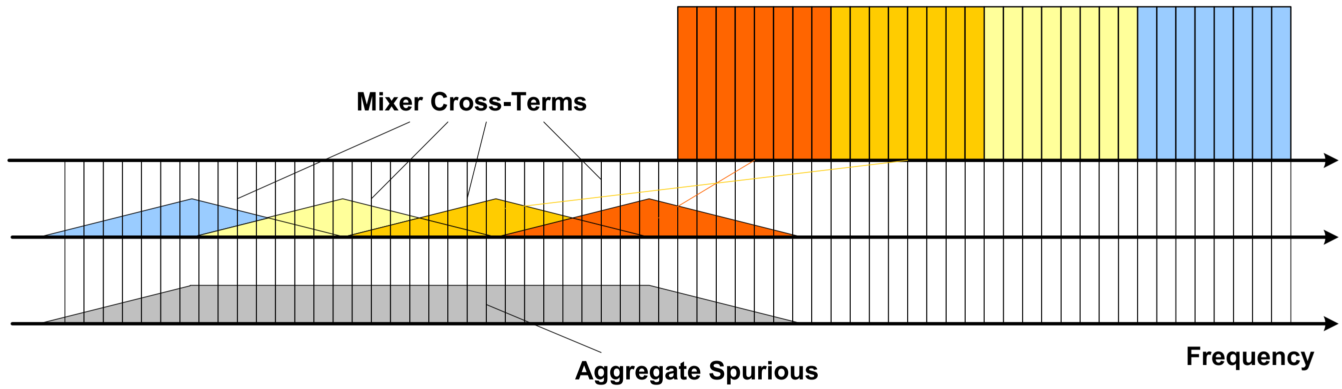

Figure 1 An example of second order mixer spurious terms for 8-channel block EQAMs wherein four devices of the same type are combined. The cross-modulation distortion from each device spans 2*N* channels (16 channels in this case). Note that higher frequency blocks cause lower frequency spurious terms and that their peaks do not aggregate. Note also that although a Self Aggregate Spurious for 119 devices is limited to –63 dBc, the emitted spurious level from a *single* device in the peak spurious channel can be up to –63 dBc.

An example in double conversion upconverters is the well known second order mixer spurious term having a spurious RF center frequency F_{spur} meeting the relation $F_{spur}=2\cdot F_{IF}-F_{LO2}=F_{IF}-F_{RF}$, where F_{IF} is the second IF frequency, F_{LO2} is the frequency of the second high-side local oscillator and F_{RF} is the RF frequency tuned to. The modulated distortion components from this mixer spurious terms have approximately a triangular power spectral densities as shown in Figure 1. The exact relation between the spurious term frequency and the RF frequency depends on the IF frequency. As evident from this simple frequency relationship, although there is some overlap between terms from devices tuned to different frequencies, the center frequency of spurious components from *all* upconverters having the *same* IF frequency (same type) are *guaranteed not to align* when they are tuned to distinct channels, enabling compliance with Self-Aggregate spurious specifications. However, this non-coincident spurious property disappears when the IF frequencies of the upconverters are distinct. In such situations, the ability to find a specific setting in which spurious alignment from *all* distinct upconverter types cannot be characterized as "improbable" but rather, as a *certainty* in many sets of distinct channel assignments. This is shown in Figure 2, where the center frequency of the second-order mixer spurious is plotted vs. the upconverter output frequency for different types of IF frequencies. The example in Figure 2 shows 7 types of upconverters having distinct second IF frequencies in the range of 1 GHz to 1.2 GHz. In the broken lines example of this figure, *all* shown types of upconverters produce a spurious component centered on 460 MHz when tuned to the respective frequencies shown by colored circles on the Tuned RF Frequency axis. It is also clear from this figure that spurious alignment not only on 460 MHz but on essentially every frequency in the range can occur for many other similar tuning configurations which have the same tuning frequency increments among upconverter types.

Of course, it is possible that if one tunes at random 7 types of upconverters there may be an alignment among less than 7 devices or a partial alignment where the spurious of width $2N_1$ channels of one type partially overlaps with that from another type having a spectral width of $2N_2$ channels. It is also possible that there will be no alignment among any types, but all these possibilities would be left to chance at the operator's risk. Suffice it to say that this example demonstrates that no matter how many distinct types of upconverters are employed, *it is certain* that one can always find *many* tuning configurations for which the spurious components from *all* such upconverter types are aligned, realizing the worst-case aggregation conditions.

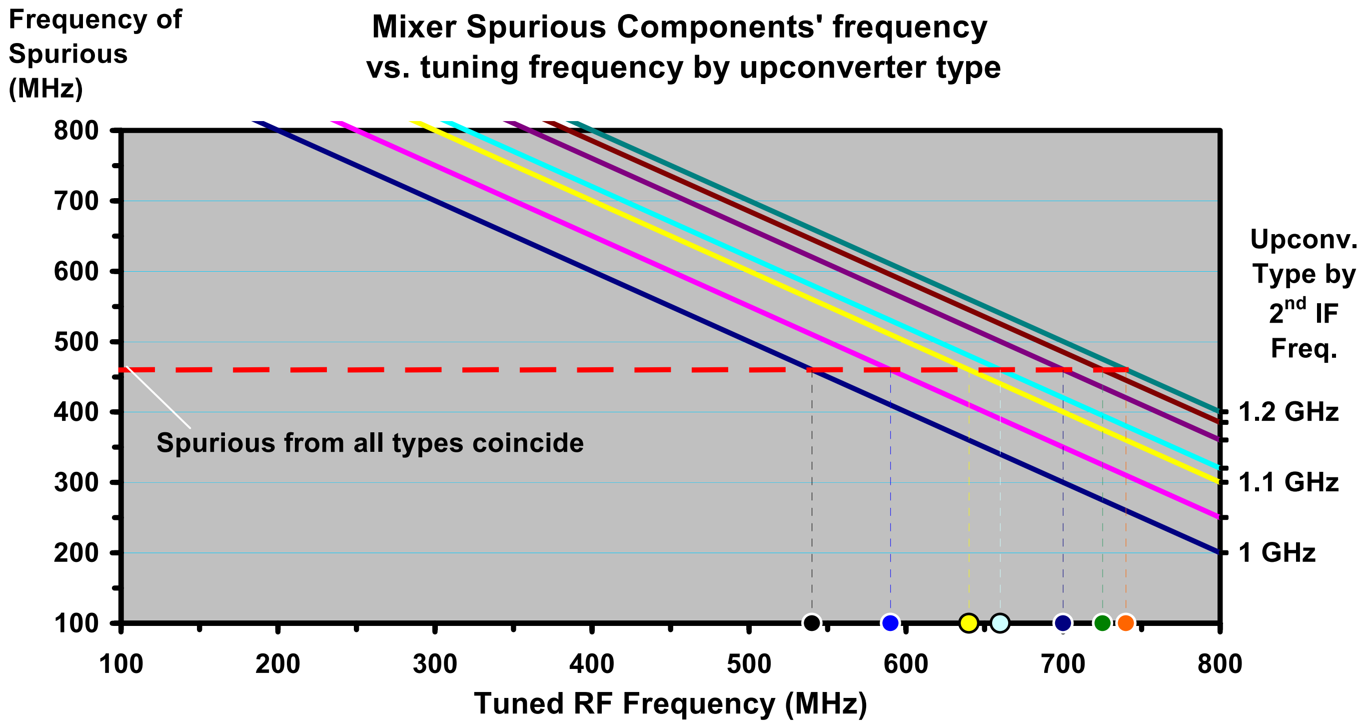

Figure 2. Cross-Type aggregation of second order mixer spurious components from 7 upconverter types having distinct 2nd IF frequencies that are tuned to distinct channels shown by the colored circles on the horizontal axis.

Returning to Figure 1, it shows a disturbing trend for the future if Items 5(d) and 8 remain: As the number of channels in a QAM block increases, permitting these mixer cross terms to reach the levels in Item 8, would result in wide -63 dBc spurious noise plateau on other channels. In fact, contrary to notions advanced by the JPSA proponents, the total self-aggregating specifications of Item 7 *does not* limit the number of channels in such –63 dBc plateaus because Item 7 is set for –55 dBc and because the permitted –63 dBc aggregate limit in Item 8 *does not* include all spurious and noise power. It should be noted that because over the tuning range, there is no escape from a condition in which these mixer terms fall immediately near the desired channels, allowance of these mixer cross-terms to reach levels of –63 dBc would necessarily also require relaxation of the third adjacent channel specifications. Therefore, look for the JPSA proponents' future attempts to expand the relaxation of item 5(d) into the third adjacent channel. Clearly, if the exemptions in Item 5(d) of the JPSA specifications were to be adopted, operators would have insufficient protection from the adverse effects of these modulated mixer spurious components - *not even the protection they enjoy today under the current DOCSIS RFI*. Thus, the JPSA exemption is a step back to inferior protection and a regression in specifications[1].

Moreover, if the exemption in Item 5(d) of the JPSA specifications were to be adopted, a discrete Local Oscillator ("LO") leakage term with a level up to –63 dBc would be permitted without any assurance

[1] The JPSA proponents argue that their exemption is an ***improvement*** over the existing RFI exemption of –60 dBc for discrete spurious. This is a misleading statement because no such exemption exists in the current RFI for ***non-discrete*** spurious components such as the mixer terms described above. If adopted, Item 5(d) will permit through Item 8 such noise-like spurious to be as high as 10 dB above the levels permitted by the current RFI, a ***degradation*** by any standard.

that it would not aggregate across product types. The aggregation of discrete first LO leakage terms of double conversion upconverters is just another example of the JPSA proponents' false sense that satisfactory Self-Aggregation of spurious components implies satisfactory protection against Cross-Aggregation of spurious components from *different* product types. Because the first LO is fixed in frequency and because tuning is accomplished in these upconverters by changing the frequency of the second LO, the discrete LO leakage term moves with channel assignment and thus never aligns with such LO leakage terms from other upconverters of the *same type*. However, no such assurance can be given for upconverters that employ different first IF filter center frequencies, wherein the frequency increment from the desired channel to the LO leakage term is different. For example, if two single-channel upconverter types employing a first IF center frequency of 44 MHz and 36 MHz respectively are tuned to two adjacent channels, then their discrete LO leakage terms may align 2 MHz apart within a single 6 MHz channel situated 6 channels away. Unfortunately, this cross-type alignment potential is applicable for more than just two types of upconverters because various upconverter types may employ either high-side or low-side first LO's and because new multichannel EQAMs may employ various non-standard wider IF filters, having different center or edge frequencies to accommodate differing number of channels in a block.

It should be generally clear from the two examples above that asking cable operators to accept the exemption in Item 5(d) of the JPSA introduces unnecessary risk to their head-end performance. To avoid these risks, operators would have to adopt an elaborate RF modulator "Type-Management" programs and controls. These programs may well have to include the following actions:

(a) Set and choose one RF modulator type (or vendor) that they employ in their channel lineup.
(b) Initiate and maintain a technical audit of the types of noise filtering characteristics of their *installed base* of RF modulators to enable their incorporation in the potentially exhausted noise budget associated with the JPSA exemption in Item 5(d).
(c) Establish certain technical characteristics for the product type they intend to adopt so as to assure similarity of "type" purchased over time when upgrading their head-ends and hubs. These would have to include RF filtering frequency break-points and IF filters' frequencies. Hence, operators would have to be involved with (and vendors would have to disclose) the internal technical workings of their RF products.
(d) Develop head-end technician's directives for testing and accepting RF modulators based on a newly introduced notion of Self-Aggregate noise and spurious specifications. Provide training material and explaining why some situations (in conjunction with measures adopted in items (a) through (c) above) permit a –63 dBc noise contribution as opposed to the previous practice of expecting better than –73 dBc noise performance. Purchase and deploy automated Self-Aggregate noise testing facilities.

Of course, if the exemption of Item 5(d) of the JPSA were to be adopted in the DOCSIS DRFI, operators would also have the alternative of ignoring it altogether and adopting tighter internal MSO specifications that do not permit such exemption, and in that respect, rendering the DOCSIS DRFI irrelevant. As discussed below, the resultant marginalization of DOCSIS would be a highly undesirable outcome.

2.2. Other reasons to reject the exemption proposed in the JPSA.

It is quite obvious that the scenarios we paint above for cable operators accepting the unprecedented complexities of managing spurious and noise aggregation from multiple product types in their head-end are unrealistic and are unlikely to happen. Even if the JPSA proponents' proposal prevails and the exemption in Item 5(d) including Item 8 becomes a part of the DOCSIS DRFI, it will likely be on paper only and would not be followed by cable operators. To avoid the trouble, operators are more likely to adopt (or retain) their internal specifications that do not incorporate the exemption. To that end, it is important to recognize that several vendors already supply MSOs with multichannel EQAM products that *do not* require the exemption and thus meet such tighter internal MSO specifications. It appears unlikely that these operators would regress to what might then be the DOCSIS DRFI exemption and abandon their protection afforded to them by their current vendors. In these situations, the DOCSIS DRFI will become irrelevant. We believe that in that event, resultant marginalization of DOCSIS will harm vendors and operators, as it will continue to keep EQAM specifications non-uniform across MSOs, uncertain or even secret. In other words, the notion of "Vendor Differentiation" cannot extend to minimum requirements in the DRFI but only to items not specified in DOCSIS. We have recently received an informal and non-binding commitment from an MSO indicating that it would harmonize its internal (unpublished) EQAM specifications with the DOCSIS DRFI once adopted. We are concerned that with the exemption proposed in the JPSA, they are less likely to stand by their commitment because to do so would mean their having to regress from established internal specifications under which they now purchase EQAMs. Other cable operators have already indicated that they would not use the DRFI specifications for their qualifications if it had the exemptions in Items 5(d) and 8.

3. Conclusion.

We support all aspects of the current DRFI except the exemptions in Item 5(d) and Item 8 of Table 6-5 and recommend their removal from the specifications. The increase in the number of vendors and types of downstream channels strongly suggests that one should exercises caution and avoid undue relaxation of spurious and noise specifications. We therefore recommend against wholesale specification relaxation in Item 5(d) and 8, as it provides no assurance for universal protection and would thus require operators to assume that their budgets for aggregate head-end spurious and noise levels would shrink.

Appendix A The draft DRFI out-of-band spurious and noise requirements.

BI's proposal would delete Item 5(d) and Item 8 in Table 6-5 and their related notes, all appearing in color below.

Table 6-5. EQAM or CMTS Output Out-of-Band Noise and Spurious Emissions Requirements.

Item	Band	N, Number of Combined Channels per RF Port				
		1	2	3	4	N >4 All Equations Are Ceiling(Power, 0.5) dBc
1	Adjacent channel up to 750 kHz from channel block edge	<-58 dBc	<-58 dBc	<-58 dBc	<-58 dBc	$<10*\log_{10}[10^{-58/10} + (0.75/6)*(10^{-65/10} + (N-2)*10^{-73/10})]$
2	Adjacent channel (750 kHz from channel block edge to 6 MHz from channel block edge)	<-62 dBc	<-60 dBc	<-60 dBc	<-60 dBc	$<10*\log_{10}[10^{-62/10} + (5.25/6)*(10^{-65/10} + (N-2)*10^{-73/10})]$
3	Next-adjacent channel (6 MHz from channel block edge to 12 MHz from channel block edge)	<-65 dBc	<-64 dBc	<-63.5 dBc	<-63 dBc	$<10*\log_{10}[10^{-65/10} + (N-1)*10^{-73/10}]$
4	Third-adjacent channel (12 MHz from channel block edge to 18 MHz from channel block edge).	<-73 dBc	<-70 dBc	<-67 dBc	<-65 dBc	For N=5: -64.5 dBc; For N=6: -64 dBc; For N≥7: $<-73 + 10*\log_{10}(N)$ dBc
5	Noise in other channels (47 MHz to 1000 MHz) Measured in each 6 MHz channel excluding the following: a) Desired channel(s) b) 1st, 2nd, and 3rd adjacent channels (see Items 1, 2, 3, 4 in this table) c) Channels coinciding with 2nd and 3rd harmonics (see Item 6 in this table) d) Channels qualifying as having Spurious Signals (Note 1) (see Item 8 in this table)	<-73 dBc	<-70 dBc	<-68 dBc	<-67 dBc	$<-73 + 10*\log_{10}(N)$
6	In each of 2N contiguous 6 MHz channels or in each of 3N contiguous 6 MHz channels coinciding with 2nd harmonic and with 3rd harmonic components respectively (up to 1000 MHz)	$< -73 + 10*\log_{10}(N)$, or -63 dBc, whichever is greater				
7	Self-aggregated noise and spurious signal measurement in other 6 MHz channels (47 MHz to 1000 MHz) (Note 2) Excludes (for each contiguous N-channel block) power from: a) Desired channel(s) b) 1st and 2nd adjacent channels (see Items 1, 2, 3 in this table) c) Channels coinciding with 2nd and 3rd harmonics (see Item 6 in this table)	<-55 dBc				
8	Self-Aggregated Spurious Signal measurement in other 6 MHz channels (47 MHz to 1000 MHz) exceeding a limit of $-73 + 10*\log_{10}(N)$. (Note 1) Excludes (for each contiguous N-channel block) power from: a) Desired channel(s) b) 1st, 2nd, and 3rd adjacent channels (see Items 1, 2, 3, 4 in this table) c) Channels coinciding with 2nd and 3rd harmonics (see Item 6 in this table) d) Channels having spurious and noise levels of less than -73 + 10*log10(N) in 6 MHz.	<-63 dBc				

Notes:
1. A "Spurious Signal" is defined herein as any signal, including intermodulation products, discrete spurs, modulated spurs, and noise, with a combined power that exceeds -73 + 10*log10(N) dBc in a 6 MHz channel. The "Self-Aggregated Spurious Signal" level is defined and determined by performing a per-channel summation of the power of the Spurious Signals in each out-of-band channel as the equipment is tuned to cover 119 contiguous, non-overlapping channels within the specified frequency range (as defined in Table 6-3). Power from 6 MHz channels having combined spurious and noise signals less than -73 + 10*log10(N) dBc is not added towards the Self-Aggregated Spurious Signal measure.
2. Self-aggregated noise and spurious signal measure is a method used to compute the headend noise and spurious floor by summing measured noise and spurious from a single device as it is tuned over the specified output frequency range (see Table 6-3). All noise and spurious power in each 6 MHz channel is measured and summed on each out-of-band channel as the output is tuned over 119 contiguous, non-overlapping channels within the specified frequency range. This aggregated measurement reflects the noise and spurious floor in each channel when combining 119 digital channels from devices of the same type.

BI's proposal is to delete Item 5(d) and Item 8 in Table 6-5 and their related notes, appearing in color above.

Appendix B Example for Self-Aggregared Spurious calculation based on measured spurious and noise data

This Appendix illustrates and explains the manner in which the values for "Self-Aggregated Spurious" as defined in Table 6-5 are derived. As attributes of a single RF QAM modulator device, the Self-Aggregated Spurious values are characterized for every 6 MHz channel in the frequency band between 47 MHz to 1 GHz by a certain power sum over many instances of tuning the device across its operating frequency range. The Self-Aggregated Spurious value in a given channel is obtained by summing spurious and noise power contributions in that channel (including all discrete spurious, intermodulation and modulated distortion spurious and noise) as measured at each tuning instance of a DRFI device. Such tuning instances provide non-overlapping channel block coverage of 119 contiguous channels over the applicable tuning range wherein the channel block has N contiguous channels Excluded from this aggregate power sum for each N contiguous channel block, are contributions from the desired channels and spurious and noise contributions from (i) adjacent, next-adjacent and third adjacent channels specified in Items 1-4 in Table 6-5; (ii) $2N$ contiguous 6 MHz channels and $3N$ contiguous 6 MHz channels coinciding with 2nd and 3rd harmonic components respectively as described in Item 6 of Table 6-5; (iii) Channels having spurious and noise levels meeting the values listed in Item 5 of Table 6-5.

An example of the construction of Self-Aggregated Spurious values from a channel-by-channel list of relative spurious and noise values is shown in Figure 3. For a given tuning instance, each of the horizontal entries correspond to a 6 MHz channel and its spurious and noise power relative to any of the two desired channels shown in black with a 0 dBc entry. The vertical dimension is used to describe the different tuning instances of the same device. For simplicity, a dual channel device having relative spurious and noise values just meeting the required specifications of Table 6-5 for the first, second and third adjacent channels is shown. For further clarity, for the most part, all other channels are shown to just meet the –70 dBc requirement of Table 6-5 with the exceptions shown in light gray boxes with a solid bounding line. These exceptions may arise, for example, from DAC generation images that are filtered unevenly by IF filters and that move with the tuning frequency. Also shown indirectly in the figure is the presence of an RF high-pass filter, as evident from the substantial attenuation of the relative spurious and noise levels on channels below the first tuned channel on the left side of the figure.

	-90	-85	-80	-75	**-70**	**-65**	-71	-70	-64	-60	**0**	**0**	-60	-64	-70	-70	**-67**	-70	-70	-70	-70	-70	-70	-70	-70	-70	-70	-70
	-90	-85	-80	-75	-73	-72	**-68**	**-63**	-70	-70	-64	-60	**0**	**0**	-60	-64	-70	-70	**-67**	-70	-70	-70	-70	-70	-70	-70	-70	-70
	-90	-85	-80	-75	-73	-72	-71	-70	**-67**	**-63**	-70	-70	-64	-60	**0**	**0**	-60	-64	-70	-70	**-67**	-70	-70	-70	-70	-70	-70	-70
	-90	-85	-80	-75	-73	-72	-71	-70	-70	-70	**-67**	**-63**	-70	-70	-64	-60	**0**	**0**	-60	-64	-70	-70	**-67**	-70	-70	-70	-70	-70
	-90	-85	-80	-75	-73	-72	-71	-70	-70	-70	-70	-70	**-67**	**-63**	-70	-70	-64	-60	**0**	**0**	-60	-64	-70	-70	**-67**	-70	-70	-70
	-90	-85	-80	-75	-73	-72	-71	-70	-70	-70	-70	-70	-70	-70	**-67**	**-63**	-70	-70	-64	-60	**0**	**0**	-60	-64	-70	-70	**-67**	-70
	-90	-85	-80	-75	-73	-72	-71	-70	-70	-70	-70	-70	-70	-70	-70	-70	**-67**	**-63**	-70	-70	-64	-60	**0**	**0**	-60	-64	-70	-70
	-90	-85	-80	-75	-73	-72	-71	-70	-70	-70	-70	-70	-70	-70	-70	-70	-70	-70	**-67**	**-63**	-70	-70	-64	-60	**0**	**0**	-60	-64
	-90	-85	-80	-75	-73	-72	-71	-70	-70	-70	-70	-70	-70	-70	-70	-70	-70	-70	-70	-70	**-67**	**-63**	-70	-70	-64	-60	**0**	**0**
	-90	-85	-80	-75	-73	-72	-71	-70	-70	-70	-70	-70	-70	-70	-70	-70	-70	-70	-70	-70	-70	-70	**-67**	**-63**	-70	-70	-64	-60
	-90	-85	-80	-75	-73	-72	-71	-70	-70	-70	-70	-70	-70	-70	-70	-70	-70	-70	-70	-70	-70	-70	-70	-70	**-67**	**-63**	-70	-70
	-90	-85	-80	-75	-73	-72	-71	-70	-70	-70	-70	-70	-70	-70	-70	-70	-70	-70	-70	-70	-70	-70	-70	-70	-70	-70	**-67**	**-63**
	-90	-85	-80	-75	-73	-72	-71	-70	-70	-70	-70	-70	-70	-70	-70	-70	-70	-70	-70	-70	-70	-70	-70	-70	-70	-70	-70	-70
"Self Aggregated Spurious" (dBc):	$-\infty$	$-\infty$	$-\infty$	$-\infty$	$-\infty$	**-65**	**-68**	**-63**	**-67**	**-63**	**-67**	**-63**	**-67**	**63**	**-67**	**-63**	**-64**	**-63**	**-64**	**-63**	**-64**	**-63**	**-64**	**-63**	**-64**	**-63**	**-64**	**-63**

Figure 3 Example of a derivation of Self-Aggregated Spurious values for a dual channel (*N*=2) device

In this example, the Self-Aggregated Spurious is obtained by first identifying for each tuning instance the channels for which the integrated spurious and noise exceeds –70 dBc. Those are shown in gray boxes bounded with black borders. The power levels are then summed vertically across columns *excluding* power from channel types enumerated in (i) through (iii) of the top paragraph of this Appendix. This means that, unlike the self-aggregated noise and spurious defined in Item 7 of Table 6-5, power from only the gray boxes with black bounding is summed. This selective summation results are shown as the Self-Aggregated Spurious in the bottom row. Note that in some channels at the low edge of the band, the resultant Self-Aggregated Spurious calculates to - ∞ dBc because the accumulated spurious and noise power on qualifying instances having power greater than $-73+10*\log_{10}(N)$ results in 0 power for these channels. Because the Self-Aggregated Spurious on any channel does not exceed the –63 dBc requirement, this device is compliant with the requirements of Table 6-5.

References

[1] CableLabs, "*DOCSIS Radio Frequency Interface Specification*", SP-RFIv2.0. Available at http://www.cablemodem.com/downloads/specs/SP-RFIv2.0-I04-030730.pdf .

[2] S. I. Rubin, A. Basovich, B. Petrovic and R. D. Katznelson, "Specifying and Measuring Aggregate Broadband Noise of CATV Modulators and Upconverters" *SCTE Cable-Tec Expo*®, San Antonio, TX, June 5-7, (2002). Available at http://www.broadbandinnovations.com/pubs/frm-pubs.html

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