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| **Radiocommunication Study Groups** |  |
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| Received: 27 May 2014  Subject: Coexistence of wired telecommunication systems with radiocommunication systems | **Document 1A/146-E** |
| **27 May 2014** |
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| Rapporteur, Working Party 1A Rapporteur Group on coexistence of  wired telecommunication with radiocommunication systems | |
| Recent Developments Concerning Coexistence of  Wired Telecommunication Systems with  Radiocommunication Systems | |
| (Question ITU-R 221/1) | |

# 1 ITU-T Recommendation G.fast – ITU-T SG 15

There has been a considerable amount of work during the November 2013 and April 2014 meetings of ITU-T SG 15 on all aspects of the development of G.fast, including the modems, the cabling and the spectrum mask. Progress on G.fast has taken account of the concerns expressed by several ITU‑R Working Parties on co-existence between the G.fast telephony cable based kerb-to-home link system and radiocommunication systems. In addition, there have been several meetings of the ITU‑T SG 15 rapporteur groups dealing with various aspects of the work.

G.fast has the capability to operate over the frequency range 2-212 MHz. However, many operators may avoid using the range below 23 MHz in order to avoid conflict with nearby VDSL wired links because, although both are DSL based and use some of the same control signalling frequencies, G.fast is not backwardly compatible with VDSL. Moreover, consistent operation above ~80 MHz is affected by several installation dependent factors.

The liaison between ITU-T and ITU-R on G.fast has proved very effective, with the result that the G.fast Recommendation has been split into two parts: the ITU-T G.fast PSD specification (containing functionality identified as having regulatory impact) and the ITU-T G.fast Physical Layer specification (containing the other transceiver functionality). The PSD part, now designated as draft Recommendation ITU-T G.9700 (ex. G.fast-psd) – *“Fast access to subscriber terminals (FAST) – Power spectral density specification”*, provides for both 106 MHz and 212 MHz PSD profiles. However, in practice, there is a fine balance between bandwidth, throughput and the line-length, which imposes practical constraints on the maximum useable frequency range over a given length of cabling.

The G.fast broadband link into homes from kerb-side fibre-optic distribution boxes uses multi-line cable bundles consisting of several twisted wire pairs or quads, together with steel reinforcing strands. The G.fast cable bundles are run into homes either underground or from overhead poles. A single line is peeled off from the multi-line cable bundle at each home passed along the cable route. This means that each connection is of different length and each line will present different electrical characteristics to the G.fast transceivers. The conditions on each wire pair/quad, together with the resulting crosstalk, are therefore different. Complex power vectoring and control is then needed in order to counter the effects of crosstalk and maintain satisfactory performance over each link connection. It is no easy matter to maintain consistent and predictable performance under these circumstances. Not only is there an inherent trade-off between bandwidth capability and link distance, but differences in data loading between individual lines will also affect the overall performance of a cable bundle.

Link lengths therefore need to be kept to a minimum in G.fast installations in order to minimize bandwidth and throughput limitations. In addition, it has been found necessary to incorporate real time adaptive power vectoring control and other mitigation features within G.fast transceivers in order to optimise the operation G.fast cables serving several subscribers. For example, strongly dominant crosstalk on one line in a bundle will disturb the entire bundle. The reduced capacity on the affected line and the induced disturbances on the other lines can reduce the SNR and effective PSD so much on the other lines that half of the overall cable capacity is lost. Mitigation measures under study include putting odd and even tones on different lines and spectrum balancing through switching off some wires in order to maintain throughput on others. The level of background noise induced on the cabling from external sources is also a significant factor, which can degrade throughput.

It is not possible to achieve the target specification of >500 mbps if the background noise level exceeds the present target figure of -140 dBm/Hz. However, while the -140 dBm/Hz figure has been accepted for frequencies below 30 MHz as the expectation for background noise in telephony cabling, it dates back to the time when there was a substantial amount of mechanical switching in the network and it was difficult to achieve anything better. Based on their field measurements, several operators now consider this to be insufficient and use noise levels as low as -150 dBm/Hz for background noise above 30 MHz when simulating G.fast performance. A number of leading network operators therefore now use -150 dBm/Hz as the cumulative estimate of background noise for typical conditions, taking into account that there are multiple sources of noise that need to be considered. Other factors such as reverse powering (under discussion with ETSI) may require an even lower figure – i.e., at least 4 dB lower at -154 dBm/Hz.

The constraints imposed by crosstalk and line noise mean that operation of G.fast up to the maximum frequency of 212 MHz, can only be achieved over short distances. A typical G.fast installation with multi-line cables operating over distances of around 100m will be limited to a maximum operating frequency of around 100 MHz. The risk of radiated interference to radiocommunication systems operating above 80 MHz from typical G.7000 compliant systems will therefore be rather small. In addition the new G.9700 specification includes options for notching in the broadcasting and amateur bands.

In consequence, ITU-T SG 15 has, as noted in Document [1A/134](http://www.itu.int/md/R12-WP1A-C-0134/en), responded to the long lists of frequencies cited by various ITU-R Working Parties as needing protection by applying a strict policy of only including details of bands where notching might be needed to protect particular radiocommunication systems for those cases where the associated receivers are likely to be in close proximity to G.fast installations or where there may be ensemble effects (i.e., cumulative interference from multiple G.fast installations). This policy naturally serves to protect the broadcasting and amateur services. However, in respect of aeronautical communication and radionavigation systems, Working Party 5B has sought more clarification of the criteria used restrict notching to only those cases where receivers likely to be in the close proximity to G.fast installations, citing concerns over ensemble effects, coupled with the very high availability requirements of aeronautical systems necessary to ensure the safety of aircraft operating in a high speed environment.

Noting that there is interest in ITU-R on collaborative work in order to develop a better understanding of how telephony type cabling operates above 30 MHz, ITU-T SG 15 has advised that the leading activity in this area is currently within the Broadband Forum as regards the design and characterisation of test loops. The [Broadband Forum](http://www.broadband-forum.org/) is an industry testing and certification group that is cooperating closely with ITU-T on the development of G.fast.

# 2 ITU-T Recommendation J.HiNoC – ITU-T SG 9

ITU-T SG  9 has responded to comments of several ITU-R Working Parties on the possibility of interference to or from this high performance cable TV distribution system operating over a frequency range of around 790-1 200 MHz.

Regarding the advice from Working Party 6A that there is a possibility of interference from LTE/IMT user equipment being operated in close proximity to J.HiNoC cable TV system,   
ITU-T SG 9 has advised that it believes that the high quality co-axial cabling expected to be used with J.HiNoC, coupled with the ability of the system to overcome incoming interference by disabling affected subcarriers, will be sufficient to avoid J.HiNoC installations being compromised by LTE/IMT use.

Regarding outgoing interference the advice from ITU-T SG 9 is that the high quality co-axial cabling recommended for use with J.HiNoC, coupled with the high levels of attenuation within buildings, will be sufficient to prevent any interference to radiocommunication systems being operated outside any buildings where J.HiNoC has been installed. Noting some examples of signal leakage into aeronautical bands from cable access TV systems in the past[[1]](#footnote-1), Working Party 5B has questioned these assumptions in respect of the aeronautical and navigation systems operating around 1 GHz – these are essential for the safe navigation and landing of aircraft. Working Party 5B has further noted that the building penetration losses assumed by ITU- SG 9 seem to be far too high and that unintended radiation though building roofs and windows could be much higher than expected. Moreover, if there is widescale deployment of J.HiNoC installations, then ensemble/cumulative effects will also need to be taken into account.

# 3 ITU-T Recommendations K.mhn and K.60 – ITU-T SG  5

The utility of Recommendations K.mhn and K.60 for dealing with cases of interference from wired telecommunication systems into radiocommunication systems has been questioned in ITU-R (see Document [1A/132](http://www.itu.int/md/R12-WP1A-C-0132/en)).

It has been noted that K.mhn does little more than advise on good practice in the installation of home networking and entertainment systems rather providing a technical assessment of interference mechanisms between systems. In addition, Working Parties 6A and 5B have both commented that the terminology used in K.mhn when referring to radio devices, needs to be aligned with ITU-R terminology.

In respect of K.60, confusion still surrounds the scope, purpose and operability of this Recommendation in resolving cases of interference. In reply to a number of questions raised within ITU-R, on the scope and applicability of the Recommendation, the reply from ITU-T   
Study Group 5 (Document [1A/127](http://www.itu.int/md/R12-WP1A-C-0127/en)) explains the situation thus: *“… that the purpose of Recommendation ITU-T K.60 is to guide administrations when considering complaints of interference between telecommunication systems. It is not intended to set compliance requirements or recommendations for protecting the radio spectrum”.*

However, this explanation still lacks clarity. The Recommendation states that it is only applicable[[2]](#footnote-2) when investigating a complaint of interference from (by implication) a wired system into a wireless system (also by implication) and is not intended to set a regulatory framework. This in itself is somewhat confusing because, ultimately, any complaint has to be assessed against the prevailing regulatory conditions. Further, the Recommendation makes reference in Section 5 to “preliminary investigations”, *“these levels”* and *“further mitigation measures”* without defining what these might be and goes on to say that the *“national responsible body can require further action to solve the case (of interference) regardless to the levels in Table 1 (of the Recommendation)”*. Moreover, the statement in Section 5.1 that the case has to be passed to the national responsible body under certain circumstances but not under others, suggests a certain expectation of the structure of administrations and the operation of the legal systems in countries around the world, which are unlikely to be the same everywhere.

Because of this situation, and the desire in ITU-R to have more definitive information available on the coupling between wired telecommunication systems and radiocommunication systems, as well as the resulting potential for interference arising, it may be that the work now commencing in   
ITU-T SG 5 on two new Recommendations – K.radio\_emc (EMC requirements for radio telecommunication equipment), and K.wire-line\_emc (EMC requirements for wire-line telecommunication equipment – will provide for better opportunities for aligning the interests of ITU-T and ITU-R on compatibility. Of interest to ITU-R, and Working Party 1A in particular, will be any studies on the coupling mechanisms involved and modelling the coupling losses, both of which would seem to be essential elements of the work.

# 4 PLT work under the G.9960 & G.9955 family of Recommendations – ITU-T SG 15

Work has been continuing in ITU-T SG 15 on refining the G.9960 family of standards in respect of broadband home networking PLT products and on the G.9955 family of standards for narrow band PLT products for SmartGrid applications. In both cases there is concern that activities on PLT in Standards Developing Organizations (SDOs) outside ITU will conflict with the work being undertaken in ITU-T. The concerns on SmartGrid PLT systems are shared by the IEC TC57 WG20, which is cooperating closely with ITU-T SG 15 in this area.

Further liaison with the SDOs concerned is continuing by means of formal liaison statements and direct high level contacts through the TSB. The latest [liaison statement](http://ifa.itu.int/t/2013/ls/sg15/sp15-sg15-oLS-00145.docx) on the issue from ITU-T SG 15 to the CENELEC SGCG makes strong representations to CENELEC for better cooperation, noting three urgent action points:

**– Action 1** – Establish more effective means of communication between SGCG   
and ITU-T

**– Action 2** – Update SGCG reports to include the latest ITU-T Recommendations

**– Action 3** – Clarify ambiguous text

A particularly interesting issue on PLT EMC issues is the continuing concern on interference from PLT systems into DSL based wired telecommunication systems. Interference from PLT systems into VDSL and G.fast systems has been found to be highly disruptive. This is not surprising given the situation reported above that G.fast needs to work under optimum conditions as regards crosstalk and noise. Radiated noise like interference from PLT can therefore be extremely disruptive.

Joint action on PLT interference is being undertaken by the Q4/15 and Q18/15 groups of   
ITU-T SG 15 during and between ITU-T SG 15 meetings. Investigations are continuing on interference from certain PLT systems into VDSL and G.fast[[3]](#footnote-3) . It has been found that certain non-ITU compliant PLT modems operate with PSD outputs 5 dB higher than their supposed PSD specifications. Moreover, there are moves in SDOs outside the ITU to develop specifications for PLT systems operating above 30 MHz with PSD outputs up to 20 dB above the ITU-T G.9960 family of standards.

Mitigation measures are being considered so that PLT, VDSL and G.fast systems complying with ITU-T Recommendations can communicate with each other so that they can adopt detect and avoid strategies that will in effect share spectrum between the various systems. An open question is how the various systems could communicate with each other if they are not part of the same home networking installation. Moreover, interference from a PLT system in one home can affect VDSL and G.fast use in neighbouring homes, and these will certainly not share any connectivity through a common home networking installation.

# 5 Conclusions

Cooperation between ITU-T and ITU-R groups on co-existence issues is improving. The main difficulty is the disjunction between meeting dates and that the ITU-T groups involved (particularly evident with the various ITU-T Question/Rapporteur Groups that do most of the detailed work) tend to meet more often than is done under the ITU-R block meeting structure.

The most intractable problem continues to be the consequences of SDOs and industry alliances outside ITU that develop products using radio frequencies for wired telecommunications without reference to parallel work or existing Recommendations in ITU that have addressed the relevant EMC aspects of the use of radio frequencies in wired systems.

ITU-R Study Groups and Working Parties need to lend support to the efforts in ITU to make representations to external SDOs and industry groups developing standards that conflict with radiocommunication services or wired telecommunication systems operating in accordance with ITU standards. A fully coordinated approach from ITU-T and ITU-R, accounting for all the information, will ensure the all wired and wireless systems can operate successfully without harmful interference.

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1. <http://hraunfoss.fcc.gov/edocs_public/attachmatch/DA-14-472A1.docx>

   <http://hraunfoss.fcc.gov/edocs_public/attachmatch/DA-14-471A1.docx> [↑](#footnote-ref-1)
2. “This Recommendation is intended to be used only in the case of a radio interference complaint. If the result of the preliminary investigation cannot verify that the source of the radiated disturbance is a telecommunication network, then this Recommendation is not applicable.” [↑](#footnote-ref-2)
3. Report from Joint meeting of Q4/15 and Q18/15 - 1 April 2014 (see Document [TD344 (WP1/15)](http://www.itu.int/md/T13-SG15-140324-TD-WP1-0344/en) ) and Ad hoc report on PLC-VDSL Interference issues (Document [TD307 (WP1/15](http://www.itu.int/md/T13-SG15-140324-TD-WP1-0307/en)) ) [↑](#footnote-ref-3)