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Question: 4/15

SOURCE[1]: MATSUSHITA ELECTRIC INDUSTRIES, CO. LTD.

TITLE: G.gen.bis: Power Control for xDSL

ABSTRACT

This contributions presents further thoughts on the needs for and benefit from a more standard approach to upstream and downstream power control for each of our future xDSL Recommendations, including G.shdsl, G.vdsl, G.dmt.bis, and G.lite.bis. This is an amplification of Temporary Document BM-055R1. The basic goals and methods remain the same, but figures, components, and some example specification details are given in order to promote discussion and counter-proposals.

1. Introduction

This contribution address the following agreed and open issues:

G.shdsl (BM-015R1)			
	Agreed	4.11	G.shdsl shall provide for automatic transmitted power cutback in both upstream and downstream directions.
	Agreed	7.2	a preactivation communication channel shall be established.
		(4.11.1)	Should a power control procedure based on a power control digital link be used in G.shdsl? (This issue is covered by Item 7.2.)
G.vdsl (BM-021R3)			
	Agreed	8.2,	Upstream power control procedure shall be applied to G.vdsl.
	Agreed	8.5	A power control procedure with a message link may be very useful to reach a proper Power Back Off (PBO) implemetation (e.g. Politeness, off hook cutback)
	Open	8.1	What Power Management and Power Cutback methods should be

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		specified?
Open	8.3	Should Power Back Off (PBO) be used for downstream?
Open	8.6	Should the power back-off (PBO) in the upstream of G.vdsl be performed with a method that uses target bit rates as parameters ?
G.lite.bis (BM-018R2		
Agreed	13.2	A power control procedure with a message link may be very useful to reach a proper power back off implementation (e.g., politeness and fast retrain cutbacks).

The agreements clearly indicate that automated power control procedure is needed for G.shdsl, G.vdsl, and G.lite.bis. Several goals are suggested:

- A method that starts with **small** signals that still allows loss and power measurements
- A method that is common among the various xDSL
- A method that allows independent upstream and downstream measurement to independently control upstream and downstream power.
- A method that provides direct feedback of the power control information using protocol-level bits.
- A method that allows programmable (e.g. frequency content, power level, duration) wide band probe signals suitable for each DSL (including any specific variations needed due to variation in deployment scenarios).
- A method that allows DSLs that include repeaters to be addressed, for example, through simple protocol extensions to address each segment.
- A method that allows upstream or downstream power control that can be enabled and disabled easily.

There are several ways of defining procedures that accomplish those goals. Three basic ideas are presented:

2. Power Control Procedures

In this section, three different methods for implementing a Power Control method are described. The three methods mainly differ in their location of the procedure with respect to the existing standards.

2.1 G.hs and G.xDSL Independent

The following sequence outlines a possible power control procedure that is part of a DSL session starting with G.hs and ending with G.xDSL.

G.hs	1. Bring up the G.hs link
	2. Use G.hs to initiate the session and negotiate a DSL
	3. Tear-down the G.hs link
Power Control	4. Bring up the power control link
	5. Exchange information about the probe signals about to be sent
	6. Send low power wide band power control probe signals in each direction
	7. Use the power control link and exchange measured information and make power control decisions
	8. Tear-down the power control link
xDSL	9. Begin the DSL cold start, warm start, or other procedures.

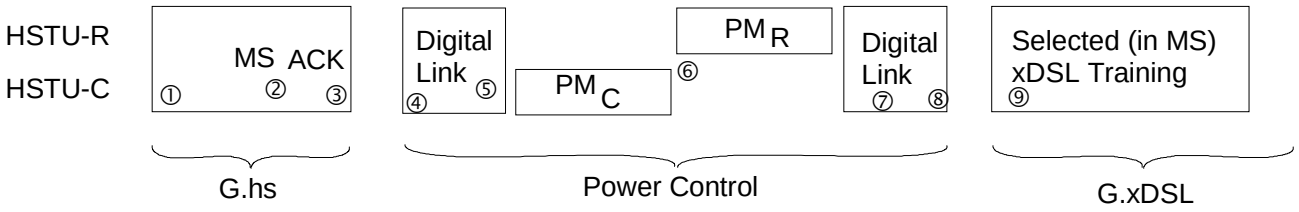

Figure 1

It should be noted that the middle procedural steps are the functional equivalent of an aborted fast retrain request in G.lite.

2.2 G.hs Duplex Modulation with Simultaneous Power Measurement

One possibility is to use the full duplex modulation and transmit the power measurement test signals simultaneously with the G.994.1 carriers. This transaction also assumes that the first message is always sent by the HSTU-R.

Transmitter	Message Name	Description
HSTU-R	PR	The message is a request for the HSTU-C to send the power measurement signals (PM_C) and includes the parameters of the desired signal (PM_C) to be transmitted.
HSTU-C	P1	This message includes: • the parameters of the PM_C signal actually transmitted (in case it cannot comply with the full request of the HSTU-R) • the parameters of the PM_R signal it desires the ATU-R to transmit. • Simultaneously, the HSTU-C transmits the power measurement signal (PM_C) for the HSTU-R to receive. If the ATU-C does not wish to receive power measurement signals, it can also indicate that here.
HSTU-R	P2	This message: • acknowledges the reception of the power measurement signal (PM_C) during P1, • transmits power level parameters to be used the HSTU-C, • includes the parameters of the PM_R signal actually transmitted (in case it cannot comply with the full request of the HSTU-C) and • simultaneously transmits the power management signal PM_R if it was requested by the HSTU-C.
HSTU-C	P3	This message: • acknowledges the reception of the power measurement signal (PM_R) during P2, • transmits power level parameters to be used in the HSTU-R
HSTU-R	ACK(1)	The message acknowledge the reception of P3

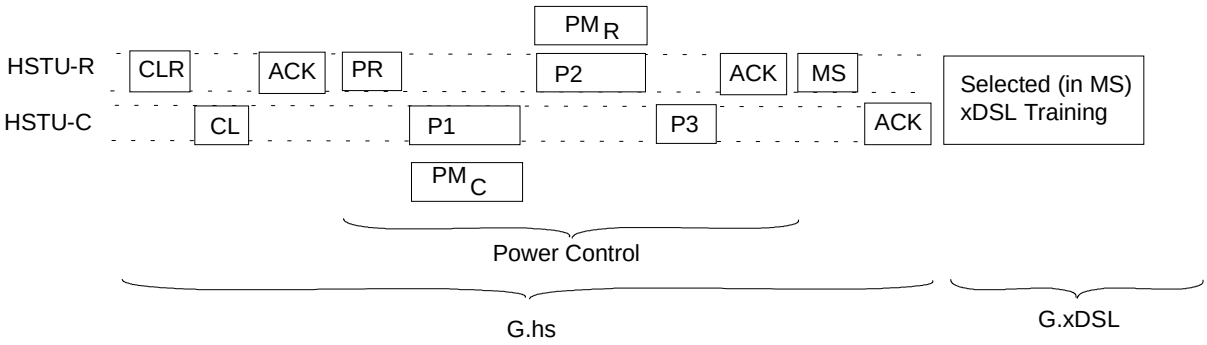

Figure 2. Power Control in duplex procedure

2.3 Half Duplex Modulation and Serial Testing

Another possible method is to use the G.994.1 half duplex modulation and all the test signals (PM_C and PM_R) to occur when the G.994.1 modulation is not being transmitted between messages. We may need to modify the G.994.1 Tau times. This also assumes the first message is always sent by the HSTU-R.

Transmitter	Message Name	Description
HSTU-R	PRR	The message is a request for the HSTU-C to send the power measurement signals (PM_C) and includes the parameters of the desired signal (PM_C) to be transmitted.
HSTU-C	PRH	This two part message includes: • the actual parameters of the PM_C signal to be transmitted (in case it cannot comply with the full request of the HSTU-R) communicated via the control communication channel and terminates the modulation. • Then, the HSTU-C transmits the power measurement signal (PM_C) for the HSTU-R to receive.
HSTU-R	PRHA	This message is transmitted via the control communication channel: • acknowledges the reception of the power measurement signal (PM_C) during PRH, • transmits power level parameters to be used in the HSTU-C.
HSTU-C	PCR	The message is a request for the HSTU-R to send the power measurement signals (PM_R)and includes the parameters of the desired signal (PM_R) to be transmitted.
HSTU-R	PCH	This two part message includes: • the actual parameters of the PM_R signal to be transmitted (in case it cannot comply with the full request of the HSTU-C) communicated via the control communication channel and terminates the modulation. • Then, the HSTU-R transmits the power measurement signal (PM_R) for the HSTU-C to receive.
HSTU-C	PCHA	This message: • acknowledges the reception of the power measurement signal (PM_R) during PCH, • transmits power level parameters to be used in the HSTU-R for the HSTU-CR.
HSTU-R	ACK(1)	The message acknowledge the reception of PCHA

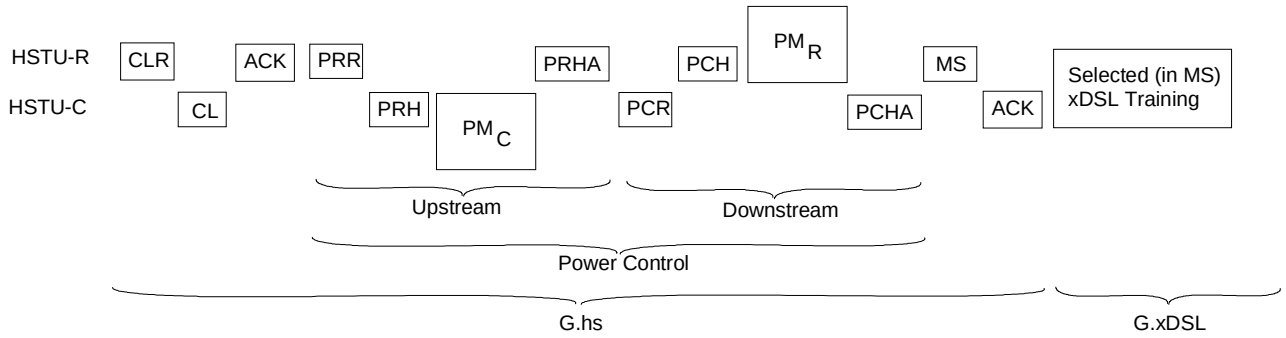

Figure 3. Power Control in half duplex procedure

3. Summary

1. Agenda Area: This should be presented in the discussion on G.gen work, and applies to each of G.vdsl, G.shdsl, G.lite.bis, and G.dmt.bis, as well as possibly to G.hs.bis.

2. Expectations:
   - An Ad hoc group discussion on the topic.
   - Open items should be added to the Call for Papers and the issue list under the agreements initial points listed in §1 above:
     - What types of signals should be used for the Power Measurement?
     - What amount of resolution and range is needed for the power measurement signal?
     - What types of information should be exchanged (on the digital link)?

Details of some example proposals are given in the following Annexes in order to promote discussion in an Ad Hoc by providing a "target to shoot at".

4. Annex A: Duplex Procedures Example

The nature of the power measurement signals PM_R and PM_C are such that they do not interfere with the simultaneous transmission of the digital negotiation and control channels. Parameters that describe PM_R and PM_C include bandwidth, duration, power levels, density of carriers, etc.

The parameters are encoded in digital messages on the negotiation and control channels that are exchanged between the HSTU-R and HSTU-C. PM_X bandwidth is indicated by only setting nonzero power levels on the desired carriers in the spectrum of interest. Although a prescribed number of carriers are defined, the density of carriers can be reduced by setting the transmit power level of individual carrier to zero. The power level of each carrier is encoded by bits that include codes for zero and nominal power. The requested measurement duration is encoded in a time expressed in milliseconds.

The HSTU-R makes power measurements based on the signals in P1 and PM_C . The signals in P1 are the carriers of the HSTU-C message modulation. The minimum number of carriers is based upon the types of xDSL modems negotiated by HSTU-X. HSTU-C message modulation carriers are shown in the last column of Table 1 and Table 2. PM_C allows measurement of the power of the downstream spectrum in areas outside of the carriers of P1. P1 is composed from carriers in at least one of A43, B43, C43, and A4. PM_C is composed from P4 and V128 carriers or P43 and V138 carriers. Carrier sets are described in Table 1 through Table 4.

The HSTU-C makes power measurements based on the signals in P2 and PM_R . The signals in P2 are the carriers of the HSTU-R message modulation. The minimum number of carriers is based upon the types of xDSL modems negotiated the HSTU-X. HSTU-R message modulation carriers are shown in the middle column of Table 1 and Table 2. PM_R allows measurement of the power of the upstream spectrum in areas

outside of the carriers of P2. P2 is composed from carriers in at least one of A43, B43, C43, and A4. PM_R is composed from P4 and V128 carriers or P43 and V138 carriers.

Table 1. ADSL band 4.3125kHz Carrier Indices

Carrier set designation	HSTU-R Upstream carrier sets	HSTU-C Downstream carrier sets
	Frequency indices (N) x 4.3125 kHz	Frequency indices (N) x 4.3125 kHz
A43	9 17 25	40 56 64
B43	37 45 53	72 88 96
C43	7 9	12 14 64
P43	-	115 138 165 198 238 255

Table 2. ADSL band 4kHz Carrier Indices

Carrier set designation	HSTU-R Upstream carrier sets	HSTU-C Downstream carrier sets
	Frequency indices (N) x 4 kHz	Frequency indices (N) x 4 kHz
A4	3	5
P4	10, 12, 14, 17, 20, 24, 29, 34, 41, 50, 59, 71, 86, 103, 123, 148, 177, 213, 255	10, 12, 14, 17, 20, 24, 29, 34, 41, 50, 59, 71, 86, 103, 123, 148, 177, 213, 255

Table 3. VDSL band 128 kHz Carrier Indices

Carrier set designation	HSTU-R Upstream carrier sets	HSTU-C Downstream carrier sets
	Frequency indices (N) x 128.0 kHz	Frequency indices (N) x 128.0 kHz
V128	10, 12, 14, 17, 20, 24, 29, 34, 41, 50, 59, 71, 86, 103, 123, 148, 177, 213, 255	10, 12, 14, 17, 20, 24, 29, 34, 41, 50, 59, 71, 86, 103, 123, 148, 177, 213, 255

Table 4. VDSL band 138 kHz Carrier Indices

Carrier set designation	HSTU-R Upstream carrier sets	HSTU-C Downstream carrier sets
	Frequency indices (N) x 138.0 kHz	**Frequency indices (N) x 138.0 kHz**
V138	8, 10, 12, 14, 17, 20, 24, 29, 34, 41, 50, 59, 71, 86, 103, 123, 148, 177, 213	8, 10, 12, 14, 17, 20, 24, 29, 34, 41, 50, 59, 71, 86, 103, 123, 148, 177, 213

For the band which occupies the spectrum up to approximately 1.1 MHz (typically referred to as the ADSL band), the existing G.hs carrier indexing method is used. For the band from approximately 1.1 MHz through approximately 30 MHz (typically referred to as the VDSL band), an indexing method is also used but the carriers have a spacing of 128.0 kHz or 138.0 kHz. The VDSL band carrier spacing is 32 times the ADSL band carrier spacing to roughly scale the approximately 27 times bandwidth increase. The first eight indices of the VDSL band carriers are not used because they overlap the ADSL band carriers.

The V128 set of carriers shown in Table 3 is for systems that prefer 4.0 kHz spacing. The V138 set of carriers shown in Table 4 is for systems that prefer 4.3125 kHz spacing. The spacing of the carriers is selected to be approximately 1.2 times the previous carrier. This allows a non linear set of carriers that scales equivalent with frequency.

Power levels are expressed in 3 bits as shown in Table 5. The power level for each carrier in the ADSL 4.3125 kHz band is coded in Table 6 The power level for each carrier in the ADSL 4.0 kHz band is coded in Table 7. The power level for each carrier in the VDSL band is coded in Table 8 .

The definition of these VDSL band power measurement carriers is effective for all types of VDSL band modulation schemes including single carrier and multi carrier modulation schemes.

Table 5. Power level encoding bits

Code	Description
000	not transmitted
001	-60 dBm (per carrier)
010	-50 dBm (per carrier)
011	-40 dBm (per carrier)
100	-30 dBm (per carrier)
101	-20 dBm (per carrier)
110	-10 dBm (per carrier)
111	Nominal

Table 6. ADSL band 4.3125 kHz Carrier Transmit Power {NPar(2)} coding

Power			8	7	6	5	4	3	2	1
Octet #1	#009	#012	x	x	x	x	x	x	x	x
Octet #2	#014	#017	x	x	x	x	x	x	x	x
Octet #3	#025	#037	x	x	x	x	x	x	x	x
Octet #4	#040	#045	x	x	x	x	x	x	x	x
Octet #5	#053	#056	x	x	x	x	x	x	x	x
Octet #6	#064	#072	x	x	x	x	x	x	x	x
Octet #7	#088	#096	x	x	x	x	x	x	x	x
Octet #8	#115	#138	x	x	x	x	x	x	x	x
Octet #9	#165	#198	x	x	x	x	x	x	x	x
Octet #10	#238	#255	x	x	x	x	x	1	1	1

Table 7. ADSL band 4.0 kHzCarrier Transmit Power {NPar(2)} coding

Power			8	7	6	5	4	3	2	1
Octet #1	#003	#005	x	x	x	x	x	x	x	x
Octet #2	#008	#010	x	x	x	x	x	x	x	x
Octet #3	#012	#014	x	x	x	x	x	x	x	x
Octet #4	#017	#020	x	x	x	x	x	x	x	x
Octet #5	#024	#029	x	x	x	x	x	x	x	x
Octet #6	#034	#041	x	x	x	x	x	x	x	x
Octet #7	#050	#059	x	x	x	x	x	x	x	x
Octet #8	#071	#086	x	x	x	x	x	x	x	x
Octet #9	#103	#123	x	x	x	x	x	x	x	x
Octet #10	#148	#177	x	x	x	x	x	x	x	x
Octet #11	#213	#255	x	x	x	x	x	1	1	1

Table 8. VDSL band Carrier Transmit Power {NPar(2)} coding

Power			8	7	6	5	4	3	2	1
Octet #1	#008	#010	x	x	x	x	x	x	x	x
Octet #2	#012	#014	x	x	x	x	x	x	x	x
Octet #3	#017	#020	x	x	x	x	x	x	x	x
Octet #4	#024	#029	x	x	x	x	x	x	x	x
Octet #5	#034	#041	x	x	x	x	x	x	x	x
Octet #6	#050	#059	x	x	x	x	x	x	x	x
Octet #7	#071	#086	x	x	x	x	x	x	x	x
Octet #8	#103	#123	x	x	x	x	x	x	x	x
Octet #9	#148	#177	x	x	x	x	x	x	x	x
Octet #10	#213	#255	x	x	x	x	x	1	1	1

Contents of Messages are shown in Table 9 through Table 12.

Table 9. PR Message content

Message type field - PR
Revision number field
P1 and PM_C signal duration (in ms)
P1 and PM_C ADSL band power transmission request (using Table 6 or Table 7)
PM_C VDSL band power transmission request (using Table 8)

Table 10. P1 Message Content

Message type field - P1
Revision number field
P2 and PM_R signal duration (in ms)
P1 and PM_C ADSL band power transmission indication (using Table 6 or Table 7)
P1 and PM_C VDSL band power transmission indication (using Table 8
P2 and PM_R ADSL band power transmission request (using Table 6 or Table 7)
P2 and PM_R VDSL band power transmission request (using Table 8)

Table 11. P2 Message Content

Message type field - P2
Revision number field
P2 and PM_R ADSL band power transmission indication (using Table 6 or Table 7)
P2 and PM_R VDSL band power transmission indication (using Table 8)
HSTU-C transmission power level parameters

Table 12. P3 Message Content

Message type field - P3
Revision number field
HSTU-R transmission power level parameters

5. Annex B: Half Duplex Procedures

In the this half duplex example, the nature of the power measurement signals PM_{RH} and PM_{CH} are allowed complete freedom since they need not be concerned about the simultaneous transmission of the digital negotiation and control channels. Parameters that describe PM_{RH} and PM_{CH} include bandwidth, duration, power levels, density of carriers, etc.

The HSTU-R makes power measurements based on the signals in PM_{CH} . The minimum number of carriers is based upon the types of xDSL modems included in a particular HSTU-X. PM_{CH} is composed from carriers in at least one of A43, B43, C43, A4, P4 or P43, and V128 or V138 carriers shown in Table 1 through Table 4 above.

The HSTU-C makes power measurements based on the signals in PM_{RH} . The minimum number of carriers is based upon the types of xDSL modems included in a particular HSTU-X. PM_{RH} is composed from carriers in at least one of A43, B43, C43, A4, P4 or P43 and V128 or V138 carriers shown in Table 1 through Table 4 above.

Contents of Messages are shown in Table 13 through Table 18.

Table 13. PRR Message content

Message type field - PRR
Revision number field
PM_{CH} signal duration (in ms)
Non Standard (NS) request = 0
PM_{CH} ADSL band power transmission request (using Table 6 or Table 7)
PM_{CH} VDSL band power transmission request (using Table 8)

Table 14. PRH Message Content

Message type field - PRH
Revision number field
PM_{CH} ADSL band power transmission indication (using Table 6 or Table 7)
PM_{CH} VDSL band power transmission indication (using Table 8

Table 15. PRHA Message Content

Message type field - PRHA
Revision number field
HSTU-C transmission power level parameters

Table 16. PCR Message Content

Message type field - PCR
Revision number field
PM_{RH} signal duration (in ms)
Non Standard (NS) request =0
PM_{RH} ADSL band power transmission request (using Table 6 or Table 7)
PM_{RH} VDSL band power transmission request (using Table 8)

Table 17. PCH Message Content

Message type field - PCH
Revision number field
PM_{RH} ADSL band power transmission indication (using Table 6 or Table 7)
PM_{RH} VDSL band power transmission indication (using Table 8)

Table 18. PCHA Message Content

Message type field - PCHA
Revision number field
HSTU-R transmission power level parameters

6. Annex C: Allowing proprietary test signals

This third example shows how manufacturers can generate their own proprietary signals to be sent instead of PM_R and PM_C or PM_{RH} and PM_{CH} yet retain a uniform negotiation and indication structure as the defined test signals. The use of the proprietary power measurement signal is indicated in messages PRR and PCR by setting the Non-Standard request to 1 as shown in Table 19 and Table 22. Table 20 and Table 23 show that

the parameters of the transmitted signals are also indicated using a private encoding. The parameter and acknowledge messages shown in Table 21 and Table 24 remain the same as Annex B. This example also assumes the band descriptions given in Annex A above.

Table 19. PRR Message content

Message type field - PRR
Revision number field
PM_{CH} signal duration (in ms)
Non Standard (NS) request =1
Proprietary Parameters (private encoding)

Table 20. PRH Message Content

Message type field - PRH
Revision number field
Proprietary Parameters (private encoding)

Table 21. PRHA Message Content

Message type field - PRHA
Revision number field
HSTU-C transmission power level parameters

Table 22. PCR Message Content

Message type field - PCR
Revision number field
PM_{RH} signal duration (in ms)
Non Standard (NS) request =1
Proprietary Parameters (private encoding)

Table 23. PCH Message Content

Message type field - PCH
Revision number field
Proprietary Parameters (private encoding)

Table 24. PCHA Message Content

Message type field - PCHA
Revision number field
HSTU-R transmission power level parameters