Effects of Duplexer Performance on H Block Use for US PCS Updated Again

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Updates and Clarification, 12 August

Agilent believes it can produce a narrow-band duplexer covering G & H blocks that would allow a handset to meet -76 dBm OOBE as per TIA-98-F. Agilent has produced duplexers that can cover A through G blocks and meet -76 dBm OOBE. Agilent does not presently believe it can produce a single duplexer that would cover A through H blocks and meet -76 dBm OOBE .

The analysis that follows was made assuming present industry operating levels would be maintained for operation of PCS services on H block. If such levels are not maintained, then Agilent believes handsets operating in H block might cause problems at A Block through OOBE.

On reflection, the assumption that high sensitivity is needed only at the edge of a cell site was erroneous – high sensitivity is needed anywhere low signal conditions occur (in buildings, RF shadows, etc.).

This presentation was not created to support any particular view either for or against operation at H block, nor was it created at the request of any one party. This presentation attempts to be an impartial discussion of duplexer capability and how it relates to H block operation.

Further Updates, 19 August

On what was page 13 (now page 14) I originally made the comment:
"3GPP TR 25.942 suggests an appropriate model for the isolation between two mobiles 1 meter apart is 32 dB.'

I want to explain this statement in more detail, and make a correction.

The 3GPP document cited refers to 1 meter spacing as an appropriate model for closely located phones. We therefore did a free-space calculation assuming zero antenna gain on both handsets, and derived the 32 dB value. Unfortunately, the frequency used for the calculation was for cell band, and should have been for PCS band. Recalculating for PCS band, the derived value turns out to be 38 dB, not 32 dB. Therefore the statement in question should read:
"A calculated value for the theoretical free space isolation between two mobiles 1 meter apart, each with zero antenna gain, and operating in the PCS band, is 38 dB."

Correcting the value to 38 dB results in changes in some of the other statements on the what were pages 13-15 (now 14-16). I have modified this paper making these corrections.

While clearly 38 dB of isolation provides more margin than 32 dB of isolation, my conclusion is not changed. Given present filter performance and a (corrected) model of 38 dB for the isolation between two mobiles at 1 m spacing, overload is theoretically possible. I continue to have no opinion on the acceptability of this possibility.

Context

Recently new spectrum has been considered for operation of US PCS type services

Original allocated bands:

A-F	Tx: 1850-1910 MHz	Rx: 1930-1990 MHz	guard band: 20 MHz

Recently allocated:

G	Tx: 1910-1915 MHz	Rx: 1990-1995 MHz	guard band: 15 MHz

Under consideration:

H	Tx: 1915-1920 MHz	Rx: 1995-2000 MHz	guard band: 10 MHz

This presentation comments on present duplexer technology with respect to operation of US PCS type services in H block.

Transmit Considerations

Role of Tx filter:
Reduction of Tx noise in Rx Band

Present "Industry Standard" filter requirements:
top of pass band=1910 MHz; IL<3.8 dB over –30 to +85C
bottom of reject band=1930 MHz; rejection > 40 dB over –30 to +85

Considerations for Tx filter for H band operation:

1. Can the required roll-off be achieved in 10 MHz?

2. Is the Noise floor higher at 10 MHz away from the carrier than it is at 20 MHz? If so, more rejection than 40 dB may be needed. (relevant for mobile-mobile jamming only)

Data sources:

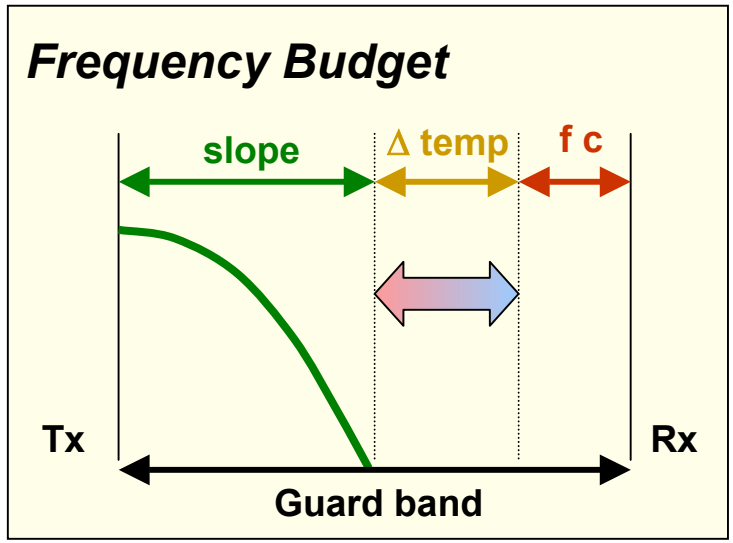
performance guarantees on Agilent duplexers

Duplexer Frequency Budget

Budget = SLOPE + Δ TEMP + f_c

SLOPE:

Spectrum required to go from pass band to minimum required rejection . For PCS duplexer Tx filter, measurement is from –3.5 dB point to –40 dB point.



Δ TEMP:

Motion of filter response with temperature .

Δtemp = temperature coefficient *f_{ref}* temp range. For PCS duplexer Tx filter, temperature range is –30C to +85 C (115 degrees), and reference frequency is 1910 MHz.

f_C:

Allowable product-to-product frequency variation. Wider permissible variation generally equates to higher yields. Supportable f_C may vary by technology type.

Improvements in slope, 2002-2004

1. Process improvements including higher acoustic coupling and improved Q have led to steeper slopes on today's FBAR filters. This trend is expected to continue.

year	3.5-40 dB rolloff	
2001	9.7 MHz	HPND-7904
2003	8 MHz	ACMD-7401
2004	7.1 MHz	today's technology

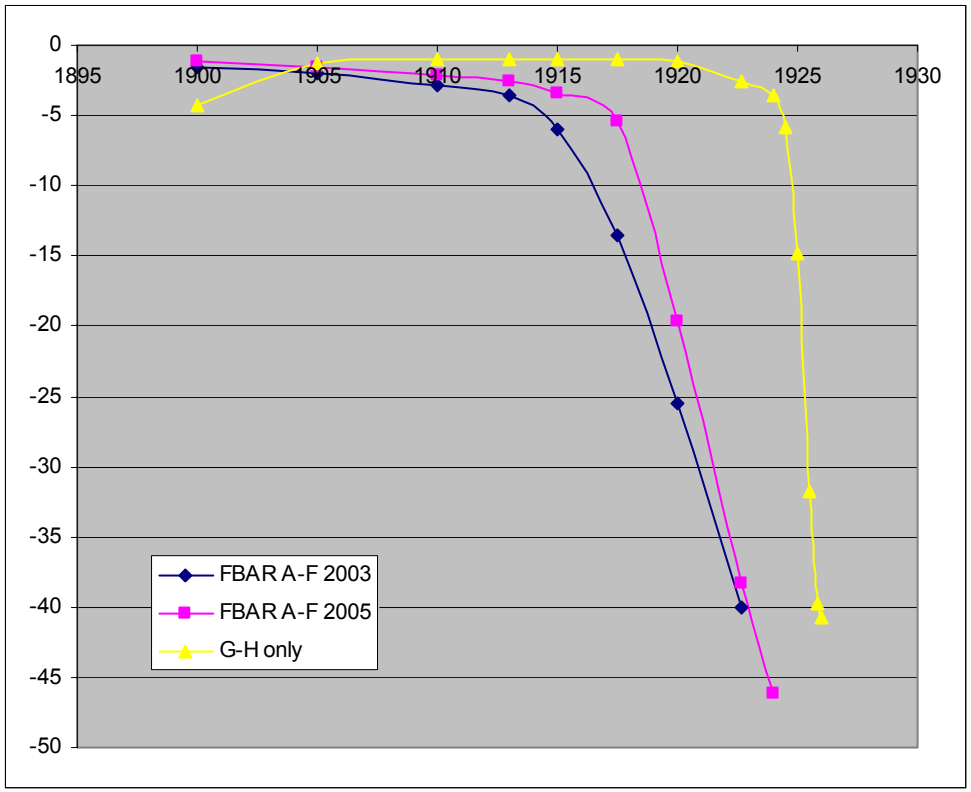
2. There is an inverse relationship between bandwidth and filter steepness: a narrow band duplexer covering only G and H blocks can have a substantially steeper slope than a duplexer covering A-H block.

BW	3.5-40 dB rolloff	
A-F or A-G	7.1 MHz	today's technology
G-H only	2.0 MHz	simulated, same technology base

Data source:

internal measurements and simulations

Improvements in slope, 2002-2004



slopes (3.5-40 dB)

A-F, 2002: 9.7 MHz

A-F, today's technology: 7.1 MHz

G-H only (simulation): 2.0 MHz

Data source:

internal measurements and simulations

Improvements in Δ Temp, 2002-2004

1. Margins required for temperature motion have not changed.

   While some promising results have been reported (industry papers, laboratory measurements), Agilent is not aware of any substantial improvements that have been achieved in volume production situations. This remains a possible area for future improvement.

Improvements in fc, 2002-2004

1. Better process controls and improvements in frequency centering techniques allow for a reduction in the margin required for frequency centering with Agilent FBAR. We believe that these improvements can provide up to a 2 MHz improvements in fc while maintaining acceptable yields in production.

Tx Consideration 1

Can 40 dB roll off be achieved in 10 MHz?

	Guard-Band Budget	=	SLOPE	+ D TEMP	+ f_c
2001 (A-F blocks):	20	=	9.7	+ 5.5	+ 4.8
2003 (A-F blocks) :	20	=	8.0	+ 5.5	+ 6.5
2004 (A-G blocks):	15	=	7.1	+ 5.5	+ 2.4

⇒ A-G block duplexer achievable with present technology

2004 (A-H blocks)	10	<	7.1	+ 5.5	+ 2.0

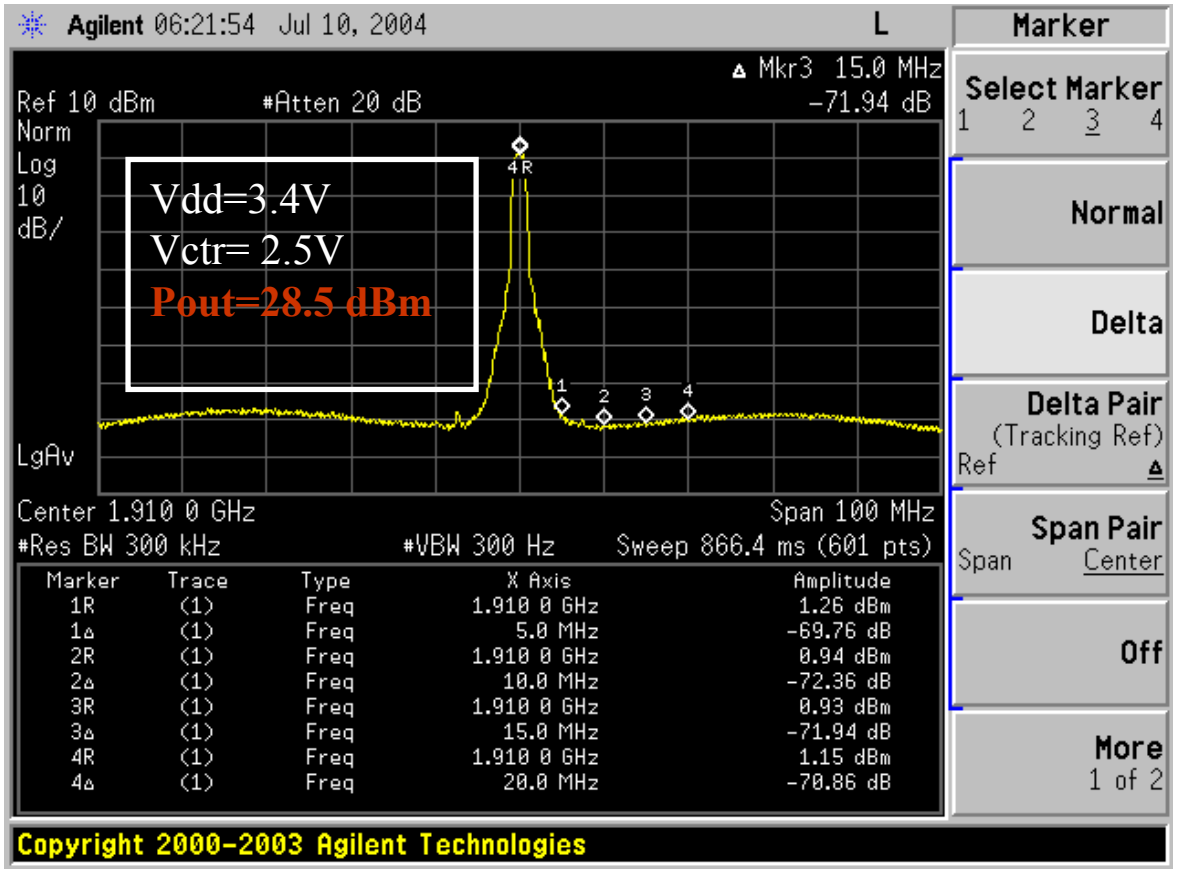
⇒ A-H block duplexer not achievable with present technology

2004 (G-H blocks only)	10	=	2.0	+ 5.5	+ 2.5

⇒ G-H block duplexer achievable with present technology

Tx Consideration 2

Is the PA noise floor higher at 10 MHz from the carrier than at 20 MHz?



In present systems PAs operate at ~28.5 dBm output for Pout of ~24.5 dBm at antenna.

Measurements show noise "skirts" at 28.5 dBm Pout reach noise floor well within 10 MHz

While these measurements are on an Agilent E-pHEMT based PA and we have not conducted similar measurements on HBT based PAs, we believe this data is a strong indication that increased noise floor at 10 MHz from the carrier is unlikely to be a problem

Data source:

internal measurements on typical Agilent PA (E-pHEMT technology)

Conclusion: 40 dB is the appropriate rejection target

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Receive Considerations

Role of Rx filter:
Prevent the Low Noise Amplifier (LNA) from being saturated by “out of band” signals

Present “Industry Standard” filter requirements:
bottom of pass band=1930 MHz; IL<4.2 dB over –30 to +85C
top of reject band=1910 MHz; rejection > 50 dB over –30 to +85

Considerations for Rx filter for H band operation:

1. Do existing Rx filters provide adequate protection from transmit signals in H band?

Rx Consideration 1

Do existing Rx filters provide adequate protection from transmit signals in H band?

Required performance of Rx filter to prevent mobile-mobile jamming:

Rejection required = rejection of Rx filter + isolation between mobiles

Examination of 3GPP specs suggests that a practical value for the minimum spacing between 2 mobiles might be 1 meter. (Perhaps the distance between two people seated on a bus)

A calculated value for the theoretical free space isolation between two mobiles 1 meter apart, each with zero antenna gain, and operating in the PCS band, is 38 dB.

Industry Standard value for minimum duplexer rejection (Rx filter in Tx band) is 50 dB. This corresponds to the case of zero separation (no isolation between mobiles)

Using these values,

required rejection from Rx filter to prevent jamming at 1 M separation = 50 dB – 38 dB = 12 dB

Data sources:

performance guarantees on Agilent duplexers

Rx Consideration 1, Part 2

Do existing Rx filters provide adequate protection from transmit signals in H band?

A) For a neighboring GSM receiver: Current worst case GSM Rx filter performance provides ~8 dB rejection at 1910 MHz, 2 dB IL at 1920 MHz over temperature. The 6 dB difference is less than the difference between GSM Tx full power and CDMA Tx full power.

B) For a neighboring CDMA receiver: Performance of Rx filter in present US PCS CDMA handsets is:

product	rejection at top of F block (1910MHz)	rejection at top of G block (1915 MHz)	rejection at top of H block (1920 MHz)	
present FBAR	>50 dB	40 dB	15 dB	(source, Agilent measurements)
present ceramics	>50 dB	>30 dB	>10 dB	(source, CTS data sheet typicals)

less than the required 12!

Conclusion:

Existing Rx filtering should be adequate to protect from G block operation. However it is not adequate to protect from H block in all cases.

Data sources:

performance guarantees on Agilent duplexers

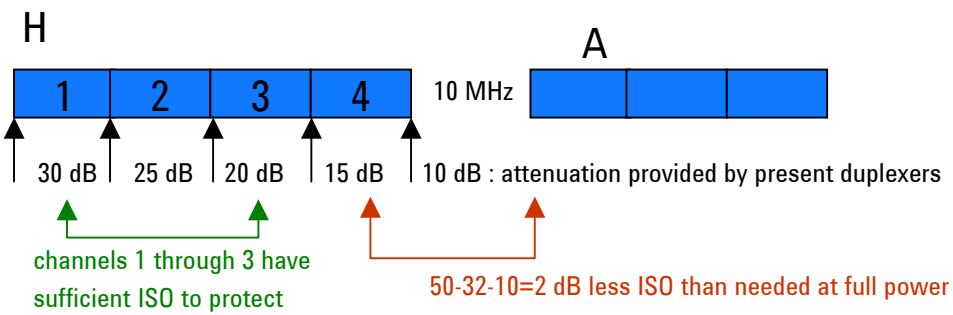
Rx Consideration 1, Footnote

Do existing Rx filters provide adequate protection from transmit signals in H band?

Simultaneous conditions necessary for H block transmission to interfere with another mobile:

- Tx is operating at a portion of H block that can interfere with a broadband PCS receiver
- Tx is operating at an output power level sufficient to interfere with the receive LNA
- The Rx is operating on a CDMA network
- The receiver is operating at full sensitivity
- The two mobiles are 1 meter apart

The frequency of operation and power levels that can cause interference (condition 1 &2) depend on the duplexer performance. Present duplexer Rx filters have a slope of about 5 dB/1.25 MHz. Assume a 1.25 MHz wide channel in H block. Considering worst case in band performance, operation above 22.5 dBm in channel 4 could cause interference. The channel of operation of the receiver doesn't matter, as the LNA is assumed to be receiving some signal at the Tx frequency.



Assumptions:
required ISO = 50 dB
worst mobile-mobile ISO = 38 dB (value at 1 m separation)
present duplexer attenuation at 1920 MHz = 10 dB min
slope on duplexer = 5 dB/1.25 MHz

Conditions 3, 4, and 5 are independent of duplexer operation

Data sources:

internal measurements;
CTS data sheet typicals

Conclusions

Agilent Technologies, Wireless Semiconductor Division believes:

- The duplexer technologies that presently support PCS can also support G Block.

- Support of H block is possible with a narrow band duplexer, but under certain circumstances interference with existing mobile receivers can occur in this situation. Agilent does not have an opinion as to whether the probability of such interference occurring would be at an acceptably low level.