Base Station Receivers Interference & Desentization APCO WRC 2015

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What we will cover

- How you can determine key IM specifications
  - IIP^3 & OIP^3
  - *1 dB* compression point
- Symbolic method for evaluating
  - IM
  - Desense from strong signals and external noise
- How to tradeoff sensitivity for less desense in a multicoupler configuration
- How to make measurements to determine IM sources from cellular base stations

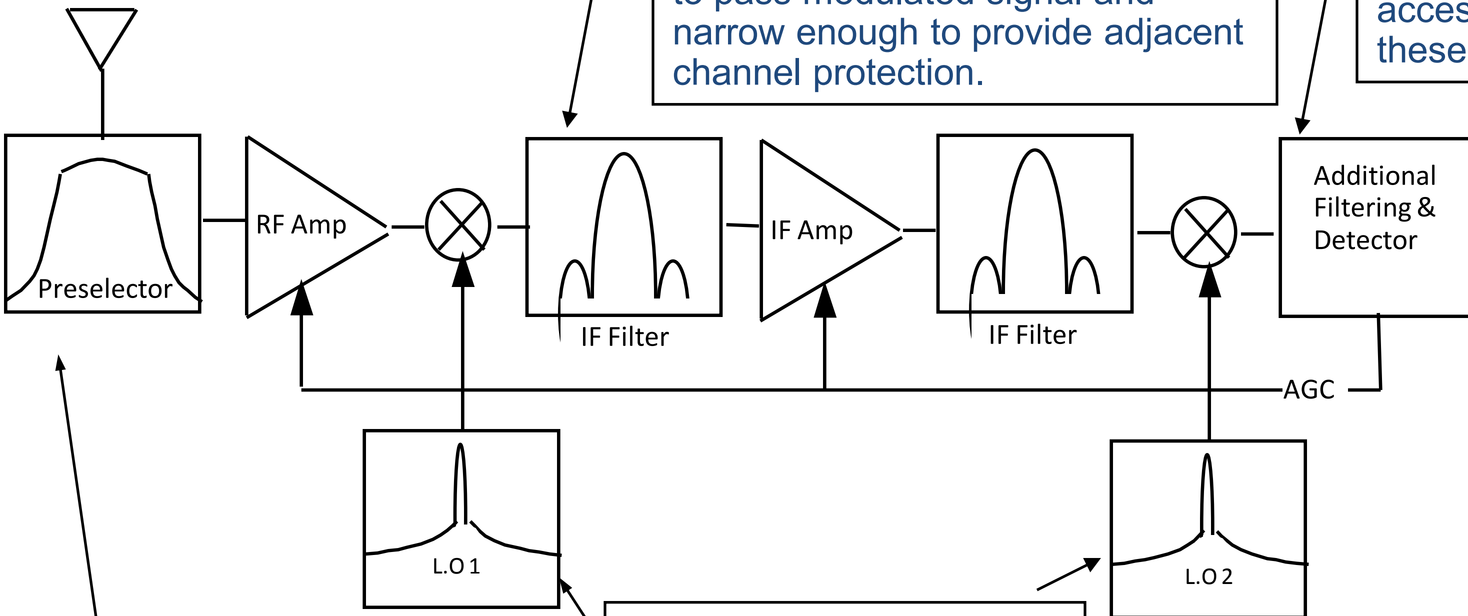
Base Interference Sources

- Inter site interference
  - Transmitter Noise
  - Receiver Desense
- Intermodulation
  - Specification
  - Strong Signals
    - Blocking
- External Noise
  - Static Discharge
- Source of Interference to mobiles

Receiver Characteristics

Receiver IF Filter(s), wide enough to pass modulated signal and narrow enough to provide adjacent channel protection.

Modern receivers have limited access to see into these stages



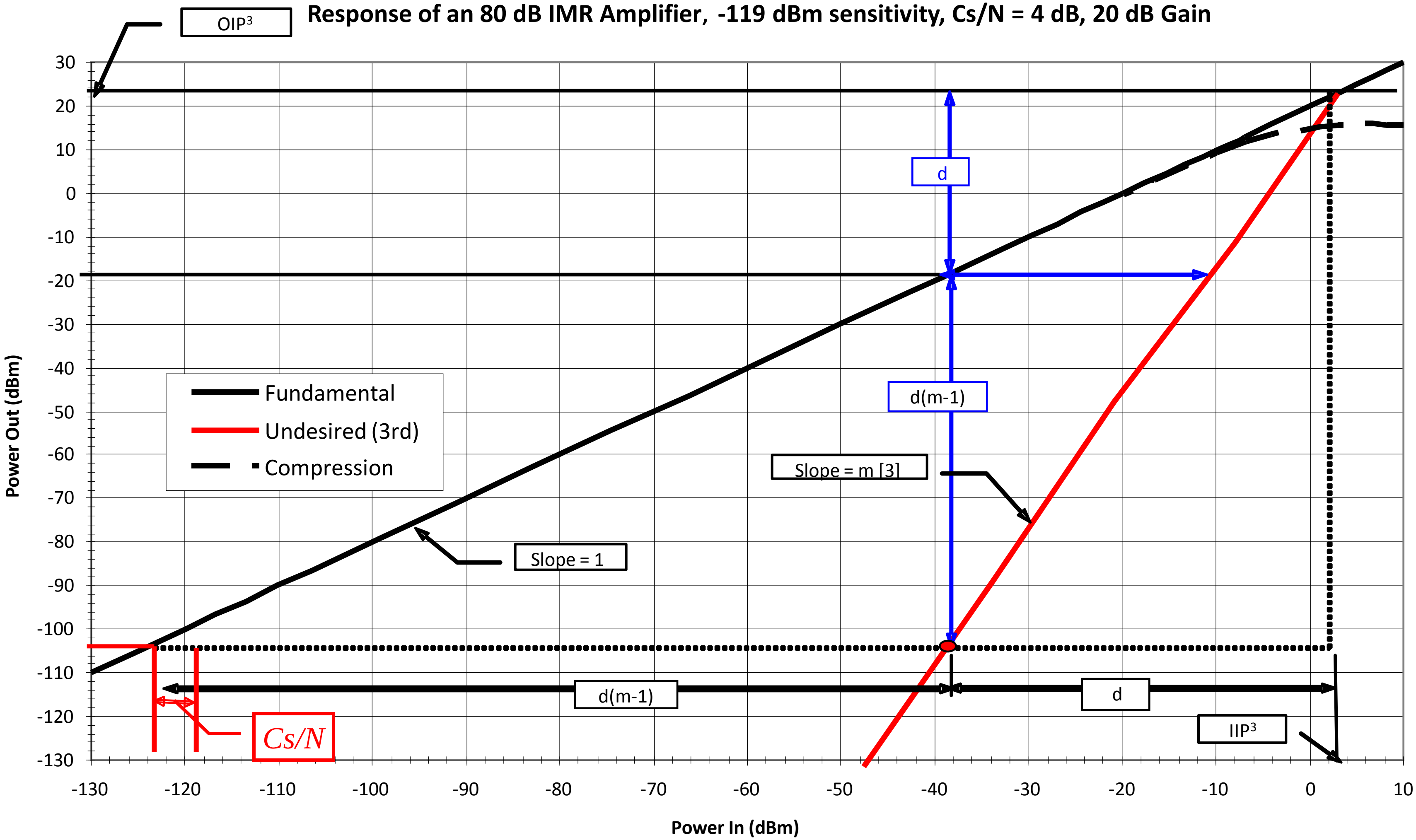
Preselector, passes the entire band of interest. Older radios had narrow preselectors. Newer radios have very wide preselectors. Sites often use a multicoupler with its own preselector.

Local Oscillator to mix the desired down to the appropriate frequency for further amplification and filtering.

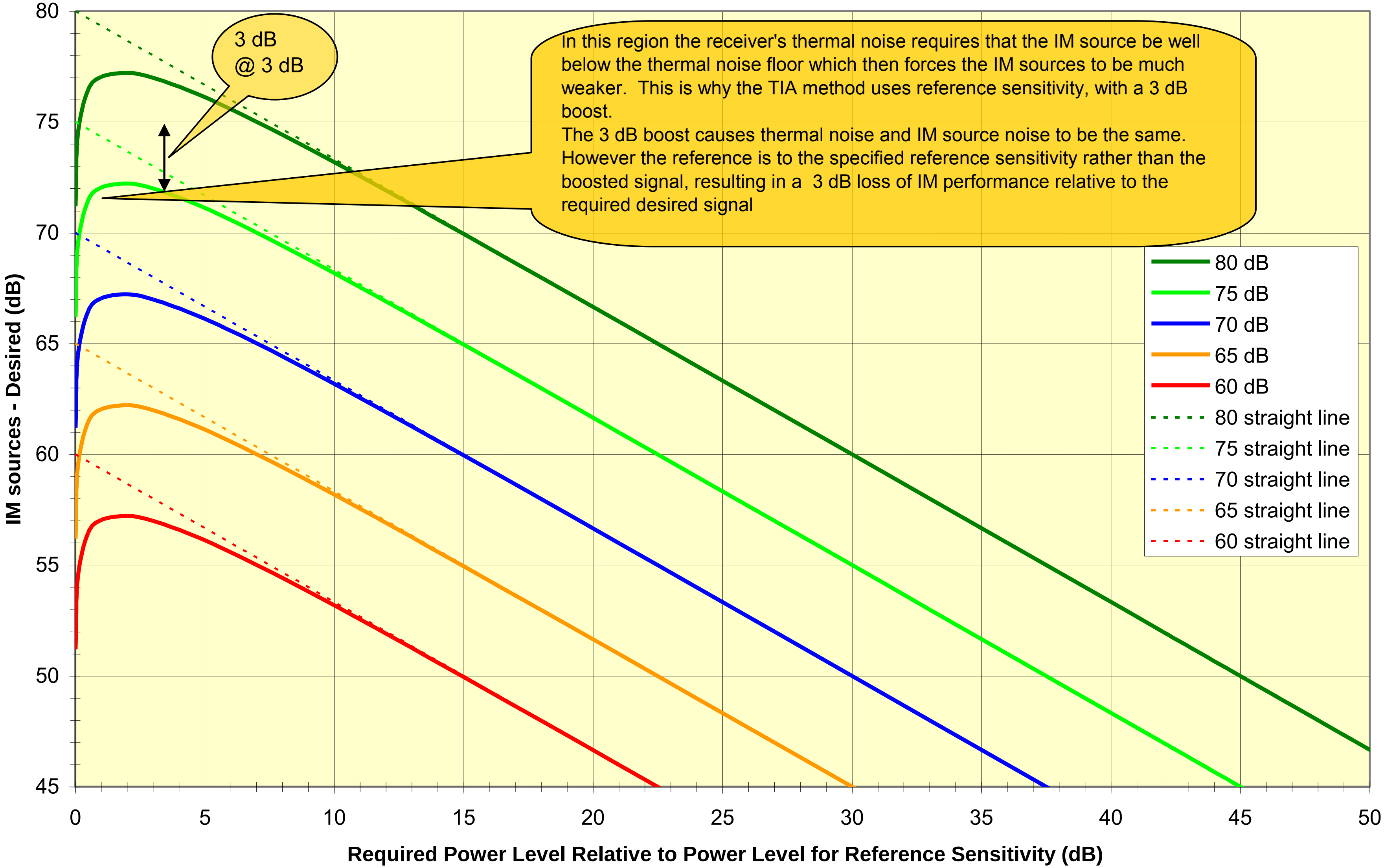
RECEIVER Specifications

- Sensitivity, 12 dB SiNAD-5% BER
- Intermodulation 60 – 85 dB
- Selectivity Method
- Spurious Responses

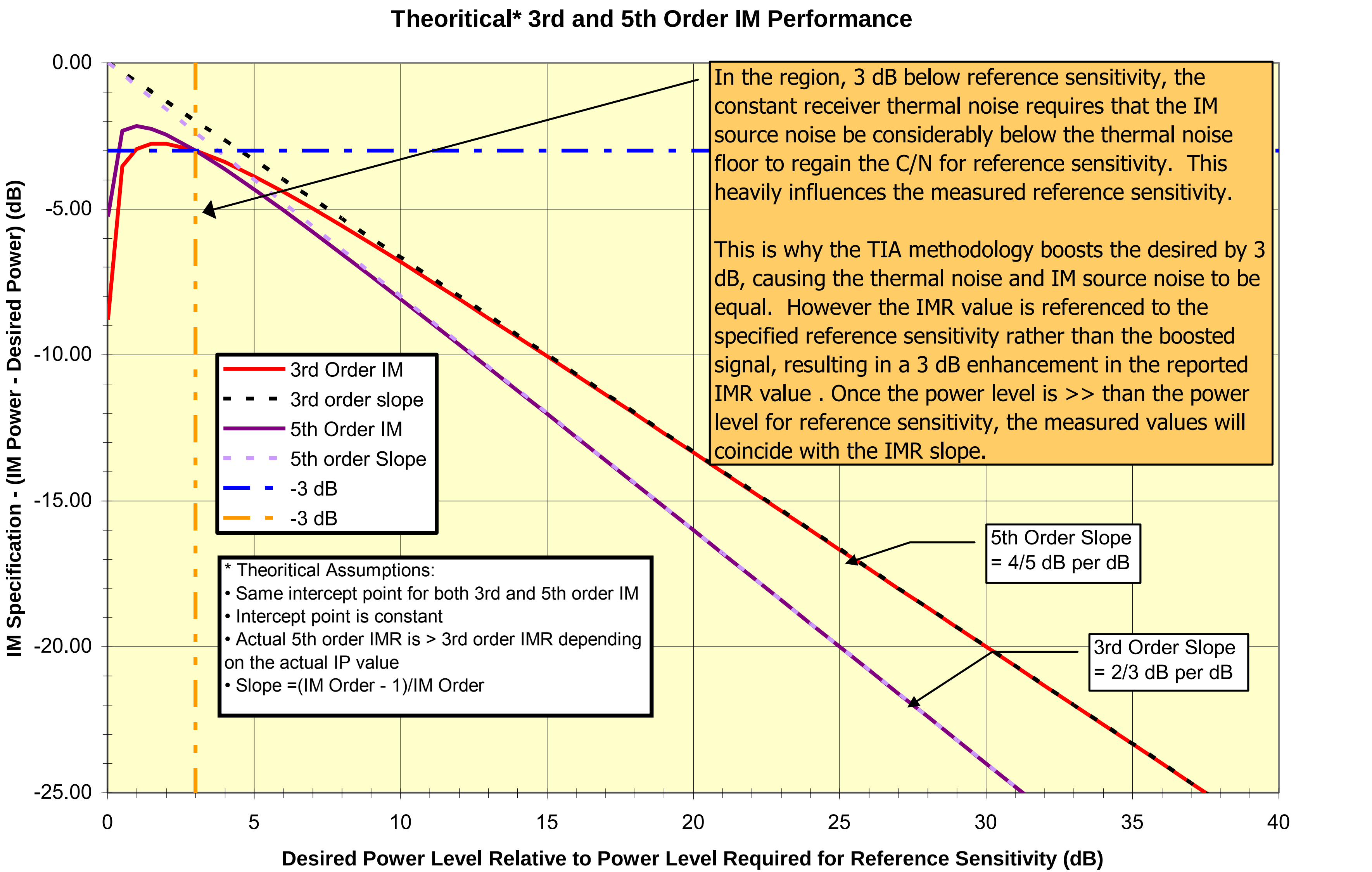
Example
Traditional IM Chart Analog FM Wide Band



IMR Slope = 2/3 dB/dB for 3rd Order IM $\frac{n-1}{n}$



Receiver IM

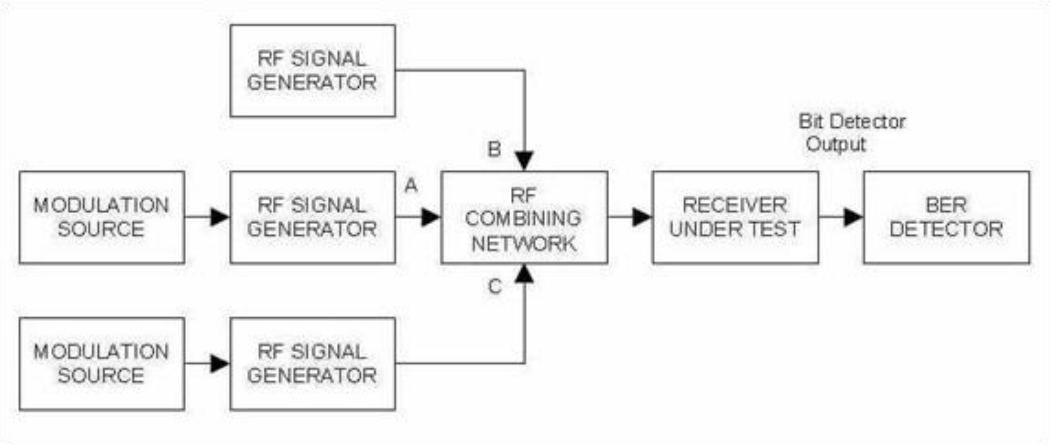


Theoritical* 3rd and 5th Order IM Performance
0.00
-5.00
-10.00
-15.00
-20.00
-25.00
IM Specification - (IM Power - Desired Power) (dB)
0
5
10
15
20
25
30
35
40
Desired Power Level Relative to Power Level Required for Reference Sensitivity (dB)
3rd Order IM
3rd order slope
5th Order IM
5th order Slope
-3 dB
-3 dB
In the region, 3 dB below reference sensitivity, the constant receiver thermal noise requires that the IM source noise be considerably below the thermal noise floor to regain the C/N for reference sensitivity. This heavily influences the measured reference sensitivity.
This is why the TIA methodology boosts the desired by 3 dB, causing the thermal noise and IM source noise to be equal. However the IMR value is referenced to the specified reference sensitivity rather than the boosted signal, resulting in a 3 dB enhancement in the reported IMR value . Once the power level is >> than the power level for reference sensitivity, the measured values will coincide with the IMR slope.
5th Order Slope = 4/5 dB per dB
3rd Order Slope = 2/3 dB per dB
* Theoritical Assumptions:
• Same intercept point for both 3rd and 5th order IM
• Intercept point is constant
• Actual 5th order IMR is > 3rd order IMR depending on the actual IP value
• Slope =(IM Order - 1)/IM Order

IMR Approach via TSB-88

- What are the common types of IM interference?
- How does the method of measurement affect the values?
- How do you handle different interfering power levels?
- How does the amount of reserve gain in a TTA or multicoupler system effect sensitivity and IM performance?
- How can I find out the IP^3?
- How can I determine what is causing my interference?

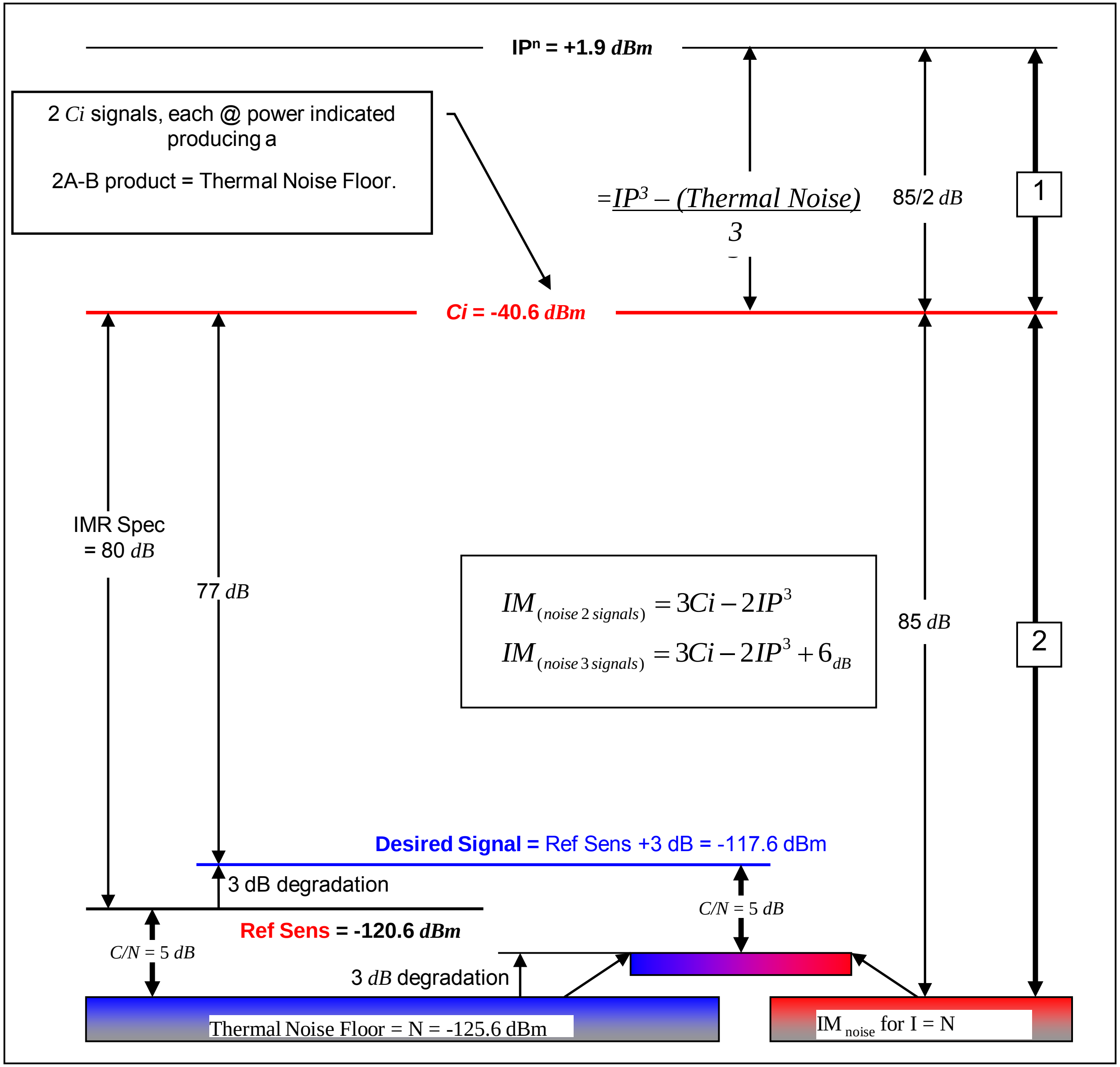
TIA IMR Test



- At A inject desired signal for reference sensitivity. Then boost by 3 dB
- At B inject unmodulated signal 50 kHz above reference frequency
- At C inject a modulated signal 100 kHz above reference frequency
- Simultaneously increase unwanted signals until reference performance reoccurs
- Do again with unwanted signals below reference frequency
- The smallest difference between the original signal power and unwanted signals power is the IMR

So what does this all mean and how can it be used?

Example for NPSPAC Analog



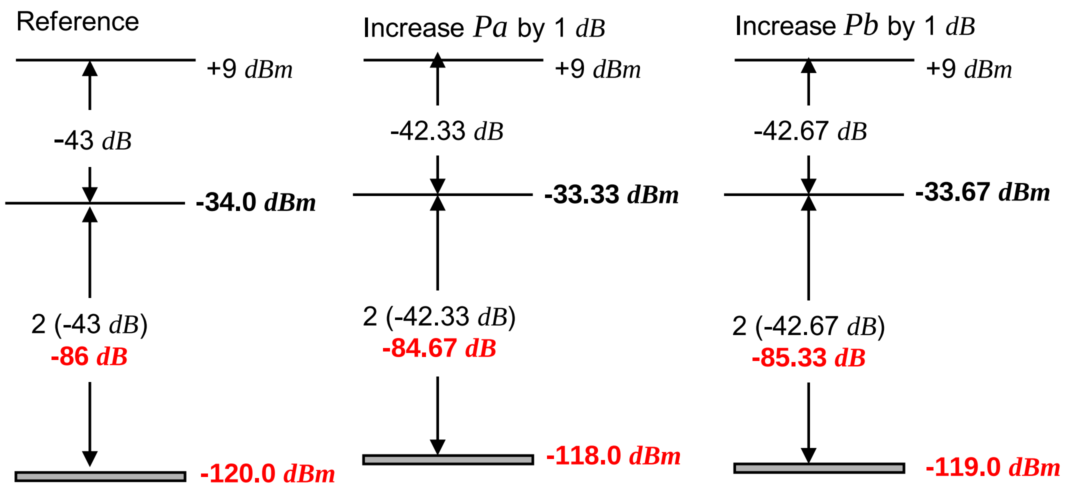
Handling unequal IM signals

Assume P_a = -30 dBm
P_b = -42 dBm
IIP^3 = +9 dBm

Reference $$Ci = \frac{2(P_a) + P_b}{3} = \frac{2(-30) + (-42)}{3} = -34.00 \ dBm$$

Increase *Pa* by 1 *dB* $$= \frac{2(-29) + (-42)}{3} = -33.33 \ dBm$$

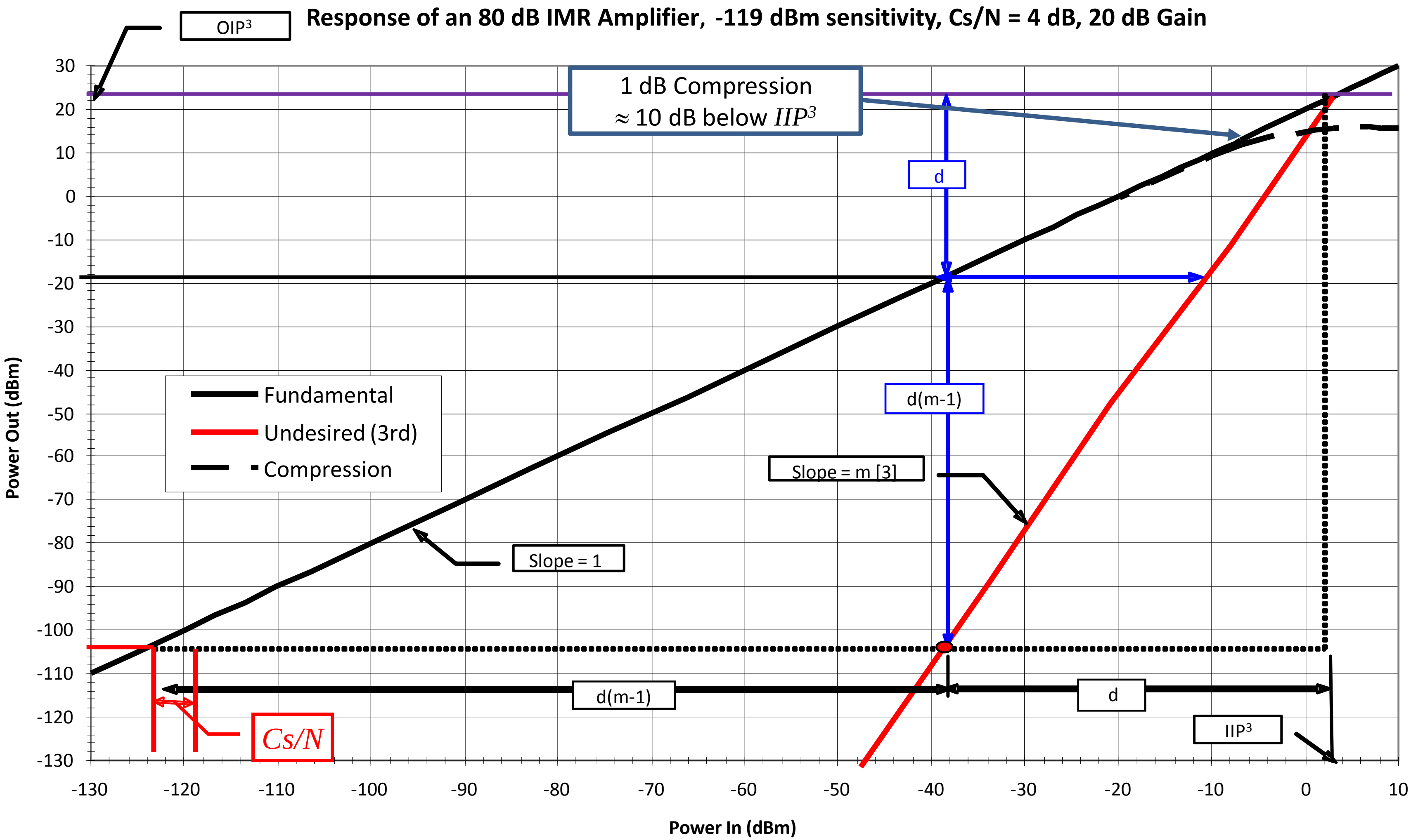
Increase *Pb* by 1 *dB* $$= \frac{2(-30) + (-41)}{3} = -33.67 \ dBm$$



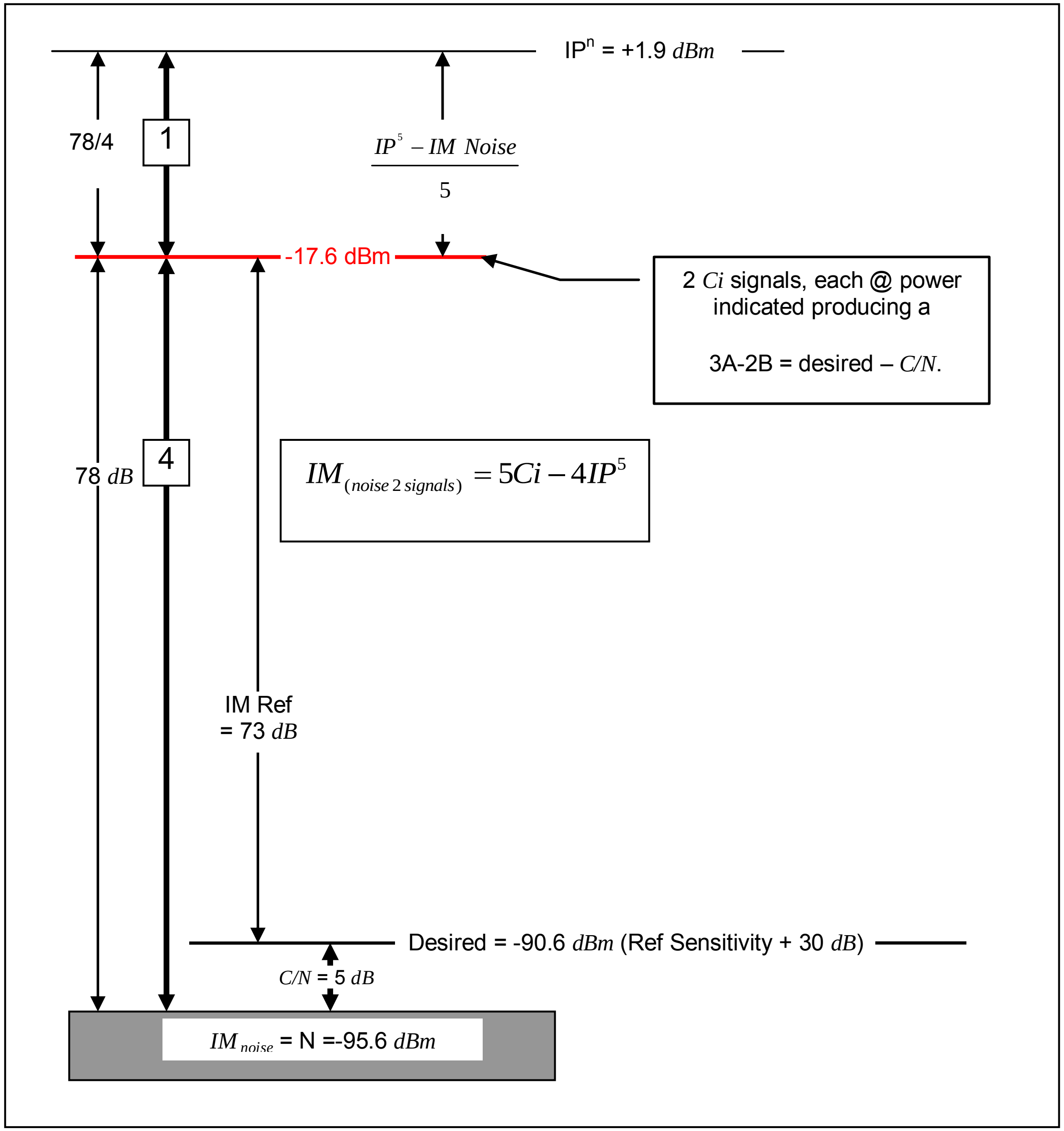
P_a is the stronger signal

$$Ci = \frac{2(Pa) + Pb}{3}$$

Example
Traditional IM Chart Analog FM Wide Band



5th Order example



- Due to measurement and phase noise considerations this is done at 30 dB above reference sensitivity
- The thermal noise floor is no longer a concern.
- IM Reference sensitivity = -90.6 dBm
- Add 4/5 dB per dB above reference sensitivity = 24 dB
- 73 + 24 = 97 dB IMR

Effective Noise Figure

Friis equation

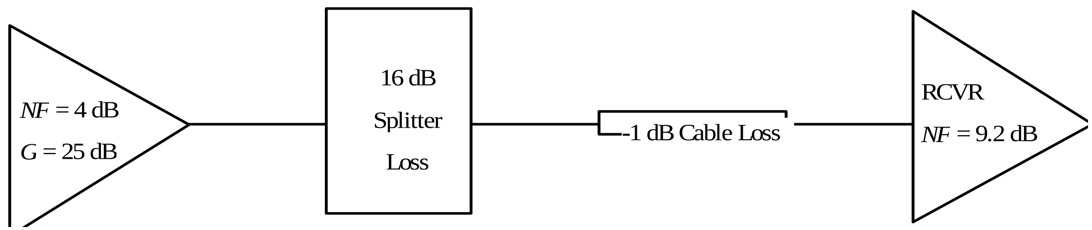
$$NF_C = NF_1 + \sum_{i=2}^{n} \frac{NF_{i-1}}{\prod_{j=1}^{i-1} G_j}$$

convert dB to Numeric

$N=10^{dB/10}$

convert Numeric to dB

dB=10*Log (N)



$NF_1 =$ 4 dB = 2.51 $G1 =$ 25 dB = 316

$NF_2 =$ 17 dB = 50 $G2 =$ -17 dB = 0.02

$NF_3 =$ 9.2 dB = 8.32

$$NFc = 2.51 + \frac{(50-1)}{316} + \frac{(8.32-1)}{(316)(0.02)}$$

$$NFc = 2.51 + 0.16 + 1.16 = 3.83 = 5.83 \text{ dB}$$

NF_{imp} = 9.2 - 5.83 = 3.37 dB

$$NF_C = NF_1 + [NF_2 - 1]/G_1 + [NF_3 - 1]/[G_1 \bullet G_2]$$

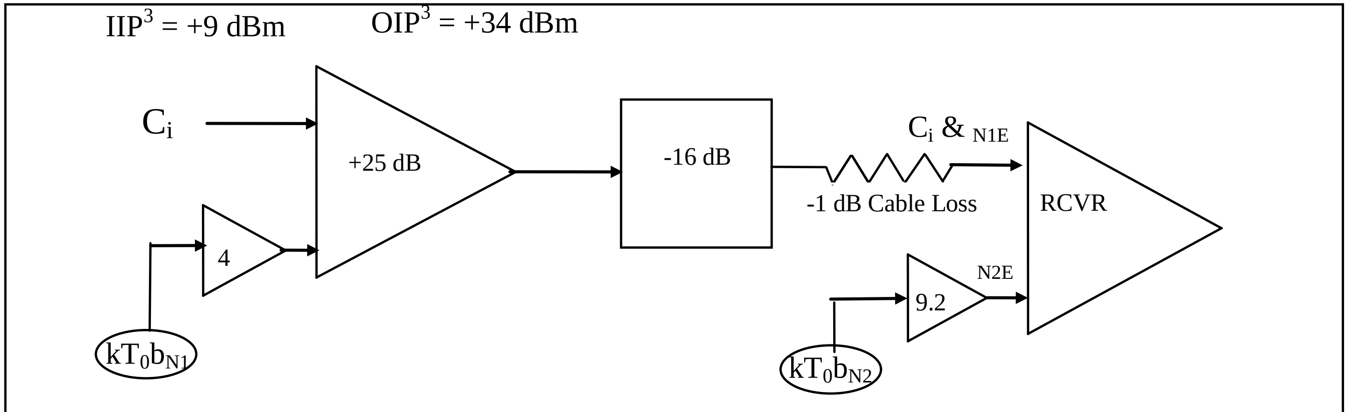
Multiple steps involved

- Convert noise figure to noise factor
  - Confusing as they both abbreviate the same
- Convert dB gain to numeric Gain
- Create the sequences
- Only calculates the noise figure, no IM.
- Works well but there are alternative methods

Symbolic Method

- Advantages
  - Logical following signal flow in dB or dBm
  - Allows IM effect to be calculated along entire chain
  - Allows external noise to be added or estimated based on measurements
- Disadvantages
  - Requires adding dB values (complex) multiple times

Same example using symbolic method



N1E = -133.2
+4.0
+25.0
-17.0
-121.2 dBm

N2E = -133.2
+9.2
-124.0 dBm

IIP^3 = +3.5 dBm
12 dBS = -119 dBm
ENBW = 12 kHz
C_s/N @ 12 dBS = 5 dB
NF_{dB} = 9.2 dB
***kT₀b* = -133.2 dBm**

$$\Sigma(N1E + N2E) = -119.37 dBm$$

$$Ci = -119.37 - 1 - 16 + 25 = -127.37 dBm$$

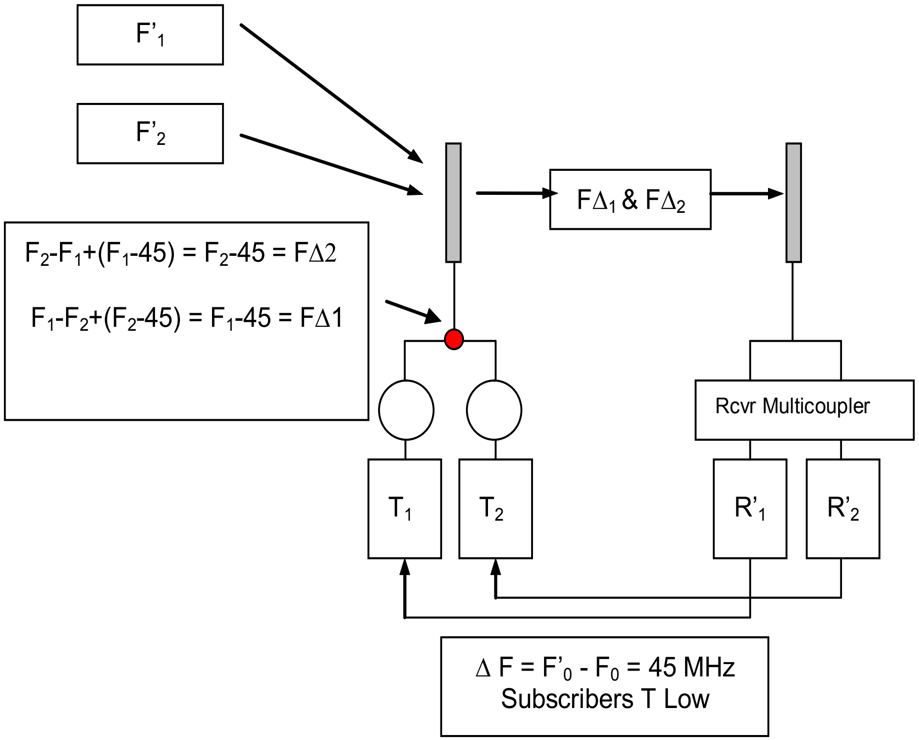
For a 5 dB C/N, $Ci = -122.37 dBm$

Performance Improvement = -119/0-(-122.37)=3.37 dB

Noise Temperature Method

- Advantages
  - Used by some consultants
  - Allows external noise to be calculated
  - Once the conversions are made the math is essentially division
- Disadvantages
  - Doesn’t address IM
  - Still requires all the conversions

IM Lockup



- Originally seen at UHF with station at a Police HQ.
- When two strong mobile signals were present their IM signals satisfy both receive frequencies
- When one de-keyed the delayed dropout kept the IM present until the 2nd one de-keyed.
- Cross talk occurred during this period

This type problem is a common occurrence on systems using receiver multi-couplers with large reserve gain, wide pre-selectors and receiving strong signals from mobiles or control stations in close proximity . Eliminate delayed dropout or use transmission trunking for trunked systems to minimize this problem.

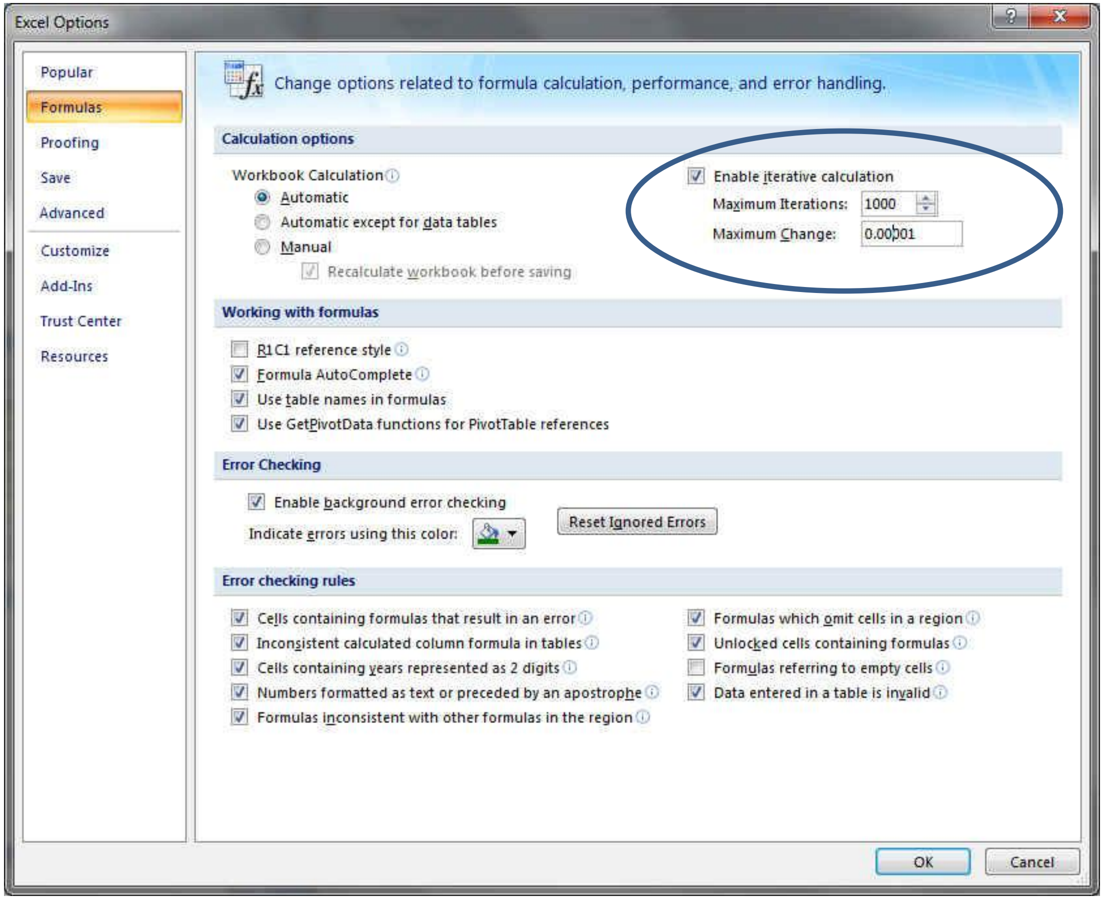
Control Station Example

Free Space Loss Calculator			
Frequency (MHz)	799		
Xmtr Power	12 W	40.8 dBm	
Antenna gain at source	6.0dBd		
Antenna gain at site	10.0dBd		
Total Power (dBm)	56.79 dBm		
Distance in Miles	1		
Loss	90.25 dB		
Signal at output of ant	-33.46 dBm		

- Problem is frequently caused by control stations in close proximity to the site.
- Mobiles in close proximity are also problematic.
- Interferers don't necessarily have be using that site.
  - Common problem with our terrain with high sites and multiple sites along a ridge.

Control stations should use only the power necessary for reliable communications. Hitting the site at greater than -55 dBm isn't necessary for system performance or reliability

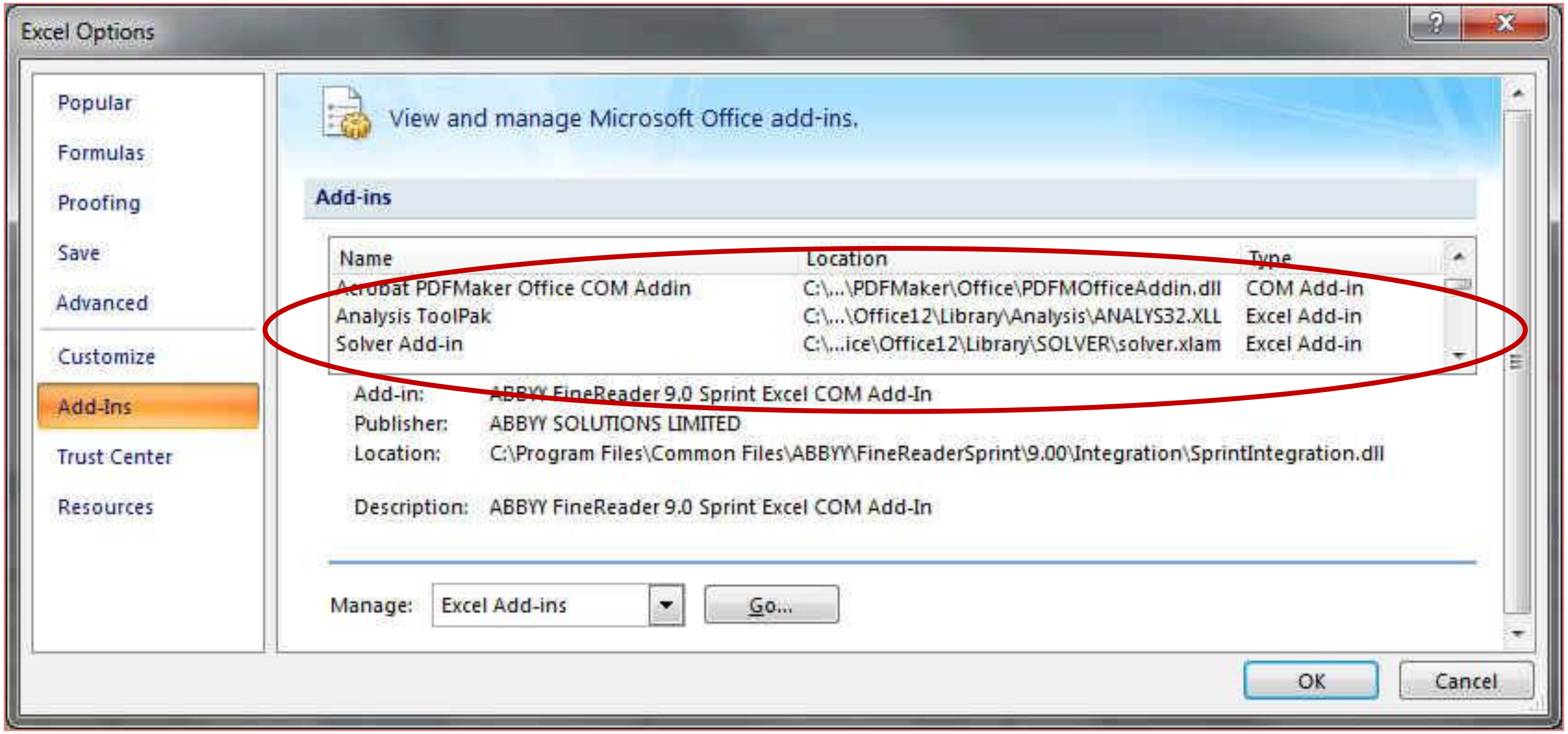
Excel Tools, Goal Seek Iterations



- Goal seek iterates your spreadsheet to achieve a value for a specific cell. The precision should be better than the normal Excel default values.
- For the multicoupler sheet this process is how you model a receiver multicoupler or TTA-MCPLR.
- Data, “What If”

Set Cell
To Value
By Changing Cell

Add-Ins for Goal Seek & Solver



GTR8000 Configuration, 2 or more 6 packs
Default Attenuator values
1 dB & 10 dB

	@ ant base	Jump 1	Filter 1	spec	AMP 1	Amp out	cable 1	Attn	Splitter-Line	spec	AMP 2	Amp out	Split/attn	Cable	Input to Base Rcvr	Rec
Value --->	-124.4 dBm	0.0 dB	1.0 dB	NF	1.80 dB		0.2 dB	1.0 dB	8.5 dB	NF	1.8 dB		18.0 dB	1.0 dB	ENBW	5.8 kHz
GTR8000 Calculator				Gain	21.0 dB					Gain	21.0 dB	split	8.0 dB		NF	10.77 dB
To eliminate source,				IIP3	14.0dBm				9.7 dB	IIP3	14.0dBm	att	10 dB		Cs/N Ref	7.60 dB
enter -999				OIP3	35.0dBm		gain	11.3 dB	25.3dBm	OIP3	35.0dBm			17.0dBm	Cf/N for CPC	15.20 dB
Only Blue numbers should be changed			30	Directional Coupler Loss (dB)											Ref Sens	-118.00 dBm
Values estimated from manual			0.5	Cable loss to Test port									Filter IM1	0.0 dB	kTB	-136.37 dBm
			30.5										Filter IM2	0.0 dB	IM spec	85.00 dB
			-94.9	Input(dBm) for Desired at output to Filter1											Noise Floor	-125.60 dBm
			-93.9	Input(dBm) for Desired at output of antenna								OIP3	17.0dBm		Calc IIP3	13.30 dBm
Desired >>>	-124.37 dBm	-124.37	-125.4	SRMU		-104.4	-104.6	-105.6	-114.1	CRMU		-93.1	-111.1	-112.1		-112.07 dBm
Strongest IM	-999.0 dBm	-999	-1000			-979	-979.2	-980.2	-988.7			-967.7	-985.7	-986.7		
Weaker IM	-999.0 dBm	-999	-1000			-979	-979.2	-980.2	-988.7			-967.7	-985.7	-986.7		
Eq IM Signal Level			-1000						-988.7					-986.7		
IM 1 Noise Eq						-3007	-3007.2	-3008.2	-3016.7			-2995.7	-3013.7	-3014.7	IM 1 Noise Eq	-3014.7
IM 2 Noise Eq												-2973.1	-2991.1	-2992.1	IM 2 Noise Eq	-2992.1
IM 3 Noise Eq															IM 3 Noise Eq	-2986.7
External Noise	-999.0 dBm	-999	-1000.0			-979	-979.2	-980.2	-988.7			-967.7	-985.7	-986.7	External Noise (dBm)	-986.7
kTB (dBm)	-136.37 dBm			-136.37						-136.37				-136.37		
Noise 1 (dBm)				-134.57		-113.6	-113.8	-114.8	-123.3			-102.3	-120.3	-121.27	Noise 1 (dBm)	-121.27
Noise 2 (dBm)										-134.57		-113.57	-131.57	-132.57	Noise 2 (dBm)	-132.57
Noise 3 (dBm)														-125.60	Noise 3 (dBm)	-125.60
Sum Noise						4.4E-12						6.4E-11	1.0E-12		Sum Noise (Pwr)	1.1E-12
Sum of Noises (dBm)						-113.57						-101.96	-119.96		Sum of Noises (dBm)	-119.67
Cs/N	7.60 dB					9.19						8.88	8.88		**Cs/N**	7.60
Margin for CPC Cf/N	-7.60 dB		Configuration spec			-6.01						-6.32				-7.60
Reserve Gain	12.30 dB	⇦	13.0 dB			20.00						31.30	13.30			
Base only NF	10.77 dB															
Equivalent NF	4.39 dB	⇦	4.7 dB	0.3 dB		2.80						3.11				4.39
Improvement	6.37 dB															
				Site RMC	Gain	**11.3 dB**					**Cabinet RMC**	Gain	**3.0 dB**		**Receiver**	
					OIP3	**25.3dBm**						OIP3	**17.0dBm**			

RMC Attenuator Settings

The required attenuation dB values are also displayed on the Receive Multicoupler (RMC) Configuration tab in Configuration/Service Software (CSS), which must be used to set up system gain according to your GTR 8000 Expandable Site Subsystem configuration.

Table 4-2 RMC Attenuator Settings for Site with Two or More Cabinets (700/800/900 MHz)

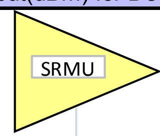
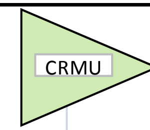
System Noise Figure (dB)	System Input Intercept (dBm)	RFDS Gain (dB)	Site RMC Attenuator Setting (dB)	Cabinet RMC Attenuator Setting (dB)	
3.4	–6.5	24	0	0	
4.1	0.9	16	1	7	
4.7*	3.4	13	1	10	Initial
5.0	4.4	12	2	10	
6.0	6.3	10	4	10	
7.1	8.2	8	6	10	First Attempt
8.0	9.3	7	8	9	Second Attempt
9.2	11.0	5	9	10	
10.0	11.9	4	10	10	
10.9	12.7	3	11	10	
12.0	13.7	2	13	9	
12.9	14.5	1	14	9	
13.8	15.2	0	15	9	

Cabinet RMC Settings must be the same in each cabinet. These settings provide maximum possible system dynamic range.

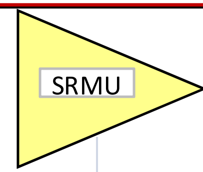
* = Default: Recommended setting as shipped from the factory.

Estimate of GTR8000

Used only as an example to show tradeoffs

	@ ant base	Jump 1	Filter 1	spec	AMP 1	Amp out	cable 1	Attn	Splitter-Line	spec	AMP 2	Amp out	Split/attn	Cable
Value --->	-124.4 dBm	**0.0 dB**	**1.0 dB**	NF	**1.80 dB**		**0.2 dB**	**1.0 dB**	**8.5 dB**	NF	**1.8 dB**		**18.0 dB**	**1.0 dB**
GTR8000 Calculator				Gain	**21.0 dB**					Gain	**21.0 dB**	split	**8.0 dB**	
To eliminate source,				IIP3	**14.0dBm**				9.7 dB	IIP3	**14.0dBm**	att	**10 dB**	
enter -999				OIP3	**35.0dBm**		gain	11.3 dB	**25.3dBm**	OIP3	**35.0dBm**			**17.0dBm**
Only Blue numbers should be changed			**30**	Directional Coupler Loss (dB)										
Values estimated from manual			**0.5**	Cable loss to Test port									Filter IM1	0.0 dB
			30.5										Filter IM2	0.0 dB
			-94.9	Input(dBm) for Desired at output to Filter1										
			-93.9	Input(dBm) for Desired at output of antenna								OIP3	17.0dBm	
Desired >>>	**-124.37 dBm**	-124.37	-125.4			-104.4	-104.6	-105.6	-114.1			-93.1	-111.1	-112.1
Strongest IM	**-999.0 dBm**	-999	-1000			-979	-979.2	-980.2	-988.7			-967.7	-985.7	-986.7
Weaker IM	**-999.0 dBm**	-999	-1000			-979	-979.2	-980.2	-988.7			-967.7	-985.7	-986.7
Eq IM Signal Level			-1000						-988.7					-986.7
IM 1 Noise Eq						-3007	-3007.2	-3008.2	-3016.7			-2995.7	-3013.7	-3014.7
IM 2 Noise Eq												-2973.1	-2991.1	-2992.1
IM 3 Noise Eq														
External Noise	**-999.0 dBm**	-999	-1000.0			-979	-979.2	-980.2	-988.7			-967.7	-985.7	-986.7
kTB (dBm)	-136.37 dBm			-136.37						-136.37				-136.37
Noise 1 (dBm)				-134.57		-113.6	-113.8	-114.8	-123.3			-102.3	-120.3	-121.27
Noise 2 (dBm)										-134.57		-113.57	-131.57	-132.57
Noise 3 (dBm)														-125.60
Sum Noise						4.4E-12						6.4E-11	1.0E-12	
Sum of Noises (dBm)						-113.57						-101.96	-119.96	
Cs/N	**7.60 dB**					9.19						8.88	8.88	
Margin for CPC Cf/N	**-7.60 dB**		Configuration spec			-6.01						-6.32		
Reserve Gain	**12.30 dB**		**13.0 dB**			20.00						31.30	13.30	
Base only NF	**10.77 dB**													
Equivalent NF	**4.39 dB**		**4.7 dB**	0.3 dB		**2.80**						**3.11**		
Improvement	**6.37 dB**													

Desense due to -35 dBm Interferers



Desired >>>	**-98.28 dBm**	-98.283	-99.3		
Strongest IM	**-35.0 dBm**	-35	-36		
Weaker IM	**-35.0 dBm**	-35	-36		
Eq IM Signal Level			-36		
IM 1 Noise Eq					
IM 2 Noise Eq					
IM 3 Noise Eq					
External Noise	**-999.0 dBm**	-999	-1000.0		
kTB (dBm)	-136.37 dBm			-136.37	
Noise 1 (dBm)				-134.57	
Noise 2 (dBm)					
Noise 3 (dBm)					
Sum Noise					
Sum of Noises (dBm)					
Cs/N	**7.60 dB**				
Margin for CPC Cf/N	**-7.60 dB**		Configuration spec		
Reserve Gain	**12.30 dB**		**13.0 dB**		
Base only NF	**10.77 dB**				
Equivalent NF	**30.48 dB**		**4.7 dB**	-25.8 dB	
Improvement	**-19.72 dB**				

-98.3 dBm - (-124.4 dBm)
= **26.1 dB** Desense

What can you do?

1. Reduce the interfering signal power
2. Reduce the Reserve Gain to reduce sensitivity and reduce the desense.
3. A combination of both if possible.

Tradeoffs: Some loss of reference sensitivity vs. Reduction in Desensitization

First Attempt.

Overall protection against -35 dBm Interfering signals.

Increase the SRMC 1 dB attenuation to 6 dB

This essentially increases the Noise Figure

Value --->	-122.2 dBm	0.0 dB	1.0 dB	NF	1.80 dB		0.2 dB	6.0 dB	8.5 dB
GTR8000 Calculator				Gain	21.0 dB				
To eliminate source,				IIP3	14.0dBm				14.7 dB
enter -999				OIP3	35.0dBm		gain	6.3 dB	20.3dBm
Only Blue numbers should be changed			30	Directional Coupler Loss (dB)					
Values estimated from manual			0.5	Cable loss to Test port					
			30.5						
			-92.7	Input(dBm) for Desired at output to Filter1					
			-91.7	Input(dBm) for Desired at output of antenna					
Desired >>>	-122.16 dBm	-122.16	-123.2	SRMU		-102.2	-102.4	-108.4	-116.9
Strongest IM	-999.0 dBm	-999	-1000			-979	-979.2	-985.2	-993.7
Weaker IM	-999.0 dBm	-999	-1000			-979	-979.2	-985.2	-993.7
Eq IM Signal Level			-1000						-993.7
IM 1 Noise Eq						-3007	-3007.2	-3013.2	-3021.7
IM 2 Noise Eq									
IM 3 Noise Eq									
External Noise	-999.0 dBm	-999	-1000.0			-979	-979.2	-985.2	-993.7
kTB (dBm)	-136.37 dBm			-136.37					
Noise 1 (dBm)				-134.57		-113.6	-113.8	-119.8	-128.3
Noise 2 (dBm)									
Noise 3 (dBm)									
Sum Noise						4.4E-12			
Sum of Noises (dBm)						-113.57			
Cs/N	7.60 dB					11.40			
Margin for CPC Cf/N	-7.60 dB		Configuration spec			-3.80			
Reserve Gain	7.30 dB		13.0 dB			20.00			
Base only NF	10.77 dB								
Equivalent NF	6.60 dB		4.7 dB	-1.9 dB		2.80			
Improvement	4.16 dB								

Value --->	-108.1 dBm	0.0 dB	1.0 dB	NF	1.80 dB		0.2 dB	6.0 dB	8.5 dB
GTR8000 Calculator				Gain	21.0 dB				
To eliminate source,				IIP3	14.0dBm				14.7 dB
enter -999				OIP3	35.0dBm		gain	6.3 dB	20.3dBm
Only Blue numbers should be changed			30	Directional Coupler Loss (dB)					
Values estimated from manual			0.5	Cable loss to Test port					
			30.5						
			-78.6	Input(dBm) for Desired at output to Filter1					
			-77.6	Input(dBm) for Desired at output of antenna					
Desired >>>	-108.07 dBm	-108.07	-109.1	SRMU		-88.1	-88.3	-94.3	-102.8
Strongest IM	-35.0 dBm	-35	-36			-15	-15.2	-21.2	-29.7
Weaker IM	-35.0 dBm	-35	-36			-15	-15.2	-21.2	-29.7
Eq IM Signal Level			-36						-29.7
IM 1 Noise Eq						-115	-115.2	-121.2	-129.7
IM 2 Noise Eq									
IM 3 Noise Eq									
External Noise	-999.0 dBm	-999	-1000.0			-979	-979.2	-985.2	-993.7
kTB (dBm)	-136.37 dBm			-136.37					
Noise 1 (dBm)				-134.57		-113.6	-113.8	-119.8	-128.3
Noise 2 (dBm)									
Noise 3 (dBm)									
Sum Noise						7.6E-12			
Sum of Noises (dBm)						-111.21			
Cs/N	7.60 dB					23.14			
Margin for CPC Cf/N	-7.60 dB		Configuration spec			7.94			
Reserve Gain	7.30 dB		13.0 dB			20.00			
Base only NF	10.77 dB								
Equivalent NF	20.69 dB		4.7 dB	-16.0 dB		5.15			
Improvement	-9.93 dB								

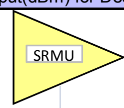
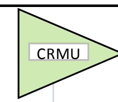
Loss of sensitivity = -122.16 dBm - (-124.37) = 2.2 dB

Desense = -108.07 dBm-(-122.16 dBm) = 14.1 dB

Comparison of desense = 26.1 – 14.1 = 12 dB reduction

Second attempt

Reduce sensitivity and allow -40 dBm Interferers

	@ ant base	Jump 1	Filter 1	spec	AMP 1	Amp out	cable 1	Attn	Splitter-Line	spec	AMP 2	Amp out	Split/attn
Value --->	-121.4 dBm	0.0 dB	1.0 dB	NF	1.80 dB		0.2 dB	8.0 dB	8.5 dB	NF	1.8 dB		17.0 dB
GTR8000 Calculator				Gain	21.0 dB					Gain	21.0 dB	split	8.0 dB
To eliminate source,				IIP3	14.0dBm				16.7 dB	IIP3	14.0dBm	att	9 dB
enter -999				OIP3	35.0dBm		gain	4.3 dB	18.3dBm	OIP3	35.0dBm		
Only Blue numbers should be changed			30	Directional Coupler Loss (dB)									
Values estimated from manual			0.5	Cable loss to Test port									Filter IM1
			30.5										Filter IM2
			-91.9	Input(dBm) for Desired at output to Filter1									
			-90.9	Input(dBm) for Desired at output of antenna								OIP3	18.0dBm
Desired >>>	**-121.43 dBm**	-121.43	-122.4			-101.4	-101.6	-109.6	-118.1			-97.1	-114.1
Strongest IM	**-999.0 dBm**	-999	-1000			-979	-979.2	-987.2	-995.7			-974.7	-991.7
Weaker IM	**-999.0 dBm**	-999	-1000			-979	-979.2	-987.2	-995.7			-974.7	-991.7
Eq IM Signal Level			-1000						-995.7				
IM 1 Noise Eq						-3007	-3007.2	-3015.2	-3023.7			-3002.7	-3019.7
IM 2 Noise Eq												-2994.1	-3011.1
IM 3 Noise Eq													
External Noise	**-999.0 dBm**	-999	-1000.0			-979	-979.2	-987.2	-995.7			-974.7	-991.7
kTB (dBm)	-136.37 dBm			-136.37						-136.37			
Noise 1 (dBm)				-134.57		-113.6	-113.8	-121.8	-130.3			-109.3	-126.3
Noise 2 (dBm)										-134.57		-113.57	-130.57
Noise 3 (dBm)													
Sum Noise						4.4E-12						1.6E-11	3.2E-13
Sum of Noises (dBm)						-113.57						-107.89	-124.89
Cs/N	**7.60 dB**					12.13						10.76	10.76
Margin for CPC Cf/N	**-7.60 dB**		Configuration spec			-3.07						-4.44	
Reserve Gain	**6.30 dB**		**13.0 dB**			20.00						24.30	7.30
Base only NF	**10.77 dB**												
Equivalent NF	**7.33 dB**		**4.7 dB**	-2.6 dB		**2.80**						**4.17**	
Improvement	**3.43 dB**												

Desired >>>	**-120.02 dBm**
Strongest IM	**-40.0 dBm**
Weaker IM	**-40.0 dBm**
Eq IM Signal Level	
IM 1 Noise Eq	
IM 2 Noise Eq	
IM 3 Noise Eq	
External Noise	**-999.0 dBm**
kTB (dBm)	-136.37 dBm
Noise 1 (dBm)	
Noise 2 (dBm)	
Noise 3 (dBm)	
Sum Noise	
Sum of Noises (dBm)	
Cs/N	**7.60 dB**
Margin for CPC Cf/N	**-7.60 dB**
Reserve Gain	**6.30 dB**
Base only NF	**10.77 dB**
Equivalent NF	**8.75 dB**
Improvement	**2.02 dB**

Increased SRMC attenuator from 6 to 8 dB, decreased CRMC from 10 to 9 dB

Loss of sensitivity from Initial case = -121.43 dBm - (-124.37) = 2.94 dB

Reduction in Desense = 98.28 dBm -(-121.43 dBm) = 23.15 dB

Desense for 2nd attempt = -120.02 dBm -(-121.43 dBm) = 1.41 dB

RMC Attenuator Settings

The required attenuation dB values are also displayed on the Receive Multicoupler (RMC) Configuration tab in Configuration/Service Software (CSS), which must be used to set up system gain according to your GTR 8000 Expandable Site Subsystem configuration.

Table 4-2 RMC Attenuator Settings for Site with Two or More Cabinets (700/800/900 MHz)

System Noise Figure (dB)	System Input Intercept (dBm)	RFDS Gain (dB)	Site RMC Attenuator Setting (dB)	Cabinet RMC Attenuator Setting (dB)	
3.4	–6.5	24	0	0	
4.1	0.9	16	1	7	
4.7*	3.4	13	1	10	Initial
5.0	4.4	12	2	10	
6.0	6.3	10	4	10	
7.1	8.2	8	6	10	First Attempt
8.0	9.3	7	8	9	Second Attempt
9.2	11.0	5	9	10	
10.0	11.9	4	10	10	
10.9	12.7	3	11	10	
12.0	13.7	2	13	9	
12.9	14.5	1	14	9	
13.8	15.2	0	15	9	

Cabinet RMC Settings must be the same in each cabinet. These settings provide maximum possible system dynamic range.

* = Default: Recommended setting as shipped from the factory.

Tradeoff Summary

Tradeoffs	Sensitivity w/o IM	Desense w/ IM
Initial	-124.37 dBm	26.1 dB w/ -35 dBm
1st attempt	-122.16 dBm	14.1 dB w/ -35 dBm
2nd attempt	-121.43 dBm	1.41 dB w/ -40 dBm

Note: To allow -35 dBm, the sensitivity would have to be reduced to approximately -116 dBm and still have approximately 1 dB of desense.

Control on strong signal powers into multi-coupler systems necessitates careful control of inter system interfering power levels. Intra system interfering power levels are more problematic and are generally only controlled by everyone using best practice guidelines.

Interference to mobiles

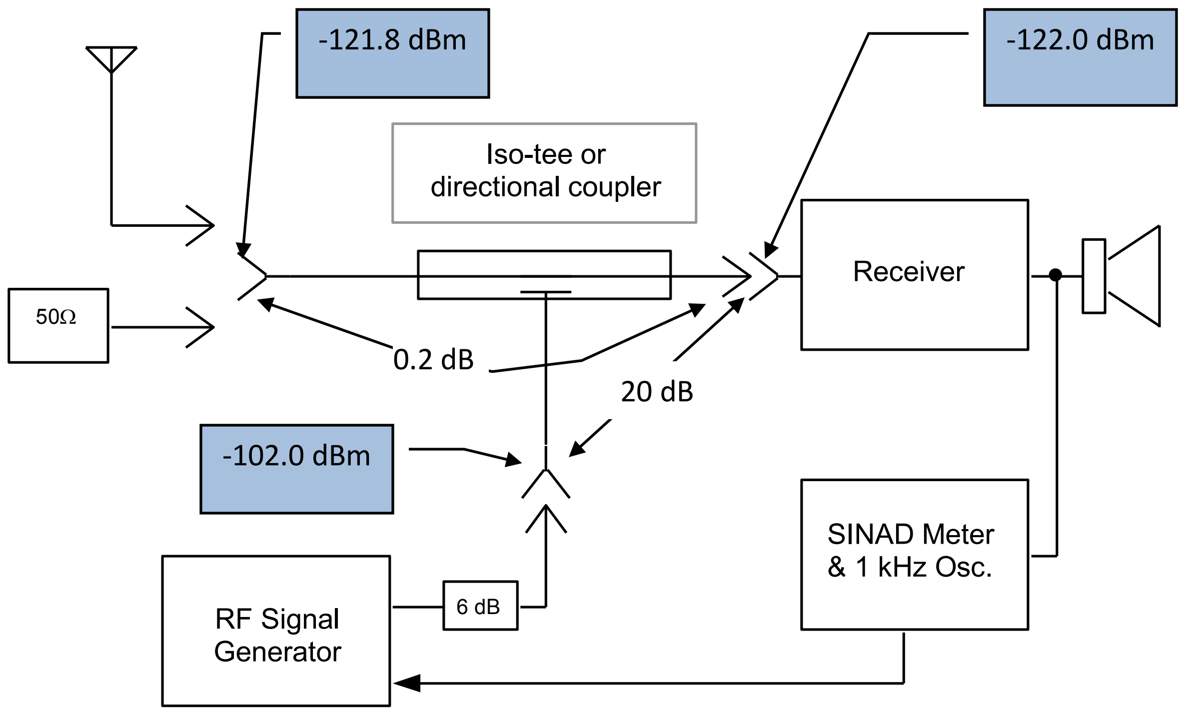
- Nextel Swiss Cheese effect
  - Near Far problem
- Cellular Systems Interference
  - Similar to Nextel cases
- White paper circa 2000 for solutions
  - Available on our web site

Interference Analysis Tool (Excel)

- Provided in release TSB-88.1-D
- Requires calibration of directional coupler
- Requires C/N for reference sensitivity (TSB-88)
- Determine power required of reestablish reference sensitivity with 2 dB steps of attenuation added
- Uses "Solver" to determine a least square curve fit to determine the power levels of the 1st, 3rd & 5th order power levels the receiver is receiving
  - Reduces the number of calculated IM combinations to consider.
- Originally developed to determine IM to mobile units from Nextel Sites
  - Useful for interference from cellular systems at 700/800 MHz.

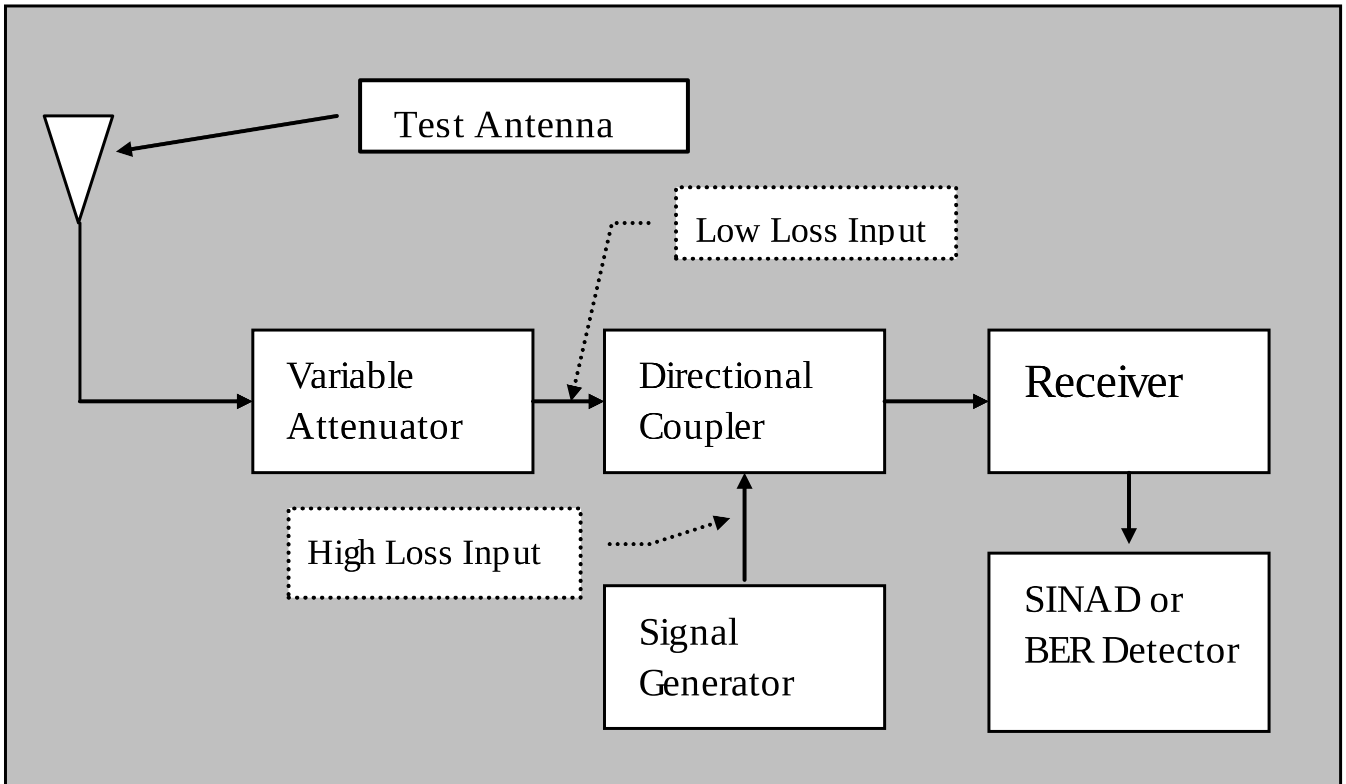
Calibrate Directional Coupler
Example is for NPSPAC analog case

		-122.0 dBm	Ref Direct
		-102.0 dBm	Ref SG Cplr
		-121.8 dBm	Ref Ant Cplr
C/N for Ref Sens	5.0 dB		
SG Coupler Loss:	20.0 dB	0.2 dB	Ant Cplr Loss

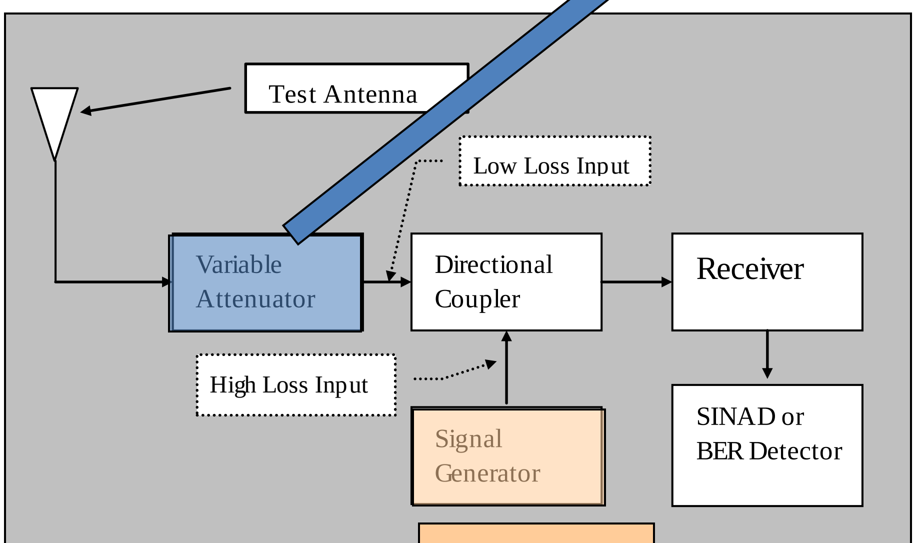


Calibrate Directional Coupler, add Attenuator

		-122.0 dBm	Ref Direct
		-102.0 dBm	Ref SG Cplr
		-121.8 dBm	Ref Ant Cplr
C/N for Ref Sens	5.0 dB		
SG Coupler Loss:	20.0 dB	0.2 dB	Ant Cplr Loss

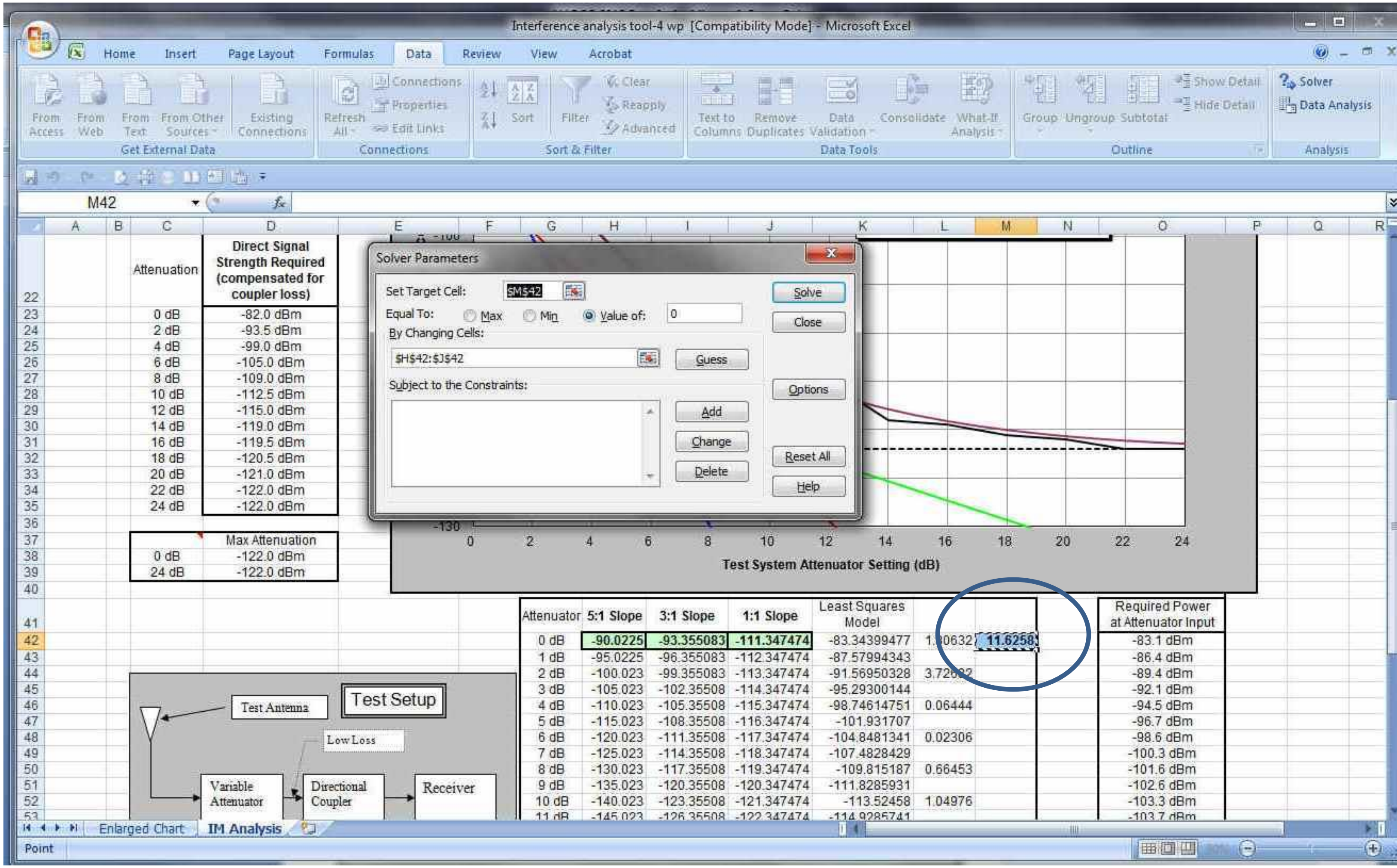


Measure Effect of Added Attenuation



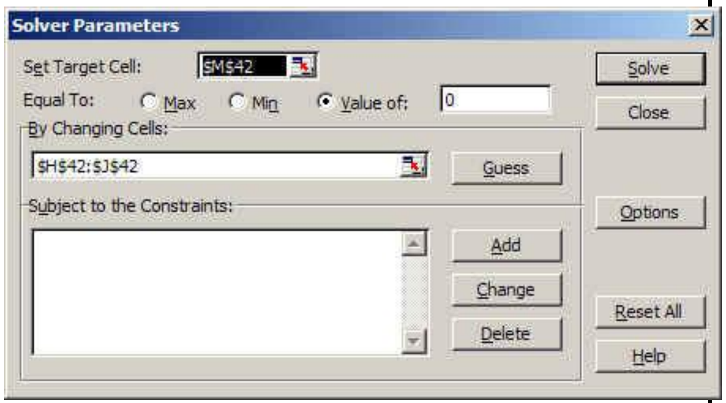
Attenuator Setting	Measured Value to re-achieve Reference Sensitivity
110 dB	-102.0 dBm
0 dB	-62.0 dBm
2 dB	-73.5 dBm
4 dB	-79.0 dBm
6 dB	-85.0 dBm
8 dB	-89.0 dBm
10 dB	-92.5 dBm
12 dB	-95.0 dBm
14 dB	-99.0 dBm
16 dB	-99.5 dBm
18 dB	-100.5 dBm
20 dB	-101.0 dBm
22 dB	-102.0 dBm
24 dB	-102.0 dBm

Excel Solver to determine signal power of the different IM powers



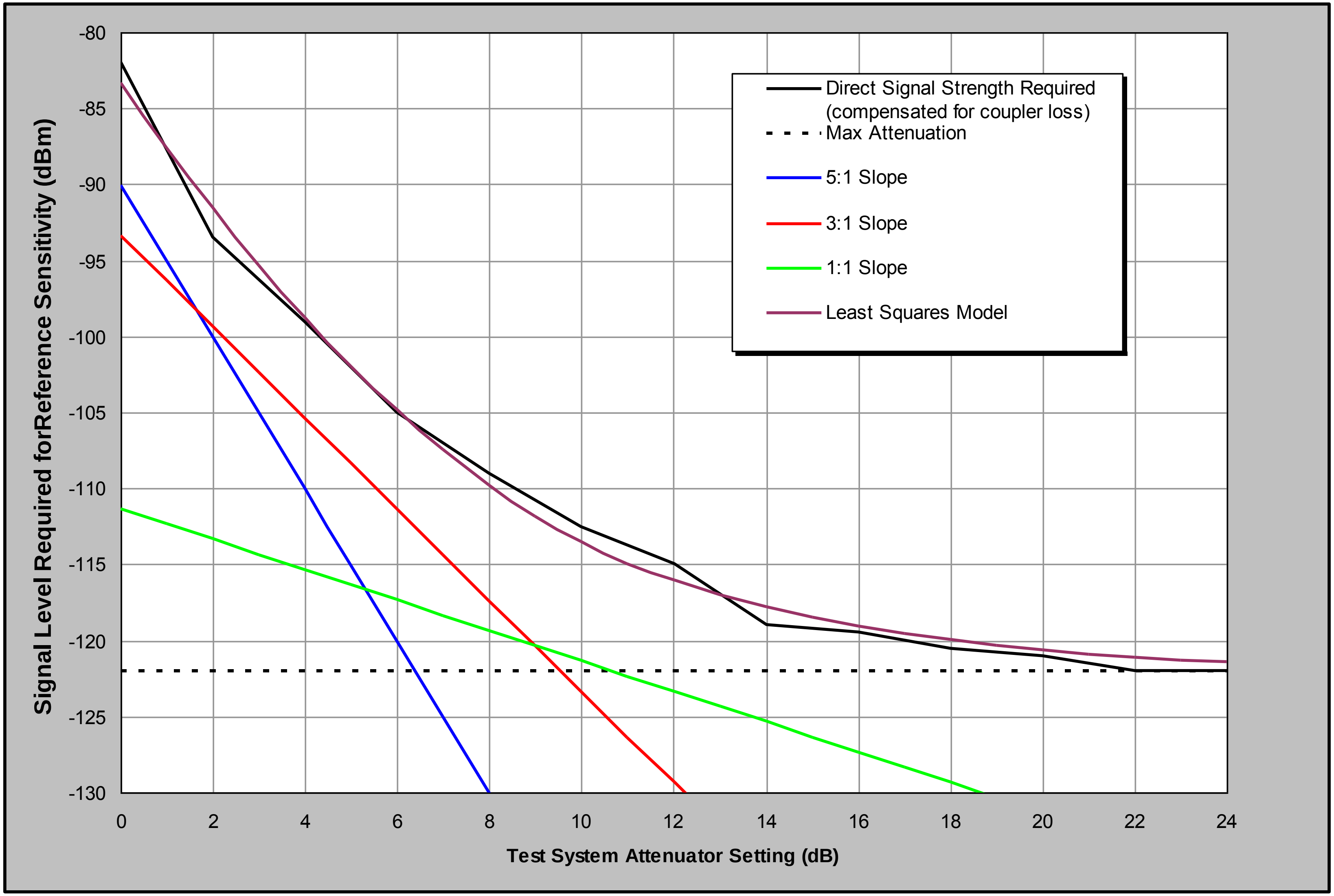
Least Square Curve Fit

Uses Excel "Solver" Function. One of the Add-ins



	H	I	J			M
Attenuator	**5:1 Slope**	**3:1 Slope**	**1:1 Slope**	Least Squares Model		
0 dB	**-90.02252**	**-93.35508349**	**-111.3474741**	-83.34399477	1.806322	**11.62577**
1 dB	-95.02252	-96.35508349	-112.3474741	-87.57994343		
2 dB	-100.0225	-99.35508349	-113.3474741	-91.56950328	3.726818	
3 dB	-105.0225	-102.3550835	-114.3474741	-95.29300144		
4 dB	-110.0225	-105.3550835	-115.3474741	-98.74614751	0.064441	
5 dB	-115.0225	-108.3550835	-116.3474741	-101.931707		
6 dB	-120.0225	-111.3550835	-117.3474741	-104.8481341	0.023063	
7 dB	-125.0225	-114.3550835	-118.3474741	-107.4828429		
8 dB	-130.0225	-117.3550835	-119.3474741	-109.815187	0.66453	
9 dB	-135.0225	-120.3550835	-120.3474741	-111.8285931		
10 dB	-140.0225	-123.3550835	-121.3474741	-113.52458	1.049764	
11 dB	-145.0225	-126.3550835	-122.3474741	-114.9285741		
12 dB	-150.0225	-129.3550835	-123.3474741	-116.0836216	1.174236	
13 dB	-155.0225	-132.3550835	-124.3474741	-117.0378725		
14 dB	-160.0225	-135.3550835	-125.3474741	-117.8343053	1.358844	
15 dB	-165.0225	-138.3550835	-126.3474741	-118.5062946		
16 dB	-170.0225	-141.3550835	-127.3474741	-119.0777865	0.178264	
17 dB	-175.0225	-144.3550835	-128.3474741	-119.5655196		
18 dB	-180.0225	-147.3550835	-129.3474741	-119.9814921	0.26885	
19 dB	-185.0225	-150.3550835	-130.3474741	-120.3348996		
20 dB	-190.0225	-153.3550835	-131.3474741	-120.633393	0.134401	
21 dB	-195.0225	-156.3550835	-132.3474741	-120.8837706		
22 dB	-200.0225	-159.3550835	-133.3474741	-121.0922866	0.823944	
23 dB	-205.0225	-162.3550835	-134.3474741	-121.2647384		
24 dB	-210.0225	-165.3550835	-135.3474741	-121.4064532	0.352298	

IM Results Graphic



What have we covered?

- How you can determine key IM specifications
  - IP^3
  - $1\ dB$ compression
- Symbolic method for evaluating
  - IM
  - Desense from strong signals and external noise
- How to tradeoff sensitivity for less desense in a multicoupler configuration
- How to make measurements to determine IM sources

What can you do proactively

- Use PIM antennas and components
- Keep area around antennas clear of “diodes”.
- Use quality components and keep them tightened.
- Control reserve gain of TTA and multi-couplers.
  - Last gain stages primarily to cover their own losses
- Control “control stations” on own system
- Best Practices guide “Technical Appendix to Best Practices guide circa 2000, v1.42a1
  - Available on our web site
- Best Practices TSB-88 series of documents

Are there any questions?

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