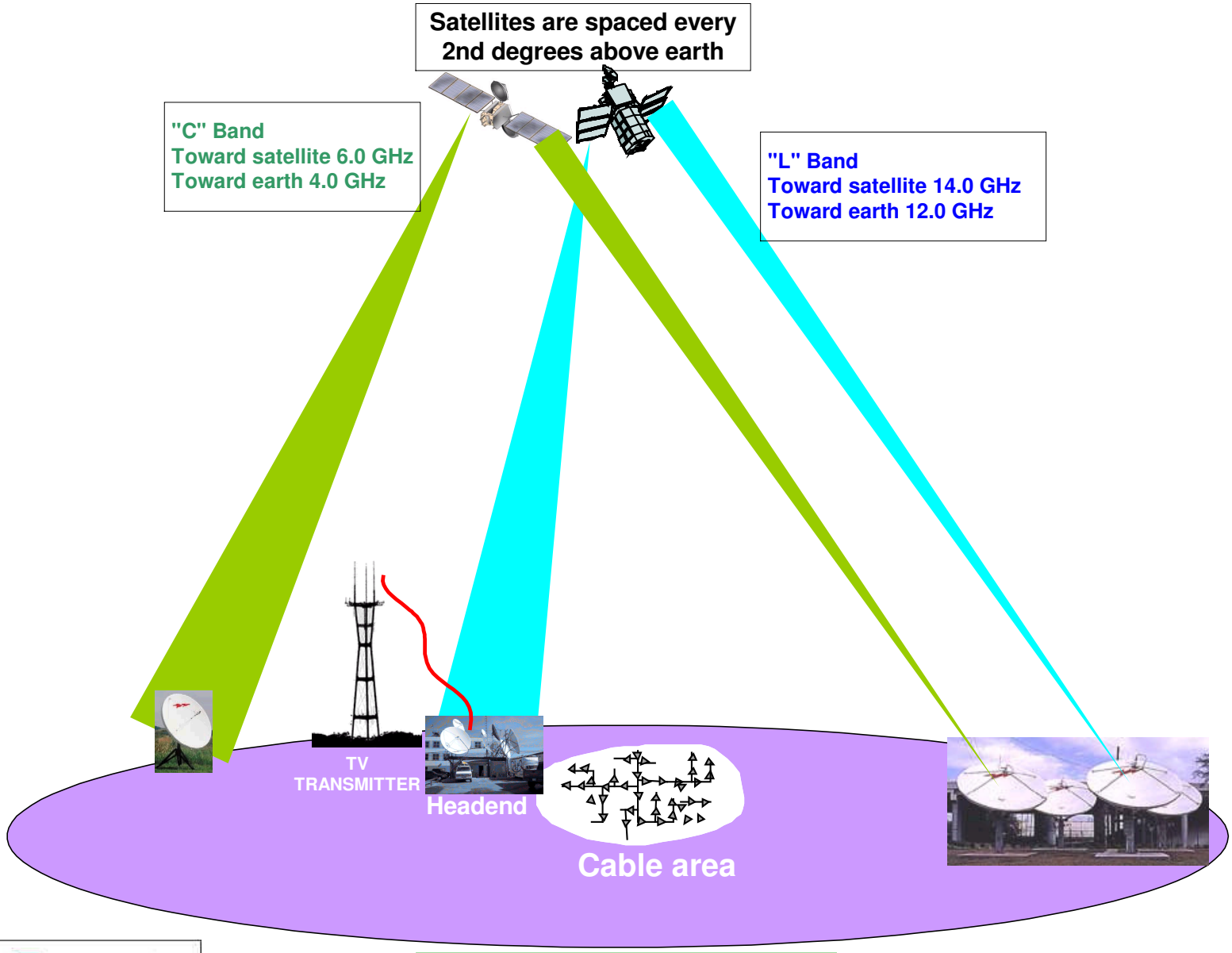
Broadband System - J



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HFC System Distortions

Distortions in a Broadband System.

In this section we will learn how to calculate the distortions in a Broadband System. This presentation will help understand, why the system performs better closer to the headend and get worst, toward the end of the system.

Distortions in a Broadband System.

Here are the distortions we will covering in this section;

- **Distortion of second order.**
- **Distortion of third order**
- **Cross modulation.**
- **Composite third order, CTB.**
- **Composite second order, CSO.**
- **Noise.**
- **Hum.**

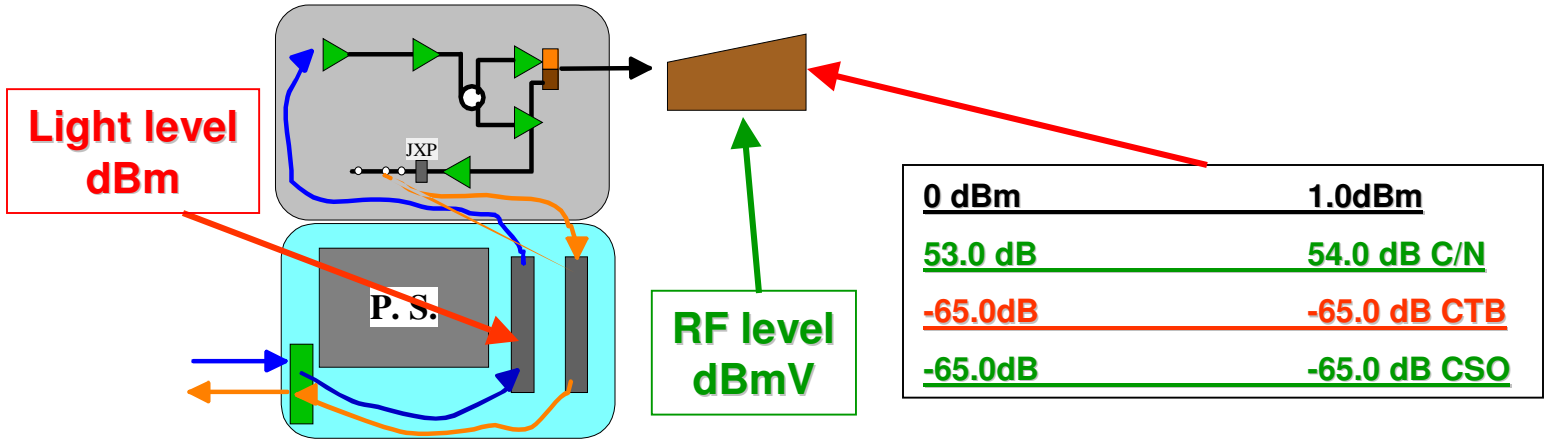
Distortions in a Broadband System.

Formulas for calculating distortions on a HFC, Broadband system, CATV.

Distortions in a Broadband System.

After you have decided the number of customers per NODE, you'll need to determinate at what level you system will operate. This is done by the following:

- **Determinate the optical level (light level) at the NODE, this will give you distortion level at the NODE.**
- **You then need to determinate the length of the coaxial system. (*how many amp. In cascade*)**
- **You will have to determinate the operating level of the amplifiers.**
- **Then you can calculate the distortion of each leg of the system.**



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Distortion in a Broadband System.

GENERAL SPECIFICATIONS	
Optical	
Optical wavelength	1310 (±20) to 1550 (±30) nm
Received optical input power range	–3 to +2 dBm
Optical input return loss	45 dB minimum
Receiver typical output level with 0 dBm receiver input power:	
77 channel load	25 dBmV
Station	
Output level	Standard 45 and High 53 dBmV minimum virtual output level at 870 MHz with –3 dBm optical power 4% OMI per channel
General	
AC input voltage	44 to 90 VAC sine or square
AC bypass current	15 A
Hum modulation	–65 dB @ 15 A bypass current
Operating temperature	–40 °C to +60 °C (–40 °F to +140 °F)
Housing dimensions	16.13" L x 9.80" W x 5.68" D (40.9 x 24.8 x 14.4 cm)
Weight	21 lbs. (9.5 kgs) maximum
RF	
Forward passband frequency	47 to 870 MHz dependant upon split
Return passband	5 to 65 MHz dependant upon split
Flatness	±0.50 dB $F_{minimum}$ to $F_{maximum}$
Return loss	16 dB
Output slope	6, 8, 10, 12.5, and 14 dB straight line slope
Performance	
0 dBm optical input power	
12.5 dB slope	
77 channel NTSC plus 300 MHz compressed data	
6 dB below analog channel level	870/550/55 MHz, 43/44/36.5 dBmV
Composite triple beat	65 dBc minimum
Composite second order	62 dBc minimum
Carrier to composite noise	50 dB minimum

Node attenuation used to achieve output level.

All features, functionality and other product specifications are subject to change without notice or obligation.

Attached are the technical specifications of a 870 MHz optical NODE

Noise Distortion in a Broadband System.

Noise distortion for one RF amplifier:

Formula is:

C-N ratio = Input signal (dBmV) + 59.2 – (Noise Figure of each amplifier).

It is always a good practice to add one (1) dB to the noise figure given by manufacture, due of the cable equalizer that will be installed at their input.

16 dBmV input

59.2 + 16 - (10+1)=64.2 dB C/N

10 dB Noise Figure

Remark:

59.2 dB is the thermal noise for: 4.2 MHz of bandwidth on a CATV amplifier.

Noise Distortion in a Broadband System.

MB87 Specifications

STARLINE®

2 Port, Parallel E-GaAs Hybrid

Enhanced Gallium Arsenide MiniBridger Amplifier

MB87S/XG+ Specifications

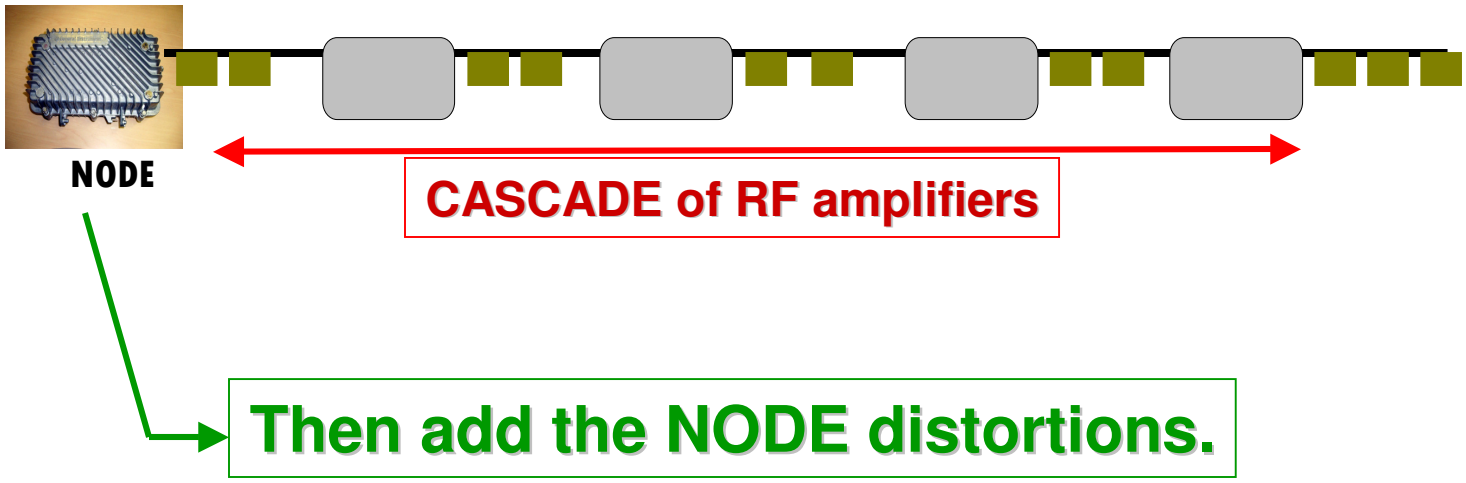
PARAMETER		UNITS	NOTE	FORWARD	RETURN RA-KIT-40H
Passband		MHz	1	50-870	5-40
Flatness		dB	2	±0.75	±0.50
Minimum Full Gain		dB	3	45	NA
Operational Gain		dB	4	40	33
Manual Gain Slope Control Range		dB	5	±5	NA
Interstage Equalizer Slope		dB	6	12 ±1	NA
Noise Figure 40/52/87/Stable		dB	7	NA / 12 / 10	9 / NA / NA
Reference Frequency		MHz	8	870 / 550 / 50	40
Output Level		dBmV		40 / 44 / 37	41 FLAT
Channel Loading		HTSC		79	4
Compressed Data Loading		MHz		222	NA
Distortion (max)	CTB	dBc	9,21,23	75	NA
	2M	dB	10,21	65	69
	CSO	dBc	9,11,21	71	NA
	CCN (+6)	dBc	13	54	NA
	STB	dBc	9	NA	39
	SSO	dBc	9	NA	39
Test Point (all)		dB	13	20 ±1.0	
Return Loss		dB	14	16	
Gain Stabilizer		dBc	15,20	20	
DC Voltage		VDC	16	+ 24.0 ±0.25	
Current DC		mA	17	1470	1610
DC Ripple		mV		15 P-P	
Power Consumption		W		44.9	48
AC Input Voltage Range		VAC		38 - 90	
AC Current Draw	@90 VAC	A	18	0.81	0.89
	@75 VAC	A		0.92	0.99
	@60 VAC	A		0.74	0.81
	@52 VAC	A		0.85	0.92
	@45 VAC	A		0.93	1.00
	@38 VAC	A		1.2	1.31
AC Bypass Current	All Ports	A	19	15	
Group Delay (max)			19		
	50.25 to 50.63 MHz	nSec		30	NA
	5.0 to 6.0 MHz	nSec		NA	45
	10.0 to 11.0 MHz	nSec		NA	19
	33.0 to 35.0 MHz	nSec		NA	12
	39.0 to 43.0 MHz	nSec		NA	35
Housing Dimensions				15.4"L x 6.8"W x 5.6"D	39.1cm x 16.97cm x 24.3 cm
Weight				15 Pounds	6.8 kg
Ambient Operating Temperature				-40° to +140° F	-40° to +60° C

Attached are the technical specifications of a 870 MHz RF amplifier

Distortion in a Broadband System.

All distortions.

You need to calculate the distortions of the CASCADE of the RF amplifiers and then married (add) these distortions to the Optical NODE, to get the actual system's distortions.



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Distortion in a Broadband System.

Carrier to Noise

For a cascade of amplifier, where all of the amplifiers operate at the same level (input and output)

$$C/N_s = C/N - \log_{10} N$$

The formula is:

N = Number of amplifier in the cascade.

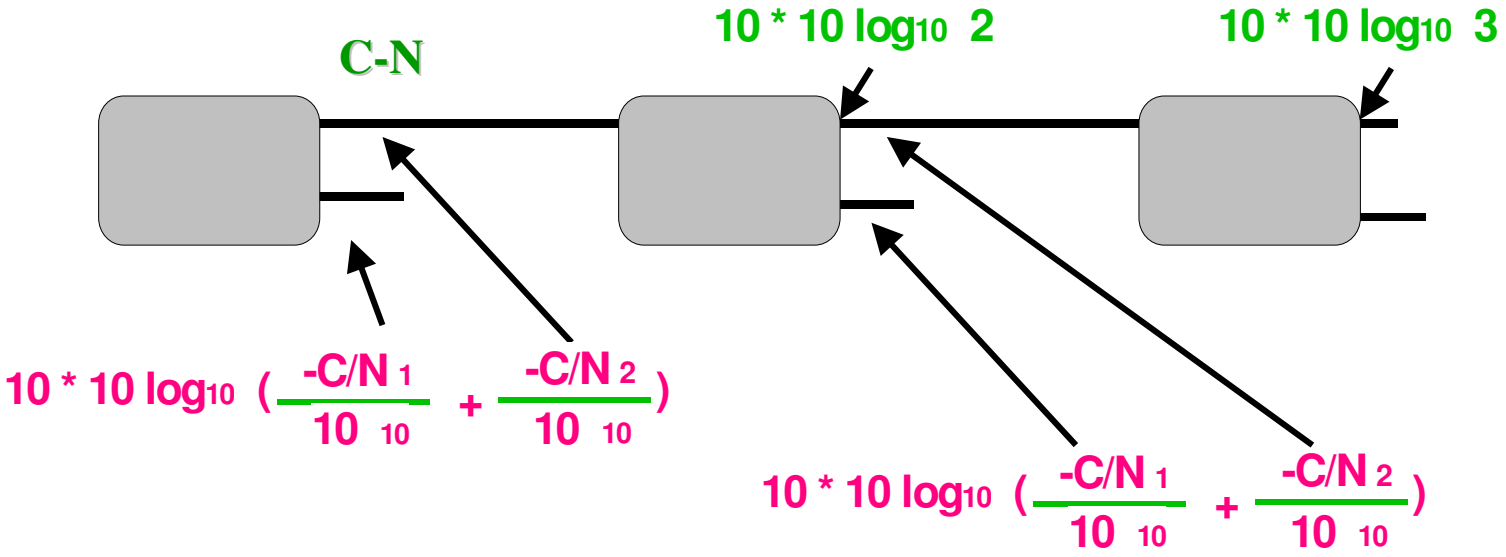
Formula for different operating level:

$$C/N_s = -10\log_{10}\left[10^{\frac{-C/N_1}{10}} + 10^{\frac{-C/N_2}{10}} + \ldots 10^{\frac{-C/N_n}{10}} \right]$$

Distortion in a Broadband System.

Carrier to Noise

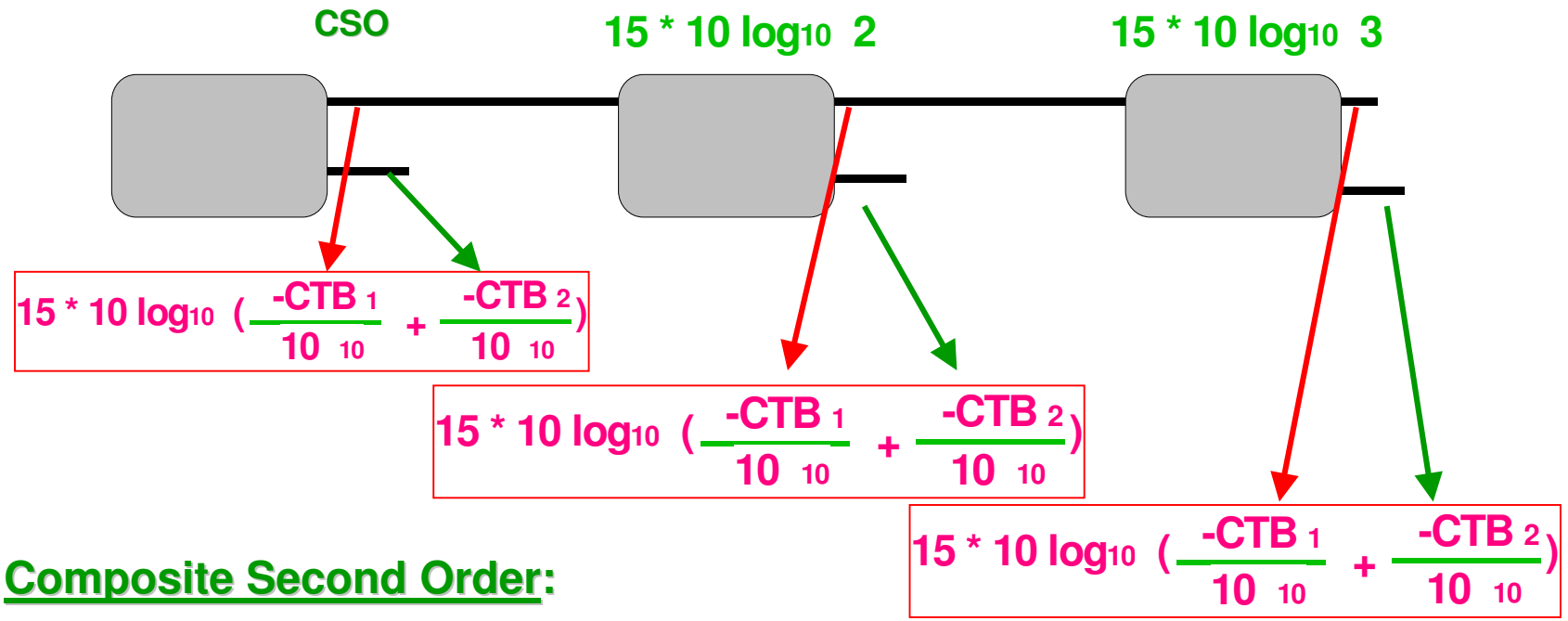
To sum differing Carrier to Noise ratios:



To do this calculation, things you need to know are; the distortion (Carrier to Noise or Noise figure) of each amplifier, their spacing at ***MHz and their operating level, so you'll know their input level.

Distortion in a Broadband System.

Carrier to CSO

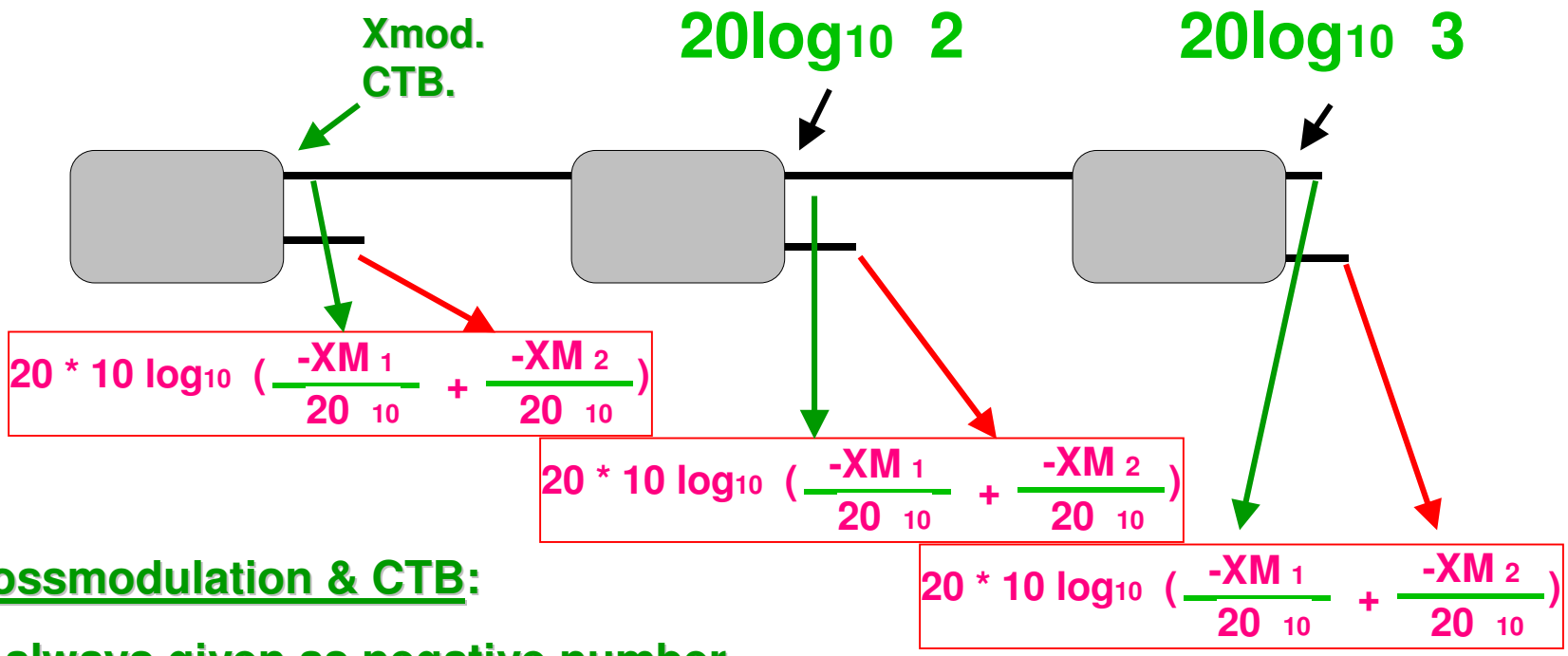


Composite Second Order:

- Is always given as negative number.
- For each 1 dB in change of output level, the change in CSO will be 1 dB.
- Each time we double the cascade, CSO distortion get worse by 3.01 dB.

Distortion in a Broadband System.

CTB & X-Modulation



Crossmodulation & CTB:

- Is always given as negative number.
- For each dB change in output level, the change in CTB and Xmod. is 2.0 dB.
- Each time we double the cascade, CTB and Xmod. get worse by 6.02 dB.

Distortion in a Broadband System.

CTB & XModulation

For a cascade of amplifiers, when they operates at the same output level, here is the formulas to calculate the CTB and Cross Modulation distortion.

The formula is:

$$\text{CTB's or Xmod's} - 20 \log_{10} N$$

N = Number of amplifier in the cascade.

Distortion in a Broadband System.

HUM

Hum can be measured in dB or in percentage (%). Since hum is often caused by a defective piece of equipment, HUM is usually not cascade distortion dependant. HUM is generally measured on a CW channel (channel without modulation).

If your HUM distortion is measured in dB, the formula below permits to transfer dB HUM to HUM percentage (%).

The formula below shows the calculation of a -60 dB HUM distortion to % HUM.

$$\% = \left(\frac{R}{R} \right) * 100$$
$$10 \quad 20$$

$$\% = \left(\frac{60}{} \right) * 100$$
$$10 \quad 20$$

$$\% = (10 \quad 3) * 100$$

$$\% = .001 \text{ X } 100 = 0.1\%$$

Distortion in a Broadband System.

All Distortions measurements.

Cascade (N)	10*log (N)	15*log (N)	20*log (N)
1	0.00	0.00	0.00
2	3.01	4.52	6.02
3	4.77	7.16	9.54
4	6.02	9.03	12.04
5	6.99	10.48	13.98
6	7.78	11.67	15.56
7	8.45	12.68	16.90
8	9.03	13.55	18.06
9	9.54	14.31	19.08
10	10.00	15.00	20.00
11	10.41	15.62	20.83
12	10.79	16.19	21.58
13	11.17	16.71	22.28
14	11.46	17.19	22.92

Distortions calculation for a series of amplifiers, when all amplifier have the same output level. This calculate C/N, CSO and CTB of a cascade of amplifiers.

At the 5th amplifier C/N will be: 6.99 dB, CSO will be: 10.48 dB and CTB will be: 13.98 dB worst than the first amplifier of the cascade,

Distortions in a Broadband System.

CTB, Xmod with different Operating Level.

dB	0.00	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90
0	6.02	5.97	5.92	5.87	5.82	5.77	5.73	5.68	5.63	5.58
1	5.53	5.49	5.44	5.39	5.35	5.30	5.26	5.21	5.17	5.12
2	5.08	5.03	4.99	4.95	4.90	4.86	4.82	4.78	4.73	4.69
3	4.65	4.61	4.57	4.53	4.49	4.45	4.41	4.37	4.33	4.29
4	4.25	4.21	4.17	4.13	4.10	4.06	4.02	3.98	3.95	3.91
5	3.88	3.84	3.80	3.77	3.73	3.70	3.66	3.63	3.60	3.56
6	3.53	3.50	3.46	3.43	3.40	3.36	3.33	3.30	3.27	3.24
7	3.21	3.18	3.15	3.12	3.09	3.06	3.03	3.00	2.97	2.94
8	2.91	2.88	2.85	2.83	2.80	2.77	2.74	2.72	2.69	2.66
9	2.64	2.61	2.59	2.56	2.53	2.51	2.48	2.46	2.44	2.41
10	2.39	2.36	2.34	2.32	2.29	2.27	2.25	2.22	2.20	2.18
11	2.16	2.13	2.11	2.09	2.07	2.05	2.03	2.01	1.99	1.97
12	1.95	1.93	1.91	1.89	1.87	1.85	1.83	1.81	1.79	1.77
13	1.75	1.74	1.72	1.70	1.68	1.67	1.65	1.63	1.61	1.60
14	1.58	1.56	1.55	1.53	1.51	1.50	1.48	1.47	1.45	1.44
15	1.42	1.41	1.39	1.38	1.36	1.35	1.33	1.32	1.31	1.29
16	1.28	1.26	1.25	1.24	1.22	1.21	1.20	1.19	1.17	1.16
17	1.25	1.14	1.12	1.11	1.10	1.09	1.08	1.06	1.05	1.04
18	1.03	1.02	1.01	1.00	0.99	0.98	0.96	0.95	0.94	0.93
19	0.92	0.91	0.90	0.89	0.88	0.87	0.86	0.86	0.85	0.84
20	0.82	0.80	0.78	0.76	0.75	0.74	0.72	0.70	0.69	0.68

You must removed the reading to the lowest of the two levels.

Trunk Distortion = 71.45 dB – Bridger Distortion = 61.44 dB or 10.20 dB diff. = 2.34 dB

61.44 – 2.34 = 59.10 dB

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Distortions in a Broadband System.

2nd Order, C/N with different Operating Level.

dB	0.00	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90
0	3.01	2.96	2.91	2.86	2.81	2.77	2.72	2.67	2.63	2.58
1	2.54	2.50	2.45	2.41	2.37	2.32	2.28	2.24	2.20	2.16
2	2.12	2.09	2.05	2.01	1.97	1.94	1.90	1.87	1.83	1.80
3	1.76	1.73	1.70	1.67	1.63	1.60	1.57	1.54	1.51	1.48
4	1.46	1.43	1.40	1.37	1.35	1.32	1.29	1.27	1.24	1.22
5	1.19	1.17	1.15	1.12	1.10	1.08	1.06	1.04	1.01	0.99
6	0.97	0.95	0.93	0.91	0.90	0.88	0.86	0.84	0.82	0.81
7	0.97	0.77	0.76	0.74	0.73	0.71	0.70	0.68	0.67	0.65
8	0.64	0.63	0.61	0.60	0.59	0.57	0.56	0.55	0.54	0.53
9	0.51	0.50	0.49	0.48	0.47	0.46	0.45	0.44	0.43	0.42
10	0.41	0.40	0.40	0.39	0.38	0.37	0.36	0.35	0.35	0.34
11	0.33	0.32	0.32	0.31	0.30	0.30	0.29	0.28	0.28	0.27
12	0.27	0.26	0.25	0.25	0.24	0.24	0.23	0.23	0.22	0.22
13	0.21	0.21	0.20	0.20	0.19	0.19	0.19	0.18	0.18	0.17
14	0.17	0.17	0.16	0.16	0.15	0.15	0.15	0.14	0.14	0.14
15	0.14	0.13	0.13	0.13	0.12	0.12	0.12	0.12	0.11	0.11
16	0.11	0.11	0.10	0.10	0.10	0.10	0.09	0.09	0.09	0.09
17	0.09	0.08	0.08	0.08	0.08	0.08	0.07	0.07	0.07	0.07
18	0.07	0.07	0.07	0.06	0.06	0.06	0.06	0.06	0.06	0.06
19	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.04
20	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04

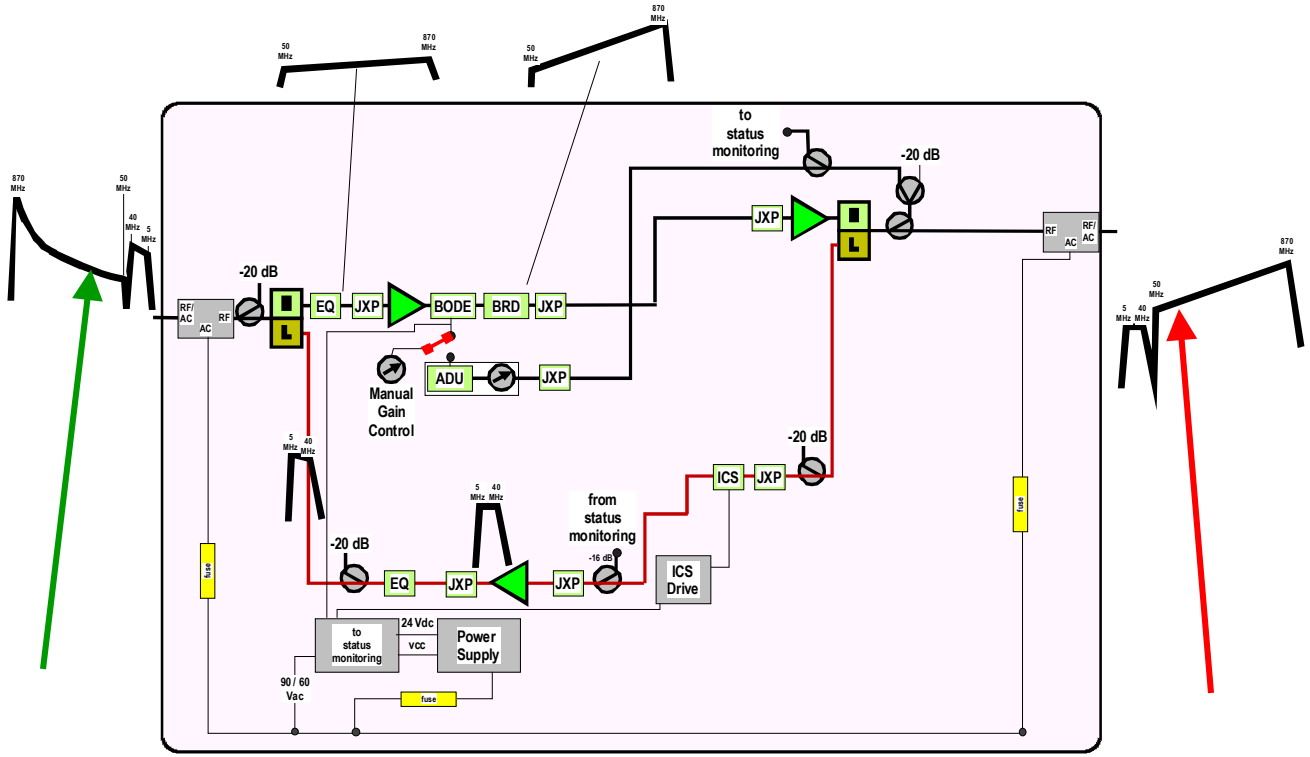
You must removed the reading to the lowest of the two levels.

Trunk distortion = 52.09 dB – Bridger distortion = 48.23dB or = 3.86 diff. = (1.48 dB)

48.23 – 1.48 = 46.75 dB

Distortions in a Broadband System.

Operating an RF Amplifier at Different Level.



If we increase the input of this amplifier, we will increase the Carrier to Noise of the amplifier. For every increase of 1.0 dB at the input, the Carrier to Noise of the amplifier will better itself by 1.0 dB.

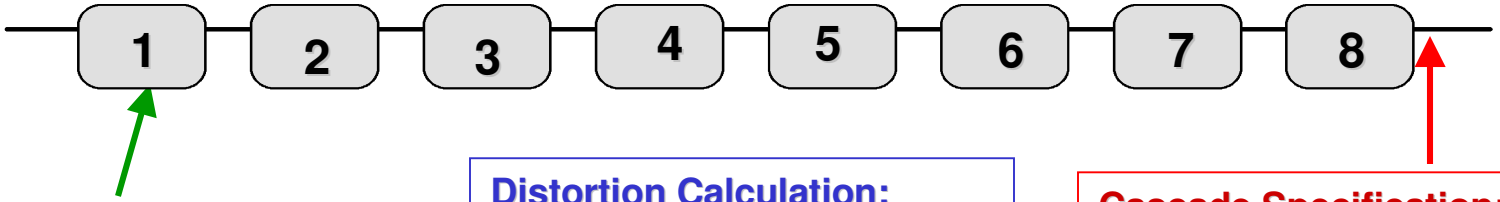
Let say this amplifier has 10.0 dB of Noise and you hit the amplifier by a level of +10.0 dBmV, his C/N will be 59+10-10=59.0 dB C/N. If you hit the same amplifier at +12.0 dBmV, his C/N will now be 59+12-10=61.0 dB C/N

If we get this amplifier to works at +45.0 dBmV and his distortions level are –75.0 for CTB, -74.0 dB for CSO, and if we increase his output to +47.0 dBmV, the CTB level will now be –71.0 dB and the CSO will now be –72.0 dB.

For every increase of 1.0 dB at the output of the amplifier, the CTB will get worse by 2.0 dB and the CSO will get worse by 1.0 dB

Distortions in a Broadband System.

Distortion on a RF Section of a HFC System.



Input; +12 dBmV

Noise Fig. = 11 dB

Output = +45 dBmV

CTB = -77.0 dB

CSO = -76.0 dB

Distortion Calculation:

CTB = 8 x 20log10 = 18.6 dB

CSO = 8 x15log10 = 13.54

C/N = 8 x 10log10 = 9.03

Cascade Specification:

C/N = 60.0 - 9.03 = 50.97 dB

CTB = -77.0 - 18.6 = 58.4 dB

CSO = -76.0 - 62.46 = 62.46 dB

Amplifier specification:

C/N = 59+12-11 = 60.0 dB

CTB = -77.0 dB

CSO = -76.0 dB

Changing the operation level:

Since at the end of this cascade the distortions are good, we could lower the output of this cascade by 1.0 dB, it input would now be 12.0 –1.0 = 11.0 dBmV, then it output would then be + 44.0 dB, then the cascade would have the following distortions:

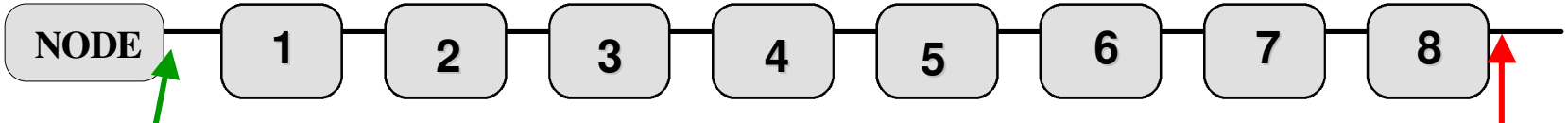
C/N = 50.97 – 1.0 = 49.97 dB

CTB = 58.4 + 2.0 = 60.4 dB

CSO = 62.46 + 1.0 = 63.46 dB

Distortions in a Broadband System.

Distortion on a RF Section of a HFC System.



NODE Distortion:

C/N = 53.0 dB

CTB = - 65.0 dB

CSO = -64.0 dB

Cascade Specification:

C/N = 60.0 - 9.03 = 50.97 dB

CTB = -77.0 - 18.6 = 58.4 dB

CSO = -76.0 - 62.46 = 62.46 dB

Overall Specification:

C/N = 53.0 – 50.97 or 50.97 – 2.03 = 48.94 dB

CTB = 65.0 – 58.4 or 58.4 – 3.33 = 55.07 dB

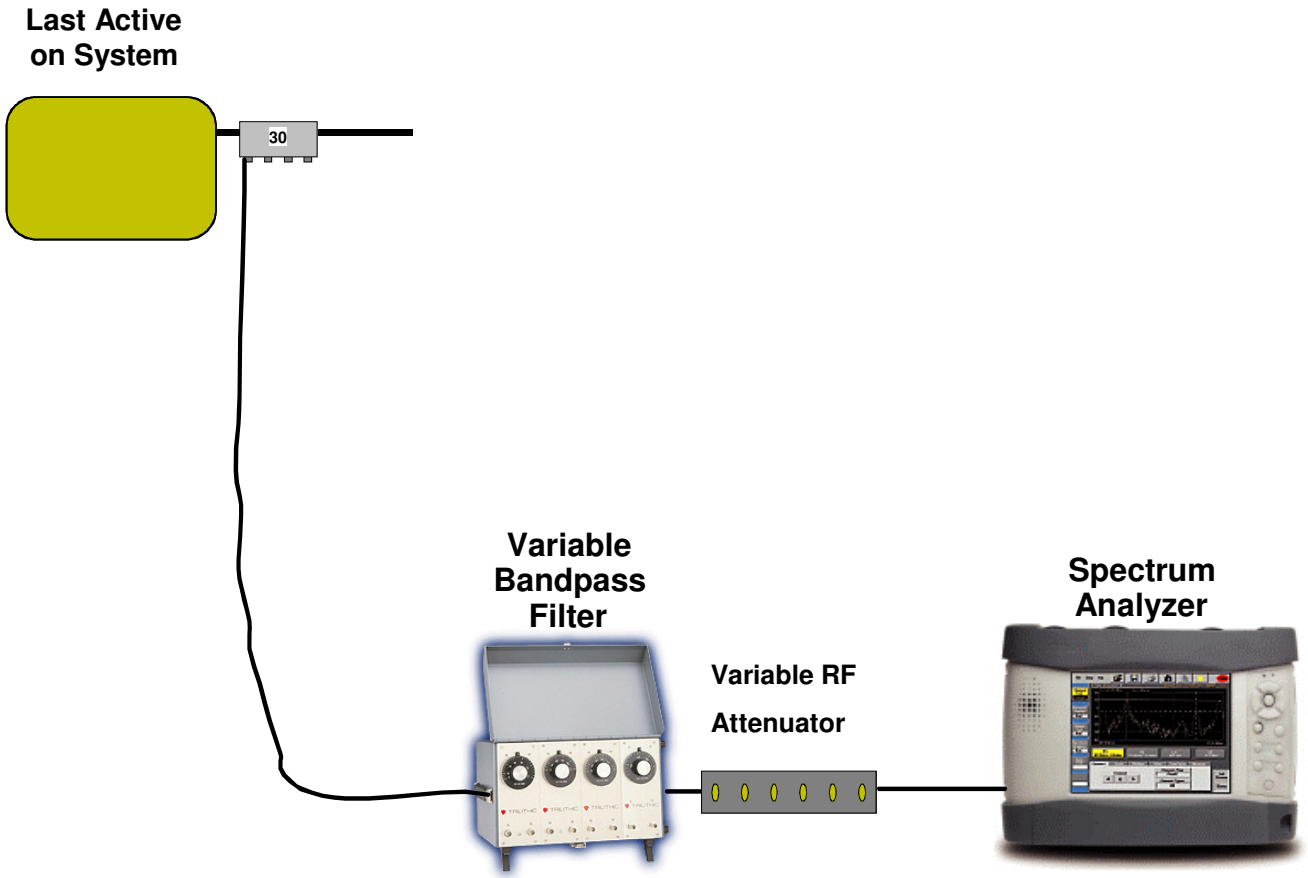
CSO = 64.0 – 62.46 or 62.46 –2.32 = 60.14 dB

Remember the minimum distortion expected at each customer are;

C/N = 48.0 dB, CTB = -51.0 dB, CSO = -51.0 dB

Distortions in a Broadband System.

How distortions are measured on a HFC system.



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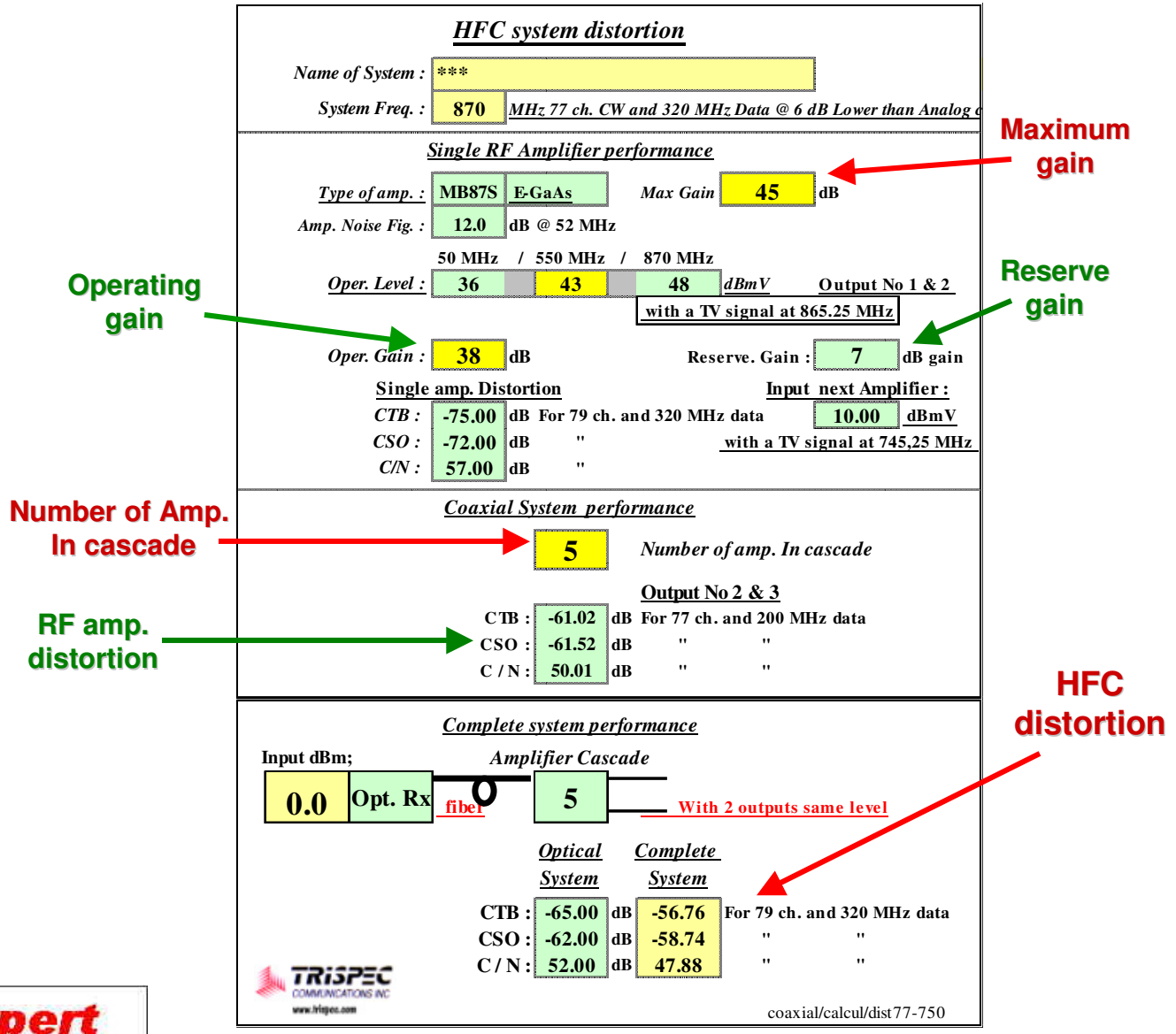
Distortions in a Broadband System.

Distortion Measurement Calculated using a Spreadsheet.



Maximum gain

Operating gain

Reserve gain

Number of Amp. In cascade

RF amp. distortion

HFC distortion

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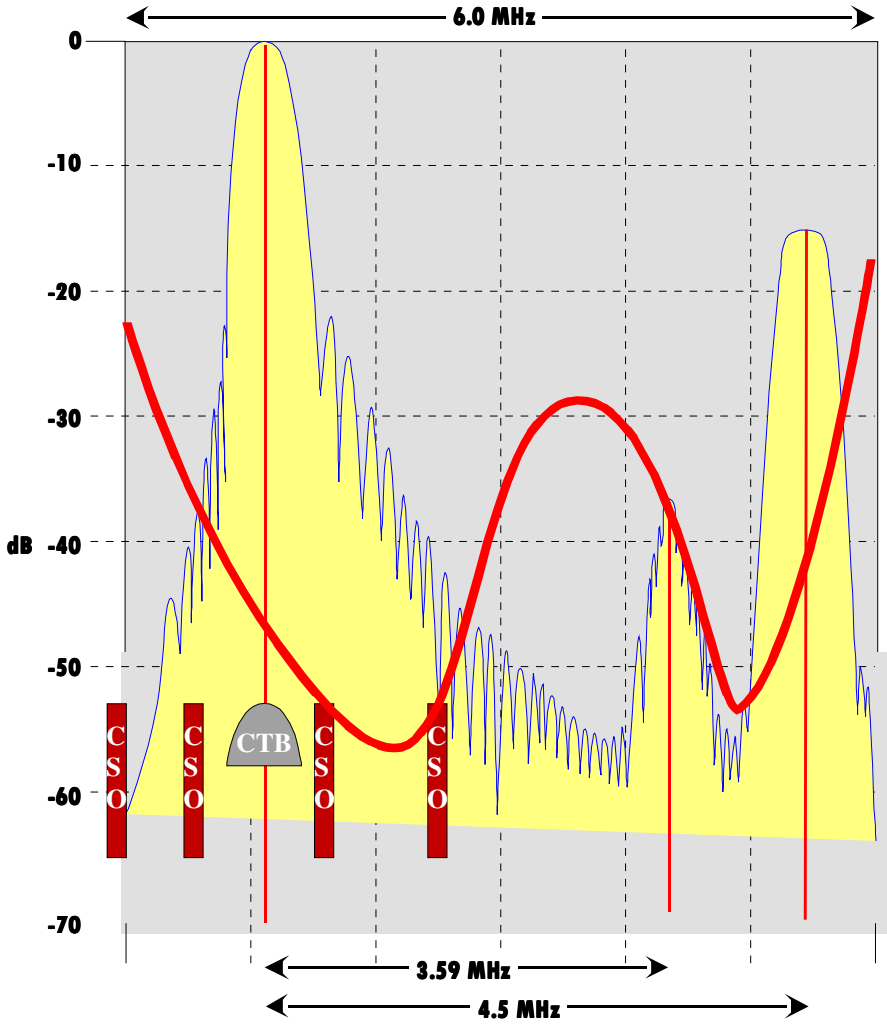
Distortions in a Broadband System.

Distortion Measurement Accepted at all the Customer.



Signal-to-Interference limites

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Test!

- What is the best Carrier to Noise possible for a 6 MHz RF signal?
- _____
- A + 10 dBmV input for an amp. with 11.5 dB Noise Fig. What is his C/N?
- _____
- A amp. has –65.0 dB CTB at 46.0 dBmV output, what is the CTB for a 42.0 dBmV?
- _____
- What does CSO stand for?
- _____
- Which of the two distortions, CTB or CSO degrade faster in a HFC system?
- _____
- First amp. Has –74.0 dB CTB, what will be the CTB after 6 amps?
- _____
- What is the minimum AC voltage for a modern amplifier?
- _____
- What is the maximum amp. Cascade on a modern HFC system>
- _____

The end of this session.