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DISTRIBUTION SYSTEM DESIGN

Objective:

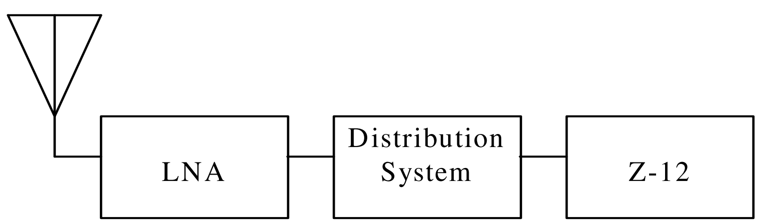
To characterize the GPS/GLONASS system in a way which will enable the design of a custom signal distribution system which would include LNAs, cables, and line amplifiers. The noise figure of the receiver must be known along with the maximum level that can be handled in the input of the receiver. With this information, the LNA, cables, and lines amplifiers can be specified to work with the GPS/GLONASS receiver.

Background:

Determining the Minimum Gain of the Distribution System

Knowing the noise figure of the receiver and the gain of the LNA, the lowest gain (or highest loss) of the distribution system can be calculated and demonstrated. Since any distribution system will have a non-zero effect on SNR, a maximum acceptable SNR reduction will have to be set. We will use 0.5 dB as the maximum acceptable SNR loss.

Given the following model:



The total system noise figure is given by[1] :

(1) $$NF_{sys}=NF_{lna} + \left[(NF_{dis}-1)/G_{lna}\right] + \left[(NF_{Z}-1)/(G_{lna} \bullet G_{dis})\right]$$

where,

NF_{lna} and G_{lna} are the noise figure and gain of the LNA,

NF_{dis} and G_{dis} are the noise figure and gain of the distribution network,

NF_{Z} is the noise figure of the Z-12 receiver.

All factors are factors of power, NOT in dB. $NF_{(in\ dB)}=10 \bullet \log(NF)$

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[1] Krause, H. and Bostian, C., *Solid State Radio Engineering*, John wiley & Sons, New York, 1980.

If the maximum SNR degradation is set to 0.5 dB, restrictions on the gain and noise figure of the distribution network would ensue. The new system noise figure should be no more than 0.5 dB more than the LNA noise figure itself.

e.g.:

(2) $NF_{sys} - NF_{lna} < 1.122$ where $0.5\text{ dB} = 10 \bullet \log[1.122]$

From (1), this also means that

$[(NF_{dis}-1)/G_{lna}] + [(NF_Z-1)/(G_{lna} \bullet G_{dis})]$ must be less than 1.122 or 0.5 dB.

In the case that the distribution network is purely a loss, such as a cable or an attenuator;

(3) $NF_{dis}=1/G_{dis.}$

Using equations (3),(2), and (1), solving for the maximum NF_{dis} gives;

(4) $NF_{dis}=[(1.122)*G_{lna}+1]/NF_{Z.}$

i.e. NF_{dis} must be less than $[(1.122)*G_{lna}+1]/NF_Z$

Also, by setting NF_Z = 25 dB (316) and G_{lna} to 35 dB(3162.3) leaves;

NF_{dis}=11.23 or 10.5 dB. This is the worst-case maximum loss allowable.

As a corollary, knowing the LNA gain and the attenuation required to achieve a 0.5 dB loss (G_{dis}), one could use equation (4) to solve for the noise figure of the receiver NF_Z.

(5) $NF_Z =[(1.122)*G_{lna}+1]/NF_{dis.}$

Determining the Maximum Gain of the Distribution System

Knowing the maximum input level of the receiver, the distribution system must then have overall gain less than $Gain_{max}$ where:

$Gain_{max}= P_{sat} - PLNA_{max}$

P_{sat} = Saturation Level in dBm

$PLNA_{max}$ = Maximum Level out of LNA in dBm

P_{sat}=-27 dBm for L1 and,

P_{sat}=-30 dBm for L2.

$PLNA_{max}$= [Thermal Noise in a 25 MHz Bandwidth+LNA NF_{max}]+[Max gain of LNA]

for L1: $PLNA_{max}$ = [-100 dBm + 4dB NF] + [41 dB] = -55 dBm

for L2: $PLNA_{max}$ = [-100 dBm + 4dB NF] + [44 dB] = -52 dBm

Therefore,

for L1:

$Gain_{max}$= -27 dBm - (-55 dBm) = 28 dB

for L2:

$Gain_{max}$= -30 dBm - (-52 dBm) = 22 dB

The most gain allowed for the distribution system is **28 dB** *and* **22 dB** *for L1 and L2 respectively.*

Specifications

Z-12 Noise Figure: 15 to 25 dB. L1 and L2

Cable losses (part# 100914): 30 Meter RG-8: L1: 10.4 dB. L2: 8.4 dB

Line amplifier (part# 700389): Gain: 19 dB@ L1, 17 dB @ L2.

Noise: 3.5 dB @ L1, 8 dB @ L2.

Conclusions:

The signal distribution system (cables and line amplifiers) must meet two criterion:

- G_{dis} must be less than P_{sat} - $PLNA_{max}$
- $[(NF_{dis}-1)/G_{lna}] + [(NF_Z-1)/(G_{lna} \bullet G_{dis})]$ must be less than 1.122 or 0.5 dB.