MEASUREMENT OF THE ATTENUATION DUE TO THE IF SIGNAL CABLES OF THE 40M RADIO TELESCOPE

David Cuadrado Calle, María Patino Esteban,
José Antonio López Pérez

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1. Introduction

The attenuation of the eight IF cables that carry the IF signals from the patch panel of the receivers' room, shown in figure 1, to the patch panel of the backends' room, shown in figure 2, has been measured and is introduced in this report.

The part number of these cables is ANDREW FSJ4-50B, whose specifications are shown in Annex I.

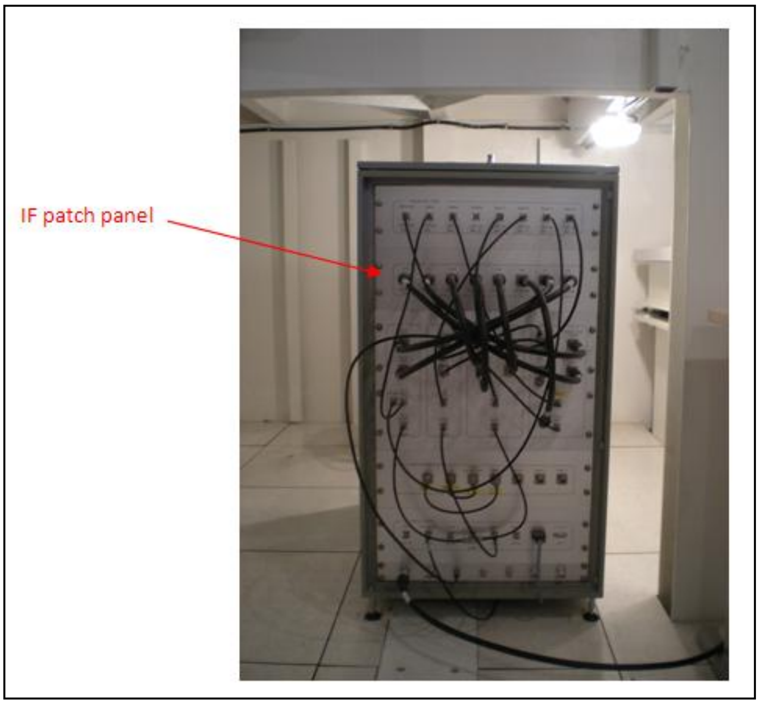

Figure 1: Receiver's room patch panel

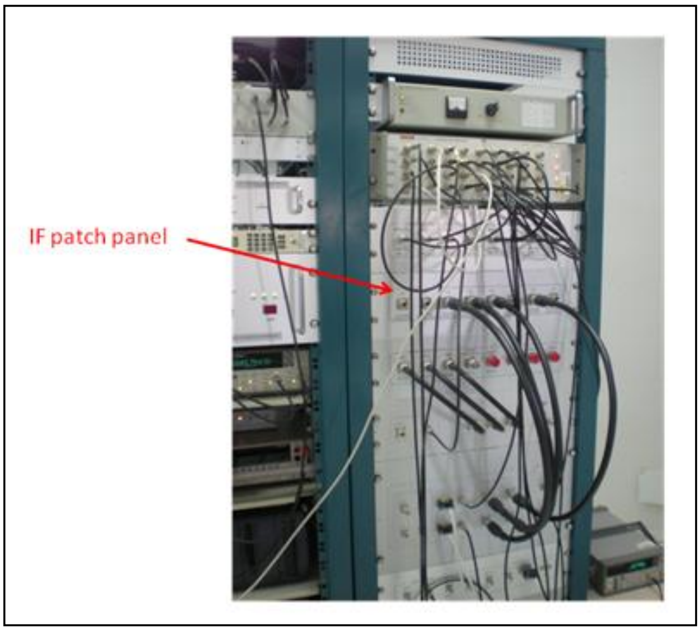

Figure 2: Backend's room patch panel

2. FI cable frequency band shape

The frequency band shape of the IF cables has been measured by injection of a 0 dBm tone in the patch panel IF8 input at the receiver’s room. The frequency range of the tone was stepped in 50 MHz up to 15 GHz with the help of a signal generator. Then, the power of the tone at the corresponding patch panel IF8 output in the backend's room was measured with an spectrum analyzer with the hold on mode active.

According to the test carried out with the Chauvin Arnoux Fault Mapper Pro CA 7026 time domain reflectometer, the eight IF cables are **47 meters in length**. Their properties are shown in Appendix A. Cable #8 was randomly selected for these measurements, which are representative for all the other ones.

The test bench used to determine the attenuation and band shape of the IF cables is shown in Figure 1.

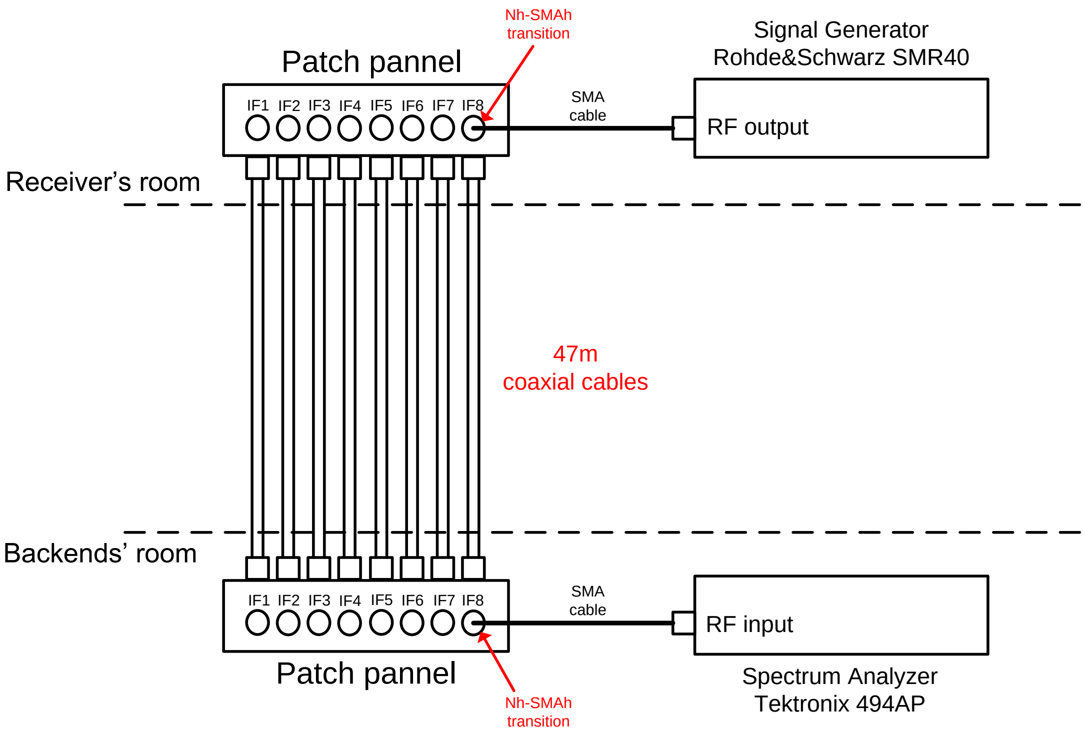

Figure 3: Test bench for IF cables measurement

It has been necessary to perform two different measurements for the characterization of the IF cables. On the one hand there is the measurement of the whole system whose result is shown in figure 4, and on the other hand there is the measurement of the two SMA cables and the two N(f)-SMA(f) transitions used for connecting the signal generator and the spectrum analyzer to the patch panels and the N(m)-N(m) transition of the patch panels. This last measurement’s result is shown in figure 5 and represents the measurement error in the first measurement of figure 4.

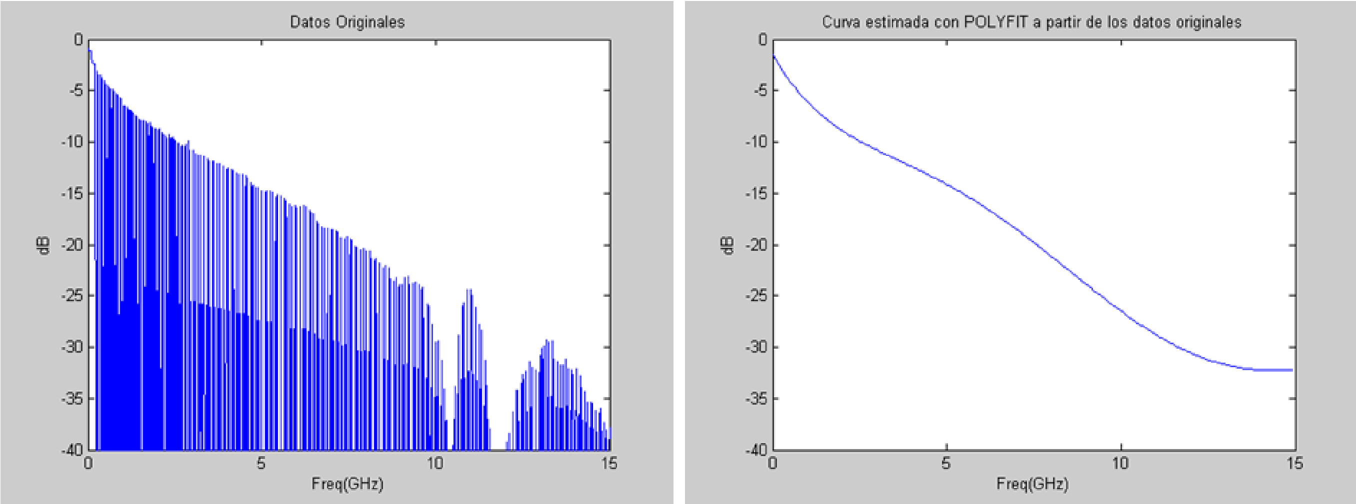

Figure 4: Band shape for the whole measurement system

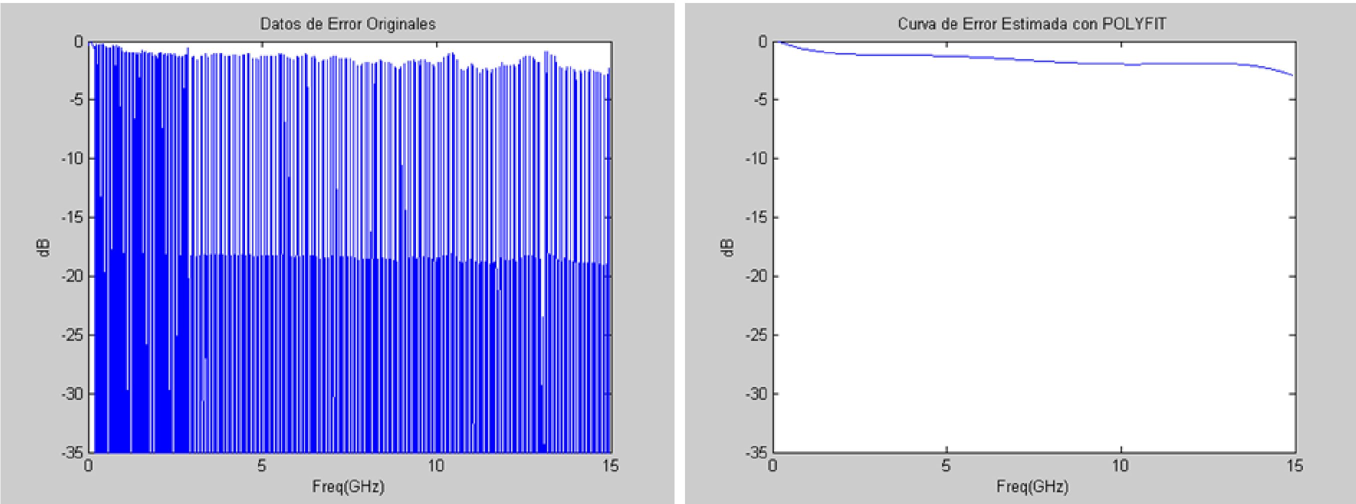

Figure 5: Band shape of the measurement cables and transitions

If the curve shown in figure 5 is subtracted from the curve shown in figure 4, the resulting curve will represent the real band shape of the IF cable and the contribution to the attenuation due to the measurement cable and coaxial adapters will be removed. This operation, which can be considered to be a calibration, has been carried out and the result is shown in the blue curve of figure 6.

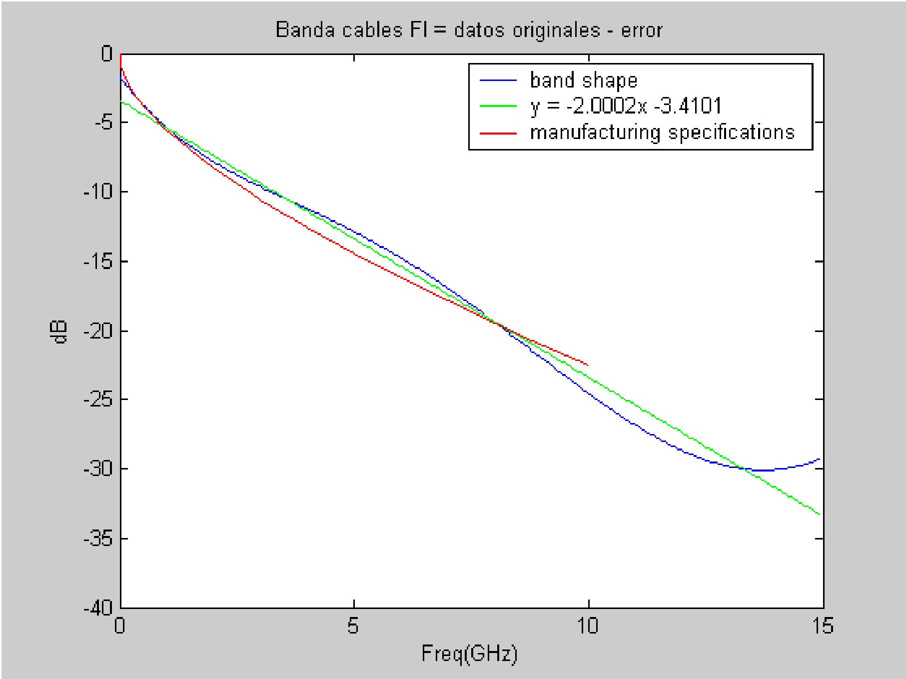

Figure 6: Band shape of the IF cables and associated trend line

The red curve in figure 6 is the specification provided by the manufacturer from DC to 10 GHz. The green line represents a linear approximation of the IF cable's band shape and it's given to simplify the equalization of the system, if needed. The equation of the trend line is:

$$A(dB) = -2 \cdot F(GHz) - 3.41$$

Where 'A' represents the attenuation level in dB and 'F' represents the frequency in GHz.

The slight difference between the manufacturer specifications and the measurements obtained with the test bench of figure 3, must be analyzed further.

The Matlab code used to compute the curve from the data taken with the spectrum analyzer and to subtract the calibration curve from the raw data is shown in Appendix B. This code can be modified to compute a higher order polynomial fit to the data, if requested.

3. Conclusions

In this report it has been shown that the 47 meter in length IF cables that connect the patch panel of the receiver's room to the patch panel of the backend's room, have a relevant frequency slope that must be taken into account, particularly in case of the design of a frequency equalizer.

The attenuation of the IF cables increases around 2 dB/GHz with frequency.

A future work could be the design and development of an equalizer in order to compensate for this slope.

Appendix A: IF cables' datasheet

Product Specifications

ANDREW® A CommScope Company

FSJ4-50B

FSJ4-50B, HELIAX® Superflexible Foam Coaxial Cable, corrugated copper, 1/2 in, black PE jacket

CHARACTERISTICS

Construction Materials

Jacket Material	PE
Outer Conductor Material	Corrugated copper
Dielectric Material	Foam PE
Flexibility	Superflexible
Inner Conductor Material	Copper-clad aluminum wire
Jacket Color	Black

Dimensions

Nominal Size	1/2 in
Cable Weight	0.14 lb/ft | 0.21 kg/m
Diameter Over Dielectric	8.890 mm | 0.350 in
Diameter Over Jacket	13.462 mm | 0.530 in
Inner Conductor OD	3.5560 mm | 0.1400 in
Outer Conductor OD	12.192 mm | 0.480 in

Electrical Specifications

Cable Impedance	50 ohm ±1 ohm
Capacitance	25.2 pF/ft | 82.7 pF/m
dc Resistance, Inner Conductor	0.820 ohms/kft | 2.690 ohms/km
dc Resistance, Outer Conductor	1.000 ohms/kft | 3.281 ohms/km
dc Test Voltage	2500 V
Inductance	0.207 µH/m | 0.063 µH/ft
Insulation Resistance	100000 MOhm
Jacket Spark Test Voltage (rms)	5000 V
Operating Frequency Band	1 – 10200 MHz
Peak Power	15.6 kW
Pulse Reflection	1%
Velocity	81%

Environmental Specifications

Installation Temperature	-40 °C to +60 °C (-40 °F to +140 °F)
Operating Temperature	-55 °C to +85 °C (-67 °F to +185 °F)
Storage Temperature	-70 °C to +85 °C (-94 °F to +185 °F)

General Specifications

Brand	HELIAX®

Mechanical Specifications

Bending Moment	2.7 N-m | 2.0 ft lb
Flat Plate Crush Strength	110.0 lb/in | 2.0 kg/mm
Minimum Bend Radius, Multiple Bends	31.75 mm | 1.25 in
Minimum Bend Radius, Single Bend	31.75 mm | 1.25 in
Number of Bends, minimum	20
Tensile Strength	79 kg | 175 lb

Standard Conditions

Attenuation, Ambient Temperature	20 °C | 68 °F
Average Power, Ambient Temperature	40 °C | 104 °F
Average Power, Inner Conductor Temperature	100 °C | 212 °F

Attenuation

Frequency (MHz)	Attenuation (dB/100 m)	Attenuation (dB/100 ft)	Average Power (kW)
0.5	0.231	0.07	15.60
1	0.327	0.1	15.60
1.5	0.401	0.122	15.60
2	0.463	0.141	15.60
10	1.044	0.318	10.14
20	1.485	0.453	7.12
30	1.828	0.557	5.79
50	2.377	0.724	4.45
88	3.187	0.971	3.32
100	3.406	1.038	3.11
108	3.546	1.081	2.98
150	4.214	1.285	2.51
174	4.558	1.389	2.32
200	4.908	1.496	2.16
300	6.095	1.858	1.74
400	7.121	2.17	1.49
450	7.592	2.314	1.39
500	8.042	2.451	1.32
512	8.148	2.483	1.30
600	8.891	2.71	1.19
700	9.683	2.951	1.09
800	10.431	3.179	1.01
824	10.605	3.232	1.00
894	11.101	3.383	0.95
960	11.555	3.522	0.92
1000	11.824	3.604	0.89
1250	13.423	4.091	0.79
1500	14.906	4.543	0.71
1700	16.027	4.885	0.66
1800	16.57	5.05	0.64
2000	17.624	5.371	0.60
2100	18.137	5.528	0.58
2200	18.641	5.682	0.57
2300	19.138	5.833	0.55
2500	20.11	6.129	0.53
2700	21.056	6.418	0.50
3000	22.432	6.837	0.47
3400	24.198	7.375	0.44
3700	25.478	7.765	0.42
4000	26.727	8.146	0.40
5000	30.693	9.355	0.34
6000	34.427	10.493	0.31
8000	41.403	12.619	0.26
8800	44.054	13.427	0.24
10000	47.914	14.604	0.22

Regulatory Compliance/Certifications

Agency	Classification
RoHS 2002/95/EC	Compliant

Appendix B: Matlab code

```
function [] = equFI (cablesFI, error, especificaciones)

close all;

%% CABLES FI

[a,b]=size(cablesFI);
fmax=cablesFI(a,1);
j=1;

for i=2:1:(size(cablesFI,1)-1)    % No evaluo ni la primera muestra ni la ultima
   if ((cablesFI(i,2)>cablesFI(i-1,2)) && (cablesFI(i,2)>cablesFI(i+1,2)) && (cablesFI(i,2)>-35))
      cables_max(j,1)=cablesFI(i,1);    % Almaceno la freq
      cables_max(j,2)=cablesFI(i,2);    % Almaceno el nivel
      j=j+1;
   end
end

[P,S]=polyfit(cables_max(:,1),cables_max(:,2),5);    % Grado impar

freq_norm=[0.01:0.05:fmax];
y=zeros(1,size(freq_norm));

for i=1:1:size(freq_norm,2)
   y1(i)=P(1)*(freq_norm(i))^5+P(2)*(freq_norm(i))^4+P(3)*freq_norm(i)^3+P(4)*freq_norm(i)^2+P(5)*freq_norm(i)+P(6);
end

figure(1)   % Pintamos los datos originals
plot(cablesFI(:,1),cablesFI(:,2))
axis([0 fmax -40 0]);
xlabel('Freq(GHz)'),ylabel('dB');
title('Datos Originales');

figure(2)   % Pintamos la curva estimada con polyfit
plot(freq_norm,y1)
axis([0 fmax -40 0]);
xlabel('Freq(GHz)'),ylabel('dB');
title('Curva estimada con POLYFIT a partir de los datos originales');


%% ERROR POR EL BANCO DE MEDIDAS: incertidumbre equipos, cables,
%% transiciones, etc...

j=1;

for i=2:1:(size(error,1)-1)    % No evaluo ni la primera muestra ni la ultima
   if ((error(i,2)>error(i-1,2)) && (error(i,2)>error(i+1,2)) && (error(i,2)>-10))
      error_max(j,1)=error(i,1);    % Almaceno la freq
      error_max(j,2)=error(i,2);    % Almaceno el nivel
      j=j+1;
   end
end

[P,S]=polyfit(error_max(:,1),error_max(:,2),5);    % Grado impar

freq_norm=[0.01:0.05:fmax];
y=zeros(1,size(freq_norm));

for i=1:1:size(freq_norm,2)
   y2(i)=P(1)*(freq_norm(i))^5+P(2)*(freq_norm(i))^4+P(3)*freq_norm(i)^3+P(4)*freq_norm(i)^2+P(5)*freq_norm(i)+P(6);
end
```

```
figure(3)   % Pintamos los datos originals
plot(error(:,1),error(:,2))
axis([0 fmax -35 0]);
xlabel('Freq(GHz)'),ylabel('dB');
title('Datos de Error Originales');

figure(4)   % Pintamos la curva estimada con polyfit
plot(freq_norm,y2)
axis([0 fmax -35 0]);
xlabel('Freq(GHz)'),ylabel('dB');
title('Curva de Error Estimada con POLYFIT');


%% CABLES FI RESTANDOLES OCASIONADO POR EL ERROR POR EL BANCO DE MEDIDAS

for i=1:1:size(freq_norm,2)
   y(i)=y1(i)-y2(i);
end

figure(5)   % Pintamos la curva estimada con polyfit
plot(freq_norm,y)
axis([0 fmax -40 0]);
xlabel('Freq(GHz)'),ylabel('dB');
title('Banda cables FI = datos originales - error');
hold on

[P_recta,S]=polyfit(freq_norm,y,1);

recta=zeros(1,size(freq_norm,2));
for i=1:1:size(freq_norm,2)
   recta(i)=P_recta(1)*freq_norm(i)+P_recta(2);
end

txt1=num2str(P_recta(1));
txt2=num2str(P_recta(2));

pendiente=['y = ',txt1,'x ',txt2]

plot(freq_norm,recta,'g');


%% ESPECIFICACIONES DEL FABRICANTE NORMALIZADAS

plot(especificaciones(:,1),especificaciones(:,2),'r');
legend('band shape',pendiente,'manufacturing specifications')
```