Measurement of Television Channel Levels on CATV Networks

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21st January 1999

1. Introduction

Traditionally the measurement of Television channels has been concerned with analogue signals on RF (HFC) CATV networks. From the early days this has been quoted as the RMS voltage of the peak of the vision carrier. The levels have been quoted in dBmV without any reference to measurement bandwidth of system impedance.

CATV coaxial networks are designed with a constant impedance throughout of 75 ohms from end to end. Also the power in an analogue channel is mainly in the vision carrier, or close to it (within 30 kHz), so that measurement of the vision carrier is within 0.5dB of the channel power.

2. Power in an Analogue channel

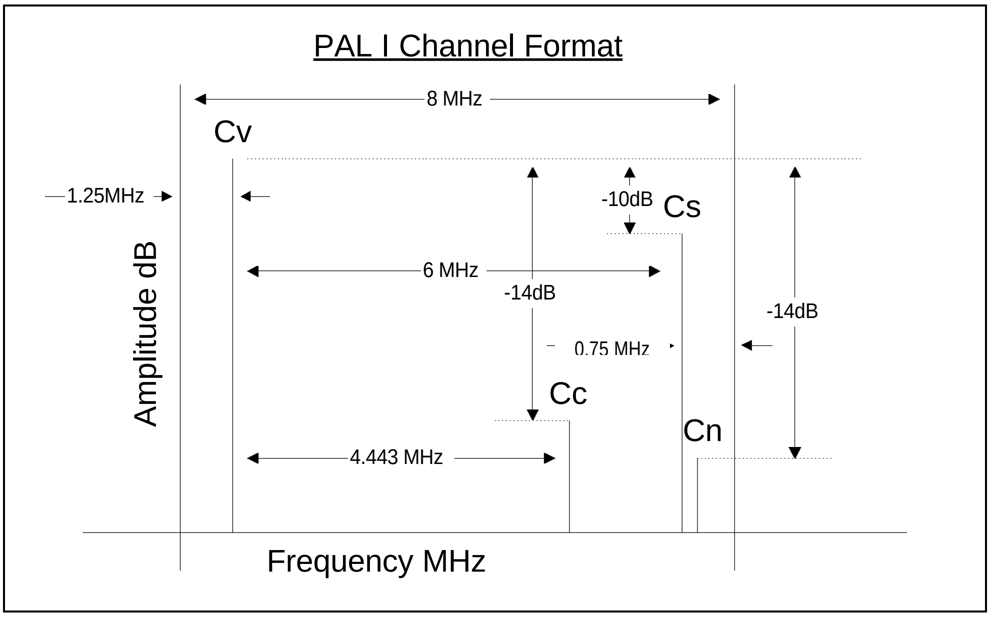

Figure 1: PAL I Television Channel

Figure 1 shows the format of a PAL I television channel.

In this drawing: Cv = The vision carrier.
Cs = The sound sub carrier.
Cc = The colour sub carrier.
Cn = The NICAM sub carrier.

2.1 Power Allowance for Audio & Colour sub carriers

The power in Cs is -10dB on Cv which adds 10% to the power in Cv. The power in Cc is -14dB on Cv which adds 5% to the power in Cv.

The actual channel power, compared with the power in the vision carrier is 115% = $10\log_{10} 1.15 = 0.61$dB. This does not allow for the vision sideband power which is very much lower than the power contribution from either of Cs or Cc.

The result of this is that the actual channel power is some 0.6 to 0.7dB above the calculated figure using just the vision carrier. For practical purposes this difference will be lost in the measurement accuracy of most measuring equipment. Where it is planned to allow for this then a figure of 0.7dB should be used. The attached plots show that the contribution from the sound sub carrier is -35.98 - (-36.51) = 0.53dB (measured on an HP spectrum Analyser).

2.2 Converting from dBm to dBmV

Assuming that the characteristic impedance of the network is R ohms.

For a level of X volts:

Power $= V^2/R \Rightarrow X^2/R$ watts.
$\Rightarrow X^2/R \times 10^3$ milliwatts.

Converting to dB (reference to 1 milliwatt) = $10\mathrm{Log}_{10} (X^2/R \times 10^3)$ dBm

$\Rightarrow 30 + 10\log_{10} (X^2/R)$
$\Rightarrow 30 + 20\log_{10} (X) - 10\log_{10} (R)$ dBm …*1*

X volts = X x10^3 millivolts $\Rightarrow 20\log_{10} (X \times 10^3)$
$\Rightarrow 60 + 20\log_{10} (X)$ dBmV …*2*

To convert from dBmV to dBm in a system with characteristic impedance of R ohms (*2* - *1*)

$\Rightarrow (60 + 20\log_{10} (X)) - (30 + 20 \log_{10} (X) - 10 \log_{10} (R))$
$\Rightarrow 60 - 30 + 10 \log_{10}(R)$
$\Rightarrow 30 + 10 \log_{10}(R)$ dB …*3*

For a 75 ohm system

$\Rightarrow 30 + 10 \log_{10} (75) =$ **48.75 dB**

This means that if a level in a 75 ohm system is known in dBmV then the equivalent power is -48.75 dB down e.g. 10dBmV = -38.75dBm

For practical purposes if the vision carrier level (dBmV) in a PAL I channel is know the equivalent channel power (dBm) can be calculated simply by subtracting 48.75. The result will be approximately 0.5 dB lower than the actual channel power.

3. Power in a QAM channel

The measurement of the power in a Quadrature Amplitude Modulated (QAM) channel is somewhat different to measuring the individual carriers in an analogue channel. With the modulation removed an unmodulated carrier results. This can be measured as for any other carrier with a level meter, spectrum analyser or power meter.

However when the carrier is (QAM) modulated this power instead of being in a single unmodulated carrier is now spread across the channel. The channel power remains essentially unchanged.

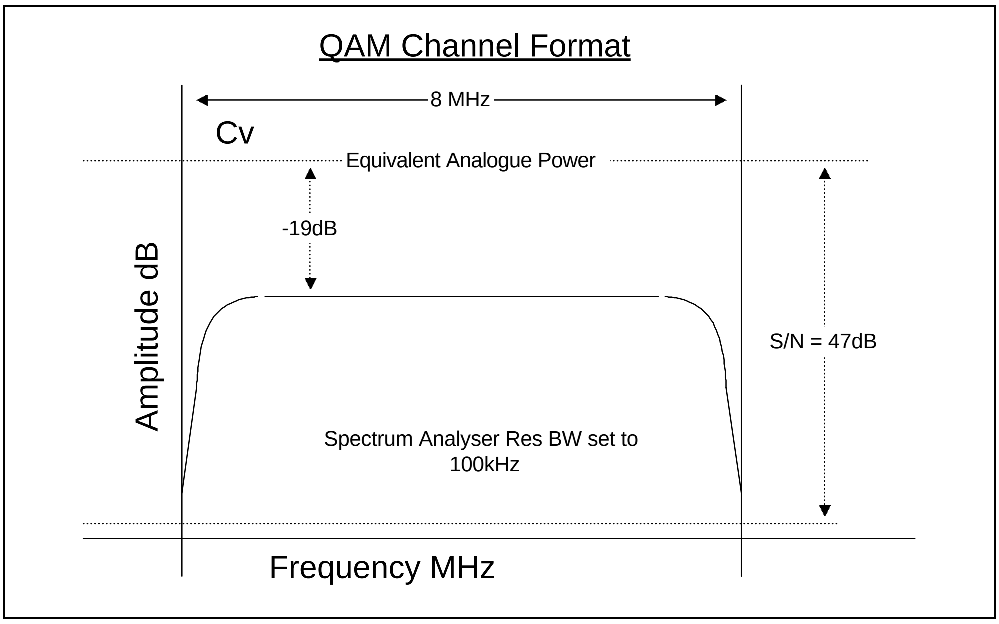

Figure 2: 8MHz QAM Channel

Figure 2 shows an 8 MHz QAM channel as displayed on a spectrum analyser with the resolution (IF) bandwidth set to 100 kHz. This resolution is needed to show the channel detail but results in a misleading display.

The channel power is now being measured in 100 kHz but the total power in an 8 MHz wide can be considered as the power in 80 x 100 kHz channels. The actual total channel power is 80 times that shown or $10 \log_{10}(80) = 19$dB.

For other channel widths (e.g. 6 MHz) resolution bandwidth settings the correction factor is $10 \log_{10}(B1/B2)$. Where B1 = The channel bandwidth and B2 = the resolution bandwidth.

From the attached plot of a QAM channel it can be seen that the total channel power is indicated as -35.95 dBm whereas the marker indicates -56.55 dBm. Applying the 19dB correction the channel power indicated by the marker is -56.55 + 19 = -37.55 dBm This is within 1.6 dB of the channel power indicated of -35.95 dBm.

To summarise in order to measure the power within a QAM channel both the channel width and resolution bandwidth must be allowed for. In addition, for a 75 ohm network the 48.75 dB correction must be applied when converting from dBmV to dBm (dBm being the lower figure). If it were possible to view a QAM channel in say an 8 MHz wide resolution bandwidth then the level at the top of the display would be 0.5 dB higher than the vision carrier of an analogue channel at the same power.

4. Measurement of C/N or S/N

The procedure for measurement of C/N in a PAL analogue channel is well known. The vision carrier level is measured in dBmV and the noise floor close to the channel is measured using a narrow resolution bandwidth (care taken to ensure that the noise is from the source and not the test equipment). The noise level in dBmV is then corrected to the channel width as outlined in *3* above i.e. by applying the $10 \log_{10}(B1/B2)$ correction in dB.

With a QAM channel the procedure is somewhat easier. Since both the indicated signal power and noise power are measured in the same resolution bandwidth the indicated S/N is independent of resolution bandwidth. If a correction was applied this would be the same for both the signal power, for the channel width in use, and for the noise power to the same channel width.

5. Setting Operating Levels on HFC Networks

When setting levels on networks the following must be allowed for:-

1. The channel power in a PAL I analogue channel can be taken as the vision carrier level. This will produce a figure which is 0.5 dB low.

2. When measuring QAM channels the indicated level must be corrected for both the channel width and resolution bandwidth using $10 \log_{10}(B1/B2)$.

3. When measuring analogue C/N the correction $10 \log_{10}(B1/B2)$. Must be applied to the noise measurement.

4. When measuring the S/N for a QAM channel the measurement is independent of resolution bandwidth, providing the same setting is used for both signal and noise.

5. It may be better to quote channel levels in power dBm which is more applicable to both analogue and QAM channels. This, however, may be difficult to switch to because of the existing use of dBmV and not dBm.

6. It is planned to carry the QAM channels at –10 dB on the PAL I channel. In order to set this the resolution bandwidth must be allowed for. Using a 100 kHz bandwidth the displayed level should be –10 dB (level offset) –19 dB (bandwidth correction) below the analogue vision carriers i.e. –29 dB.

7. Where equalisation is present on a coaxial feed then allowance must be made for the slope on the cable when setting levels at a particular frequency.

8. Note:- Analogue channel frequencies are specified as the vision carrier frequency whereas the QAM channels are specified as centre frequency. For the 8 MHz HRC plan proposed the centre frequency is Vision carrier plus 2.75 MHz.

6. Acknowledgements

Thanks are due to Chris Swires of Swires Research for providing the plots attached to this document.

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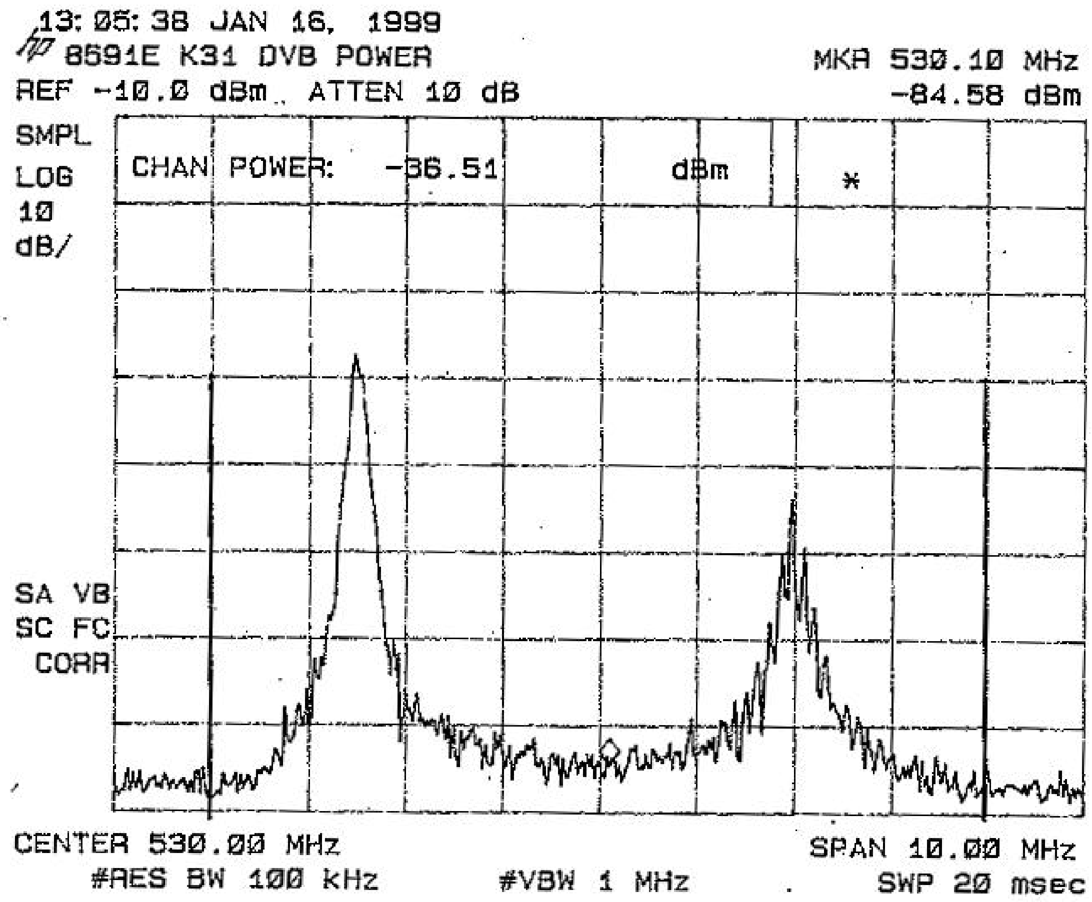
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-84.58 dBm
SMPL
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10
dB/
CHAN POWER: -36.51 dBm
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CORR
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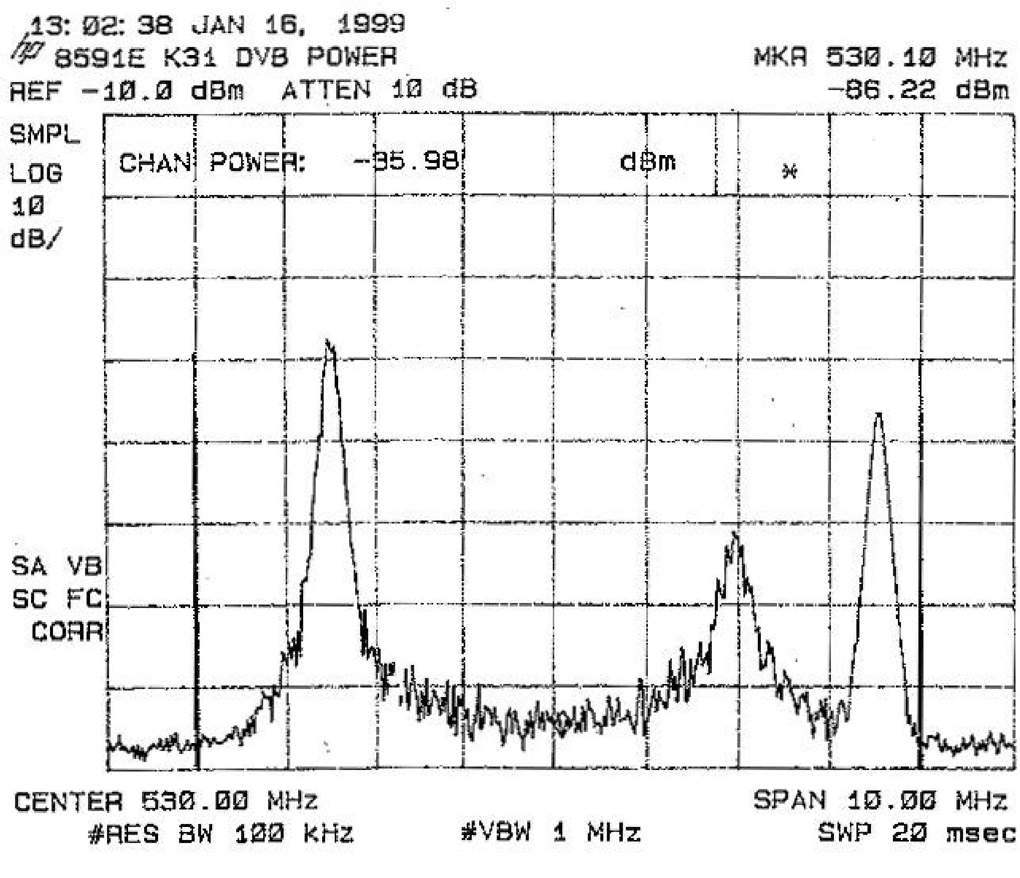
SWP 20 msec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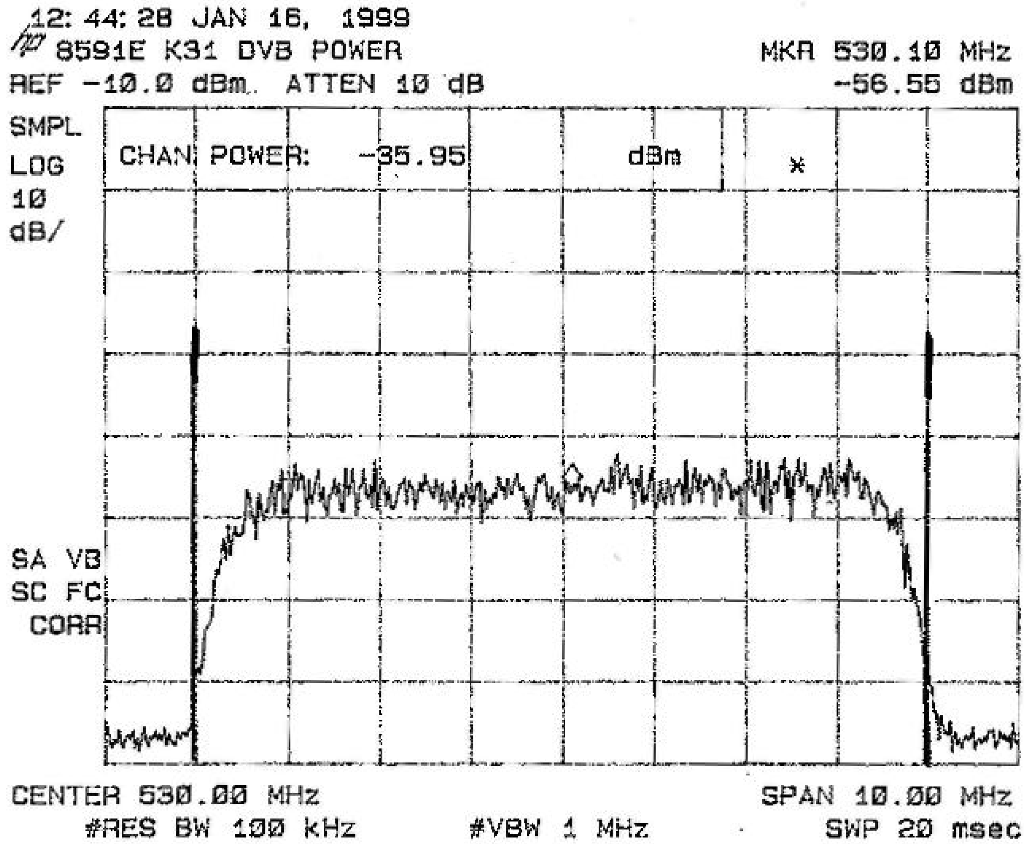
SMPL
LOG
10
dB/
CHAN POWER: -35.98 dBm
SA VB
SC FC
CORR
CENTER 530.00 MHz
SPAN 10.00 MHz
#RES BW 100 kHz
#VBW 1 MHz
SWP 20 msec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−56.55 dBm
SMPL
LOG
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dB/
CHAN POWER: −35.95 dBm
SA VB
SC FC
CORR
CENTER 530.00 MHz
SPAN 10.00 MHz
#RES BW 100 kHz
#VBW 1 MHz
SWP 20 msec