THE DILEMMA OF MIXED SYSTEMS

Nate Levine
Vice President, Engineering
Sammons Communications, Inc.

Most of us who operate cable systems and are providing twelve channels of service to our customers at a fixed fee have probably considered, at one time or another, the possibility of adding several additional channels in the mid or super band frequency range, providing converters to customers who desire these channels and charging an additional $2-$3 per month for this service. At the onset, this does not look like a difficult task since most cable systems today already have the necessary band width to carry mid band frequencies and most new systems being installed today have extended bands with widths of 260 or even 300 MHz.

At this point in time, it should be apparent to most of us that this should only be attempted on systems where second order distortion is at a minimum, such as a push-pull system. For the purpose of this presentation, we will assume that second order problems are non-existent and explore the other problems that arise when mid band and super band channels are added.

If only a portion of the total system subscribers request the extra services, we become faced with the problems of a "mixed system". It is categorized as mixed because it is a mixture of subscribers with converters and subscribers without converters. Under these conditions, several problems can occur. The first to be discussed is oscillator leakage from the non-converter subscriber's TV set into a particular feeder line.

Table I depicts the conventional mid band and super band video carrier frequencies.

TABLE I

CHANNEL MID BAND	VIDEO CARRIER	CHANNEL SUPER BAND	VIDEO CARRIER
A	121.25	J	217.25
B	127.25	K	223.25
C	133.25	L	229.25
D	139.25	M	235.25
E	145.25	N	241.25
F	151.25	O	247.25
G	157.25	P	253.25
H	163.25		
I	169.25		

Table II depicts the television receiver oscillator frequencies of all VHF channels and their relationship to the affected mid band channels.

TABLE II

VHF CHANNEL	OSCILLATOR FREQUENCY (MHz)		MID BAND CHANNEL CARRIERS	INTERFERING BEAT
2	101			
3	107			
4	113			
5	123	MID BAND	A = 121.25	1.75 MHz
6	129		B = 127.25	1.75 MHz
7	221		J = 217.25	3.75 MHz
8	227		K = 223.25	3.75 MHz
9	233		L = 229.25	3.75 MHz
10	239	SUPER BAND	M = 235.25	3.75 MHz
11	245		N = 241.25	3.75 MHz
12	251		O = 247.25	3.75 MHz
13	257		P = 253.25	3.75 MHz

As can be seen from this table, television sets tuned to Channels 5 or 6 have oscillator frequencies that are in the mid band spectrum. It can also be noted from Table II that all the high band channels have oscillator frequencies falling in the band commonly referred to as super band, frequencies 216-260. These frequencies appear at the antenna terminal points of a TV receiver and travel back into the feeder line.

Table III shows the amount of oscillator signal available at the antenna terminal of various TV receivers tested.

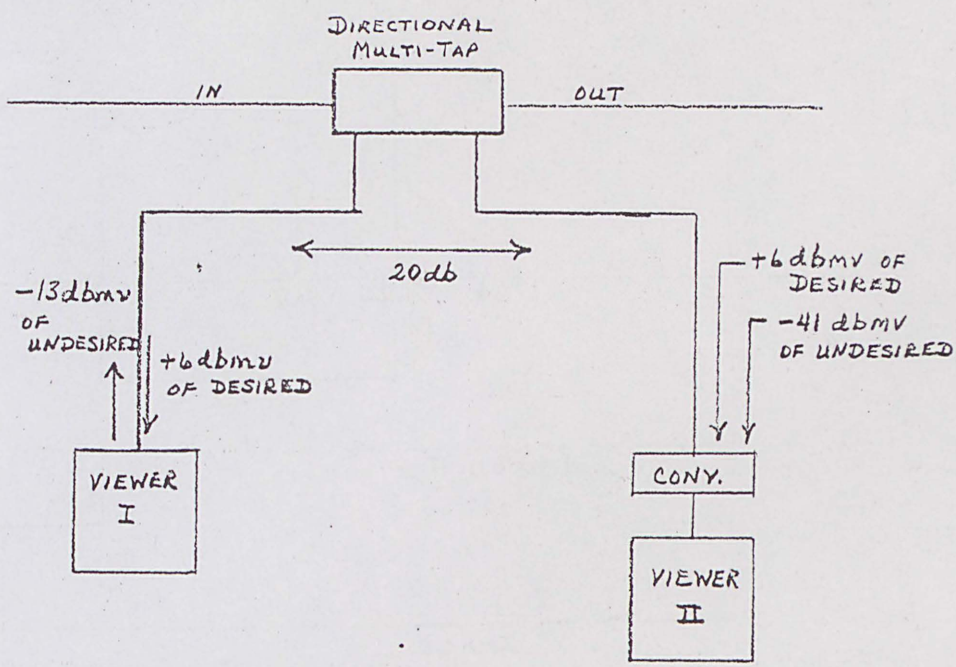
TABLE III[1]

OSCILLATOR LEAKAGE OF VARIOUS TELEVISION RECEIVERS

CHANNEL	RECEIVER A	RECEIVER B	RECEIVER C	RECEIVER D	RECEIVER E	RECEIVER F
4	-22.0	-12.0	-15.0	-12	-13.0	-24.0
5	-14.0	+ 2.0	-13.0	-11	- 8.0	-30.0
6	-11.0	+ 4.0	-13.0	- 9.5	- 7.5	-30.0
7	- 3.0	+19.0	- 4.0	+ 6	- 3.0	-18.0
8	+ 1.0	+21	- 4.0	+ 5.5	- 1.5	-14.0
9	+ 1.0	+21	- 2.0	+ 8.0	- 2.0	-10.0
10	0.0	+24.5	- 3.0	+ 9.0	- 4.0	-20.0
11	- 3.0	+20.0	- 4.0	+10.0	- 8.0	-20.0
12	- 7.0	+11.0	0.0	+ 8.0	- 3.0	-11.0
13	- 5.0	+10.0	- 1.0	+ 6.0	- 4.0	-12.0

Figure 1 is a diagram of two subscribers receiving signal through a directional multi tap.

FIGURE 1



Viewer 1 does not have a converter and is tuned to Channel 5 using TV Receiver Set C which has an oscillator leakage of -13 dbmv. Viewer 2 is tuned to Channel A. Both lines are delivering +6 dbmv of desired signal.

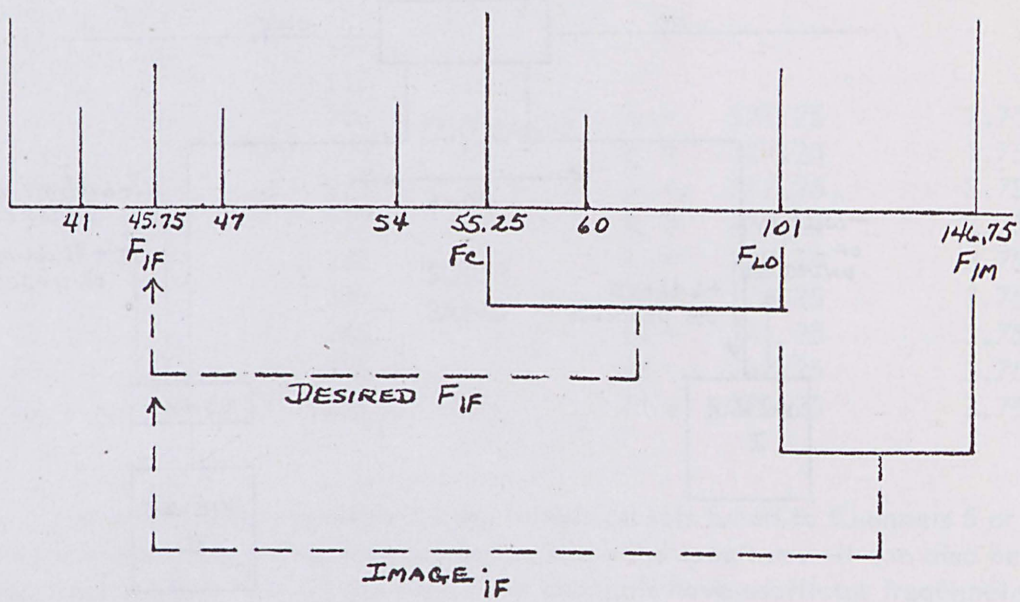
Viewer 1 originates on 123 MHz carrier at -13 dbmv. The oscillator signal travels up the drop line losing approximately 4 db. It travels through the directivity of the coupler, approximately 20 db, and down converter's B drop line, losing an additional 4 db. Total loss of undesired signal: 4 + 20 + 4 = 28. Oscillator leakage signal appearing at Viewer 2 is, therefore, -41 dbmv (-13 dbmv from Viewer 1 oscillator + 28 db of loss). Ratio between desired +6 dbmv and undesired -41 dbmv = 47 db.

Video carrier Channel A at Viewer 2, beating with undesired signal at 123 MHz, produces a 1.75 MHz beat, 47 db below the desired signal. This type of beat, because of its proximity to the desired video carrier, must be at least 60 db down for it not to be objectionable.

Referring back to Table III, you will note that TV Receiver Set C having an oscillator leakage of -13 dbmv was chosen. You will note that other TV receivers have oscillator signals as high as +2 dbmv. This much leakage would produce a beat only 32 db down.

Another problem that faces us when we carry more than twelve channels on a cable system is one called "image". The image frequency of a receiver is defined as the desired signal ± two times the receive IF. This is best shown by Figure 2.

FIGURE 2



Here we see desired Channel 2 at 55.25 MHz beating with the local oscillator signal at 101 MHz to produce IF at 45.75. Also observe that a signal at 146.75 can beat with the local oscillator to produce the desired IF signal. The 146.75 MHz frequency is referred to as Channel 2's image. Its presence into the receiver's IF is limited by the tuner's image rejection capability. Image rejection typically runs as follows:

A. 3 circuit tuners: used in low cost TV sets
low band 50 db
high band 35 db

B. 4 circuit tuners: used in better black and white sets and color sets
all VHF channels 60 db

Let us now explore the possible image problems. Table IV depicts all the VHF carriers' image frequencies and interference possibilities.

TABLE IV

CHANNEL	VIDEO CARRIER (MHz)	IMAGE FREQUENCY	BEAT	CAUSE
2	55.25	146.75	1.5 MHz	E Video
3	61.25	152.75	1.5 MHz	F Video
4	67.25	158.75	1.5 MHz	G Video
5	77.25	168.75	-.5 MHz	I Video
6	83.25	174.75	-.5 MHz	7 Video
7	175.25	266.75		
8	181.25	272.75		
9	187.25	278.75		
10	193.25	284.75		
11	199.25	290.75		
12	205.25	296.75		
13	211.25	302.75		

It should be noted that mid band Channels E, F and G are the only serious potential offenders since Channel 7 and I Video carriers produce a negative beat in relationship to the desired carrier. A negative beat is less objectionable because of the added attenuation offered by its position on the IF slope in a TV receiver. High band channel images fall 266 to 305 MHz and are not a problem until that portion of the band is used.

Let us now summarize our potential problems: (1) In the mid band, we are faced with oscillator leakage problems from Channels 5 and 6 into Channels A and B and image problems into Channels 2, 3 and 4 caused by E, F and G Video; (2) In the super band, oscillator leakage from Channels 7 through 13 affects Channels J through P, but image problems are non-existent.

What are the possible solutions to these problems when we try to operate a mixed system? The simplest solution would be to carry only Channels C, D, H and I in the mid band since these are the only channels that are not affected by local oscillator and image problems. Another suggestion that would permit us to carry mid band Channels A and B would be to delete Channels 5 and 6 or carry material on Channels 5 and 6 that is not significantly viewed such as the weather scan. Still another possible solution is to supply mid band band-stop filters and super band band-stop filters to non-converter subscribers. The mid band filters would eliminate the local oscillator feedback into the system, and the super band band-stop filters would not allow the images of the VHF channels into the subscribers' TV sets. The problems of this solution should be apparent. Perhaps the best solution is to carry a limited number of out-of-band channels and carefully select the frequencies so that the offending beats fall in a less objectionable portion of the IF curve.

To date, we can only speculate on the magnitude of the problems discussed since there are not enough "mixed" cable systems in operation for us to gather sufficient data. It is quite possible that image rejection of most TV sets will be sufficient. Perhaps as more extended band systems are built and additional channels are added, the proper solution will become self-evident.

---

[1] Jeffers, Mike, "Best Frequency Assignments for Mid Band and Super Band Channels", 19th Convention Transcript, Page 66-78.

TABLE I

CHANNEL MID BAND	VIDEO CARRIER	CHANNEL SUPER BAND	VIDEO CARRIER
A	121.25	J	217.25
B	127.25	K	223.25
C	133.25	L	229.25
D	139.25	M	235.25
E	145.25	N	241.25
F	151.25	O	247.25
G	157.25	P	253.25
H	163.25		
I	169.25		

TABLE II

VHF CHANNEL	OSCILLATOR FREQUENCY (MHz)	MID BAND CHANNEL CARRIERS	INTERFERING BEAT
2	101		
3	107		
4	113		
5	123	A = 121.25	1.75 MHz
6	129	B = 127.25	1.75 MHz
7	221	J = 217.25	3.75 MHz
8	227	K = 223.25	3.75 MHz
9	233	L = 229.25	3.75 MHz
10	239	M = 235.25	3.75 MHz
11	245	N = 241..25	3.75 MHz
12	251	O = 247.25	3.75 MHz
13	257	P = 253.25	3.75 MHz

TABLE III

OSCILLATOR LEAKAGE OF VARIOUS TELEVISION RECEIVERS

CHANNEL	RECEIVER A	RECEIVER B	RECEIVER C	RECEIVER D	RECEIVER E	RECEIVER F
4	-22.0	-12.0	-15.0	-12	-13.0	-24.0
5	-14.0	+ 2.0	-13.0	-11	- 8.0	-30.0
6	-11.0	+ 4.0	-13.0	- 9.5	- 7.5	-30.0
7	- 3.0	+19.0	- 4.0	+ 6	- 3.0	-18.0
8	+ 1.0	+21	- 4.0	+ 5.5	- 1.5	-14.0
9	+ 1.0	+21	- 2.0	+ 8.0	- 2.0	-10.0
10	0.0	+24.5	- 3.0	+ 9.0	- 4.0	-20.0
11	- 3.0	+20.0	- 4.0	+10.0	- 8.0	-20.0
12	- 7.0	+11.0	0.0	+ 8.0	- 3.0	-11.0
13	- 5.0	+10.0	- 1.0	+ 6.0	- 4.0	-12.0

FIGURE 1

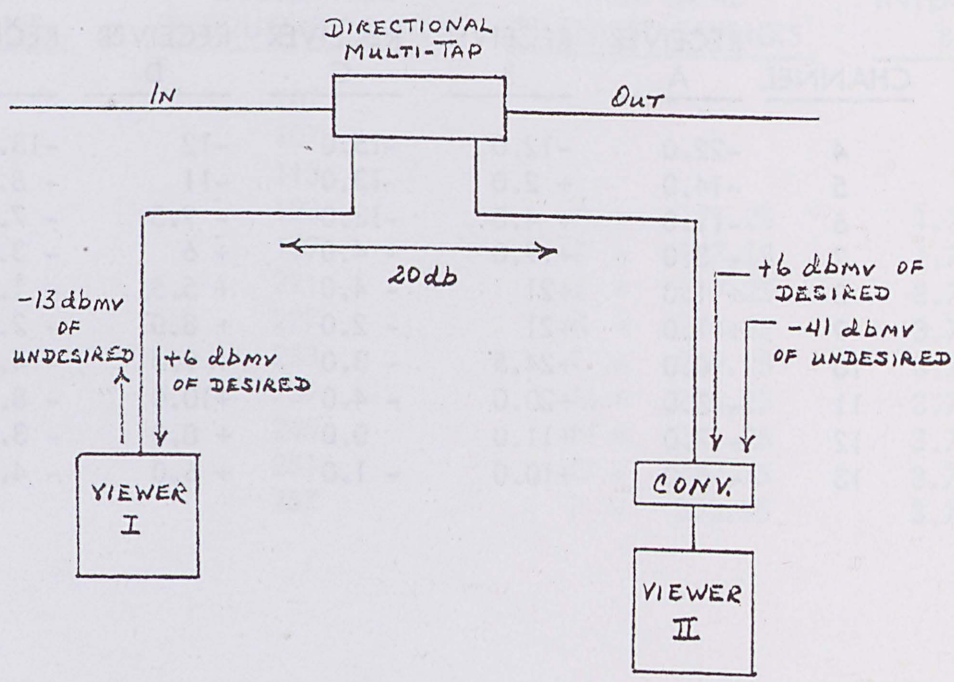

DIRECTIONAL
MULTI-TAP
IN
OUT
20db
-13 dbmv
OF
UNDESIRED
+6 dbmv
OF DESIRED
+6 dbmv OF
DESIRED
-41 dbmv
OF UNDESIRED
VIEWER
I
CONV.
VIEWER
II

FIGURE 2

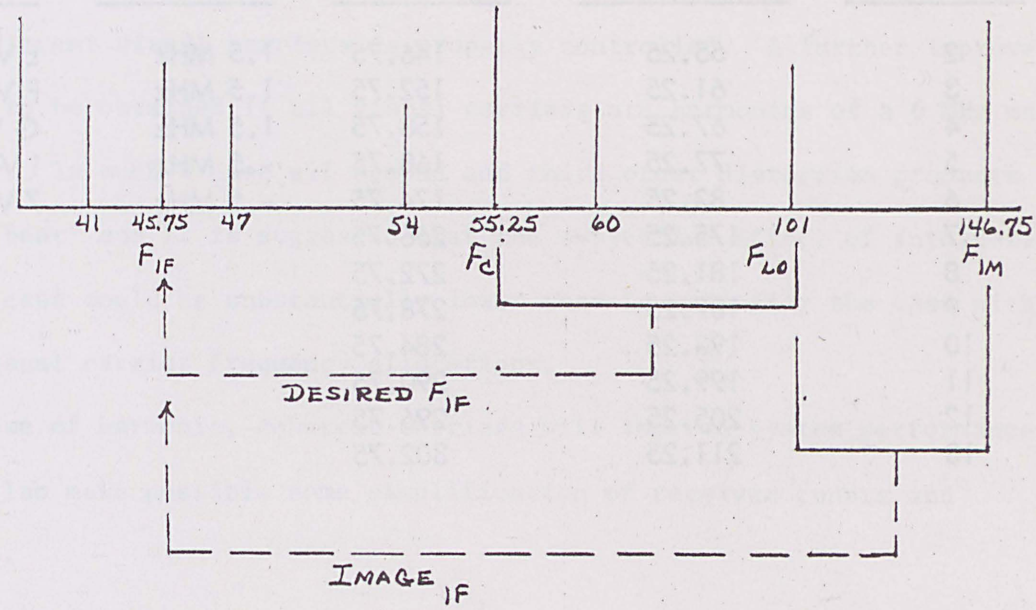

41
45.75
47
54
55.25
60
101
146.75
F_{IF}
F_C
F_{LO}
F_{IM}
DESIRED F_{IF}
$IMAGE_{IF}$

TABLE IV

CHANNEL	VIDEO CARRIER (MHz)	IMAGE FREQUENCY	BEAT	CAUSE
2	55.25	146.75	1.5 MHz	E Video
3	61.25	152.75	1.5 MHz	F Video
4	67.25	158.75	1.5 MHz	G Video
5	77.25	168.75	-.5 MHz	I Video
6	83.25	174.75	-.5 MHz	7 Video
7	175.25	266.75		
8	181.25	272.75		
9	187.25	278.75		
10	193.25	284.75		
11	199.25	290.75		
12	205.25	296.75		
13	211.25	302.75		