COMPOSITE TRIPLE BEAT MEASUREMENTS

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Abstract

This paper presents a set of curves which show the relative readings between a power meter signal level meter and spectrum analyzer, when measuring the composite (summation) triple beat on a particular channel. The curves allow the CATV operator to obtain a correct measurement (RMS) of composite triple beat for system performance when using common instruments such as the spectrum analyzer or signal level meter.

A plot of a computer run made at RCA is also given showing the total equivalent triple beats on the worst case channel versus the number of channels.

Introduction

The question of how to measure triple beat (third order intermodulation) has been a problem in the CATV industry. One method is to measure a single triple beat and extrapolate to a 35-channel case. The problem with this method is that the single triple beat level will vary depending on the test frequencies used, resulting in poor correlation with the composite triple beat level produced when all channels are operated. A measurement of the composite triple beat per channel would be more practical since the composite triple beat produces the undesirable effects on a Television screen. The problem with measuring the composite level is that it is below the system noise level in the trunk line. In the high level distribution, the composite level is above the system noise level, but the problem becomes one of instrumentation. Most signal level instrumentation available to the CATV operator is not capable of true power (RMS) measurement of complex signal waveforms such as noise or multiple sine waves. Correction factors need to be established for typical signal level instrumentation used in the cable industry such as spectrum analyzers and signal level meters. The purpose of this paper is to present a set of curves which show the relative readings between a power meter (RMS), signal level meter (peak) and a spectrum analyzer (peak or average).

Figure 1

This figure shows the relative instrument measurement in dB versus the total equivalent triple beat per channel for the worst case channel. The data was taken by measuring a single frequency signal with each of the instruments to obtain a reference point on the meter or CRT. Additional signals were added, then additional attenuation to return the readings to its reference point. The attenuator reading was used as the measured value. Individual signal generators were combined to form the composite beats when the number of measured beats was below 7. Amplifier distortion was used to generate beat combinations which were greater than 7. The Test Setup is shown in Appendix A.

Curve 1 has a 20 log N slope and is shown for reference only.

Curve 2 was plotted using the readings of the noise peaks measured on a spectrum analyzer in the log mode without the video filter. The analyzer used was a HP8554L/8552A.

Curve 3 is the reading on a Jerrold 727 Signal Level Meter.

Curve 4 is the true RMS reading mode with an HP 435A power meter.

Curve 5 was made with the spectrum analyzer in the linear mode and with the 100 Hz video averaging filter switched in.

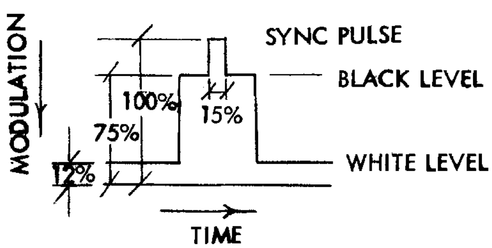
Curve 6 was made with the spectrum analyzer in the log mode and with the 100 Hz video averaging filter switched in.

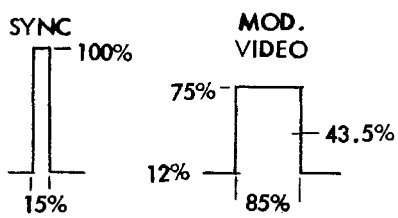
One can see from the curves that the commonly used instruments can be calibrated to the power meter or to each other. The averaged readings on the spectrum analyzer parallel the power meter readings which would require a constant correction factor, whereas the signal level meter would require a variable correction factor depending on the number of channels.

Effects of Modulation

The threshold of perceptibility of the composite triple beat on a TV receiver, based on subjective tests performed at RCA, was the same RMS level for modulated carriers as it was for unmodulated carriers. The difference was that the output level of the amplifier could be increased approximately 5 dB when the carriers were modulated to obtain the same RMS level for the composite triple beat.

The 5 dB change in level would mean that the modulation caused the average level to change 5 dB. This can be verified by calculating the average level of a modulated carrier, assuming that the distribution of grey level information is approximately uniform.





Total Average Level = Average level in sync pulse + average level in modulated video

$$= 100 \times .15 + \frac{(75 + 12)}{2} \times .85$$

$$= 100 \times .15 + 43.5 \times .85$$

$$= 51.98\% = 52\%$$

The average level in a modulated carrier versus an unmodulated carrier would be 52% or 5.6 dB from the peak carrier.

When measuring the composite triple beat with a power meter (true RMS), the reference should be measured without modulation on the observed channel because the power meter will not measure the peak (which is the desired reference) with modulation.

Threshold of Perceptibility

Figure 2 is a plot of two curves, Curve 1 being the required system level of an individual triple beat as a function of the total number of beats per channel. The measured points on Curve 1 were found by observing the threshold of perceptibility on a TV receiver of the total third order intermodulation (composite triple beat) on one channel and then measuring the level of an individual triple beat.

Curve 2 is a plot of the threshold level of perceptibility of the total third order intermodulation (composite triple beat) per channel. Curve 2 was derived from Curve 1 mathematically by summing levels of the third order intermodulation products that fall on one channel and the curve was verified by measuring the composite triple beat with the power meter as indicated in this paper.

A detailed analysis of Figure 2 is given in a previous paper. (1)

Figure 3

This figure is a plot of a computer run made at RCA showing the total equivalent triple beat on the worst case channel versus the number of channels. The worst case channel as shown in the computer run is the center channel in any group of channels. For this figure, channel 8 was used as the worst case channel and other channels were added evenly on each side of Channel 8.

The lower curve was derived by adding channels, 6 MHz apart on each side of channel 8. The discontinuity shown by the dotted lines is the point where the low band channels (2-6) were added, beginning with channel 6.

The upper curve began with the standard 12 channels adding the midband channels and then the superband channels.

Summary

1. The correction factor can be found from Figure 1 for two common instruments used in CATV for measuring the composite triple beat.

2. The effect of modulation is to reduce the average level approximately 5 dB.

(1)
Arnold, Bert "Required System Triple Beat Performance" RCA, North Hollywood, California 91605, 1973.

3. Figure 2 gives the threshold of perceptibility for third order intermodulation (triple beat) for a single triple beat and a composite triple beat.

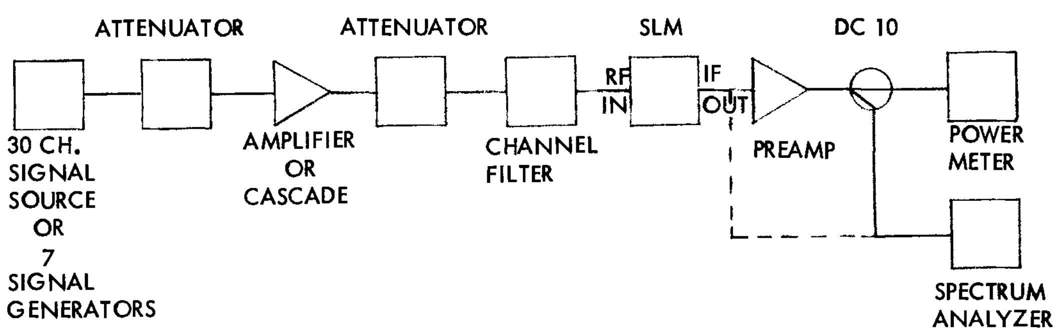
4. Figure 3 gives total triple beat per channel versus the number of channels.

5. The curves in this paper gives the system designer the tools to design and proof a system to insure the system is within the output capabilities of the system equipment.

APPENDIX A

Test Set Up for Triple Beat Measurement

Equipment	Manufacturer	Model
30 Ch. Signal Source	Theta Com	KTSS
Signal Generators	Hewlett-Packard	3200
Attenuators	Texscan	SA-70
Amplifier	TRW	206
Cascade	RCA	150
Filter	RCA	-
Signal Level Meters	Jerrold	727
Directional Coupler	Dolphin	DC-10
Power Meter	Hewlett-Packard	435A
Spectrum Analyzer	Hewlett-Packard	8554L/8552A



The IF output (TP2, J203) was used on the Jerrold 727 in order to provide selectivity for the power meter.

FIGURE 1

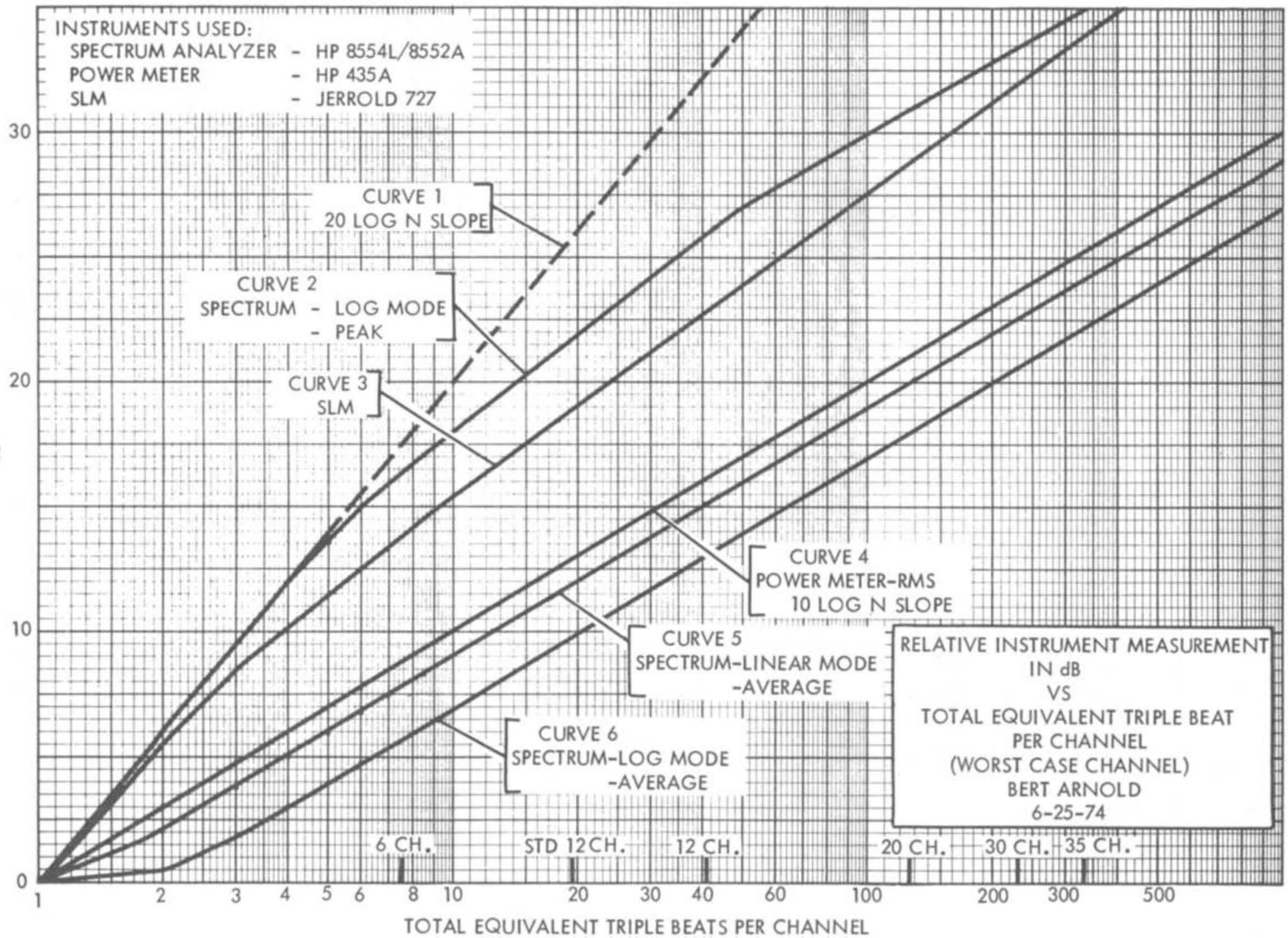
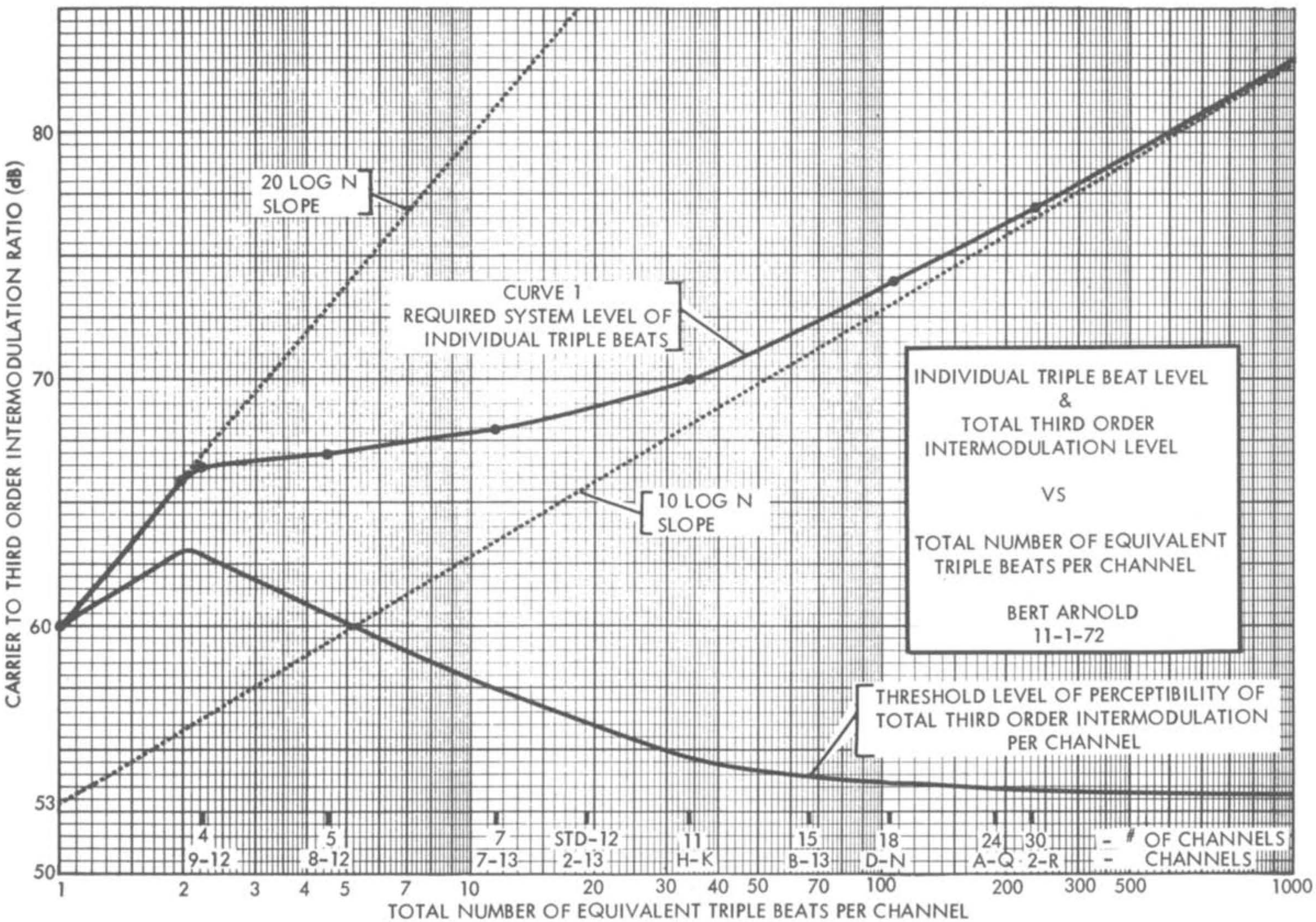
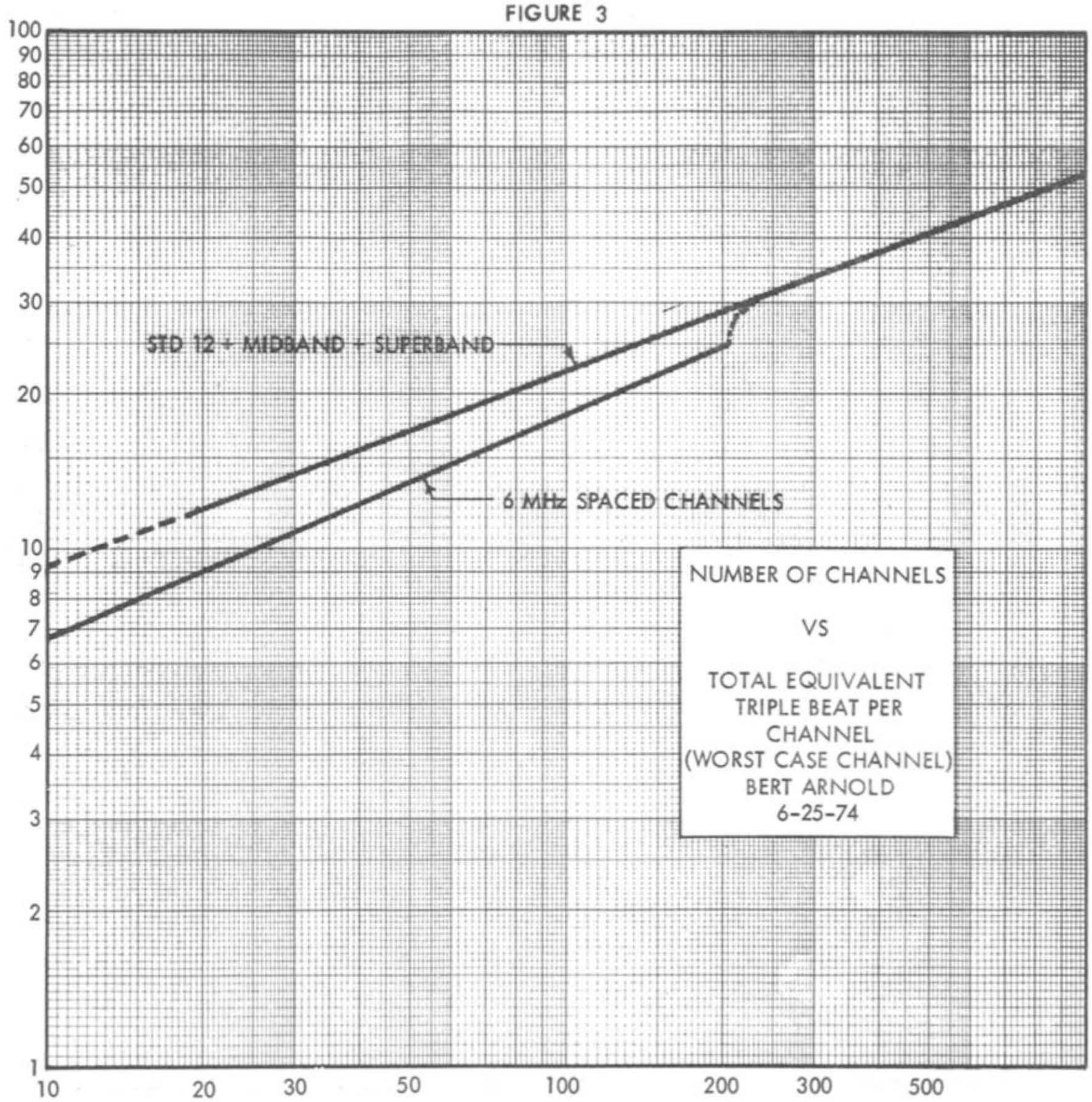

INSTRUMENTS USED:
SPECTRUM ANALYZER - HP 8554L/8552A
POWER METER - HP 435A
SLM - JERROLD 727
CURVE 1
20 LOG N SLOPE
CURVE 2
SPECTRUM - LOG MODE
- PEAK
CURVE 3
SLM
CURVE 4
POWER METER-RMS
10 LOG N SLOPE
CURVE 5
SPECTRUM-LINEAR MODE
-AVERAGE
CURVE 6
SPECTRUM-LOG MODE
-AVERAGE
RELATIVE INSTRUMENT MEASUREMENT
IN dB
VS
TOTAL EQUIVALENT TRIPLE BEAT
PER CHANNEL
(WORST CASE CHANNEL)
BERT ARNOLD
6-25-74
6 CH.
STD 12 CH.
12 CH.
20 CH.
30 CH.
35 CH.
dB
0
10
20
30
1
2
3
4
5
6
8
10
20
30
40
60
100
200
300
500
TOTAL EQUIVALENT TRIPLE BEATS PER CHANNEL

FIGURE 2



CARRIER TO THIRD ORDER INTERMODULATION RATIO (dB)
80
70
60
53
50
20 LOG N SLOPE
CURVE 1
REQUIRED SYSTEM LEVEL OF INDIVIDUAL TRIPLE BEATS
10 LOG N SLOPE
INDIVIDUAL TRIPLE BEAT LEVEL & TOTAL THIRD ORDER INTERMODULATION LEVEL VS TOTAL NUMBER OF EQUIVALENT TRIPLE BEATS PER CHANNEL
BERT ARNOLD
11-1-72
THRESHOLD LEVEL OF PERCEPTIBILITY OF TOTAL THIRD ORDER INTERMODULATION PER CHANNEL
4 9-12
5 8-12
7 7-13
STD-12 2-13
11 H-K
15 B-13
18 D-N
24 A-Q
30 2-R
- # OF CHANNELS
- CHANNELS
1
2
3
4
5
7
10
20
30
40
50
70
100
200
300
500
1000
TOTAL NUMBER OF EQUIVALENT TRIPLE BEATS PER CHANNEL

FIGURE 3



STD 12 + MIDBAND + SUPERBAND
6 MHz SPACED CHANNELS
NUMBER OF CHANNELS
VS
TOTAL EQUIVALENT
TRIPLE BEAT PER
CHANNEL
(WORST CASE CHANNEL)
BERT ARNOLD
6-25-74
100
90
80
70
60
50
40
30
20
10
9
8
7
6
5
4
3
2
1
10
20
30
50
100
200
300
500