SUPERFLAT FEEDFORWARD TRUNK AMPLIFIER DESIGN

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JERROLD/CENTURY III

ABSTRACT

It is well known that a cable system's performance depends to a large extent on the peak -to-valley response maintained along the cascade. As the peak-to-valley response begins to degrade, it becomes increasingly difficult to keep proper operating levels through the cascade. In the past, minimum cascade performance specifications have allowed a maximum peak-to-valley of (N/10)+1 at the end of the cascade. Other formulas have been used as well depending on the length of the cascade or on system sensitivity to changes over temperature. This performance specification could only be met after the module had been aligned in the system.

Prior amplifier designs allowed each amplifier to have a minimum peak-to-valley variation, which if allowed to propagate through the cascade, could result in additional alignment time required on the part of the field service technician. If the number of "mop-up" controls within the amplifier were too large, then the number of variables under the technician's control would increase. This resulted in a great degree of control over the cascade peak-to-valley, but with more variables the chance of detuning in the field was increased. In order to solve this problem a "superflat" amplifier would have to be designed which would allow the field technician to plug it directly into the cascade without requiring any additional field alignment.

This amplifier would require a peak-maximum peak-to-valley of less than 0.2 dB over the 50 to 550 Mhz bandwidth, in order to maintain a maximum of 2.6 dB peak-to-valley response at the end of a 16 amplifier cascade. If the amplifier could meet this specification on the bench it could then be installed into the cascade without any additional mop-up. The time required to obtain satisfactory system performancer would be decreased. If an amplifier should fail then replacing it would not require any system realignment. This paper will describe the basic design concepts and performance results of such an amplifier.

AMPLIFIER CONCEPTION

The superflat amplifier concept was introduced to improve the trunk cascade system performance while reducing field alignment time. The basic concept was to integrate the individual components of the feedforward trunk module into independent assemblies.

This permits the individual testing of subassemblies which make the complete module function. If each subassembly, such as the slope control, gain control, interstage equalizer, and feedforward stage can be individually tested and evaluated to a known standard, then accurate repeatable results may be obtained at the final module level.

THE BUILDING BLOCKS

The first requirement for this trunk amplifier would be a very flat feedforward gain block. The TRW FF224/FF124 stage met this requirement with the aid of Jerrold/Century III feedforward enhancement circuits (patent pending) which include feedforward thermal compensation networks. An excellent yield of feedforward stage "clones" satisfying the basic requirements of flatness and performance over temperature were used.

The feedforward gain blocks input and output matches were typically >= 20 db with a peak-to-valley response of +/-.15 dB between 50 and 580 mhz The typical crossmodulation observed in each feedforward stage was an average of -80 db at +46 dBmV when measured with a 6 db linear tilt. The C T B measurements appeared to be within the same range

The module's standard push-pull pre-amp cascode input I C. would have to be chosen based on flatness, noise figure, crossmodulation performance, and composite second order beat as measured at 547.25 Mhz. It appears that one limiting factor in the system design will be composite second order beats at the highest channels. This is due primarily to the contribution by the input stage when the gain and slope controls are operating with attenuation at cold temperatures.

The input I.C. chosen was a PHI 5517-21. This device combines excellent noise figure, ideal gain, low crossmodulation and composite beat products.

SPECIAL CONSIDERATIONS

The use of surface mount capacitors was essential in minimizing the series inductances and non-uniformities which result from the use of leaded bypass and coupling capacitors. The performance near 550 Mhz was dramatically improved and insertion loss throughout the board was significantly reduced at 550 Mhz.

AGC REQUIREMENTS

The basic block diagram as shown in Fig. 1 displays the complete feedforward amplifier and its associated AGC circuits which are used to maintain output levels constant with temperature related cable attenuation.

The A.G.C. circuits must be capable of pilot level control at 500Mhz. This required a strip line type filter which maintains stability while providing sufficient bandwidth attenuation for adjacent carriers. A high stability R.F. amplifier must be provided (a pair of Motrola MHW110 's) to guarantee sufficient gain and stability.

Shielding the A.G.C. section from the R.F. broadband section is extremely important in the feedforward module design because the signals present in the A.G.C. are at elevated levels and are capable of interfering with the low distortion feedforward signals. The high pilot filter, the A.G.C R.F. amplifiers, and the video amplifiers must be well shielded.

The 550 Mhz wide bandwidth will require a pilot near each end of the band for sufficient A.G.C. control. Pilot channels are 67.25 Mhz and 499.25 Mhz The module's broadband frequency response would have to be 50 to 580 Mhz, in order to allow sufficient guard band for 550 Mhz cascadeability

SLOPE AND GAIN CONTROL

To insure adaquate slope control range and linearity the pivot point for the slope control is hinged at 550 Mhz. with the low pilot channel controlling the slope. The slope control must introduce a minimum amount of insertion loss at the pivot point while allowing 20 dB return loss over the entire bandwith and over 8 dB of cable change.

AMPLIFIER FLATNESS CONTROL

An early design goal was to eliminate all "mop-up" controls from the module. However, due to a slight amount of low frequency roll off occurring in the feedforward stage, a single low frequency control was necessary. This control was set up at the bench level and required no further adjustment once in the cascade. The only other controls available for system alignment are the actual equalizers which are located at the input and interstage.

PERFORMANCE REQUIREMENTS

The design formula used for system flatness over temperature was dB = N/10+1. Therefore, in a 16 amplifier cascade the maximum peak-to-valley would be 2.6 dB worst case. If we assume that the room temperature peak-to-valley is 1.6 dB then we may allow a 1 dB change to occur over the temperature gradient, if we are to maintain a peak-to-valley response of 2.6 dB at the end of the 16 amplifier cascade. The response of each amplifier must therefore average 1.6/16 or .1 dB peak-to-valley at room temperature.

If each amplifier was bench aligned to ±.1 dB peak-to-valley, then we could install the modules without additional cascade alignment time. This precise requirement of accurate bench alignment means that an absolutely flat digitized reference be used so that the signatures within the sweep system can be completely cancelled out.

BENCH ALIGNMENT EQUIPTMENT

Fig 2 illustrates the bench alignment setup used to acheive the desired results. A sweep system that can resolve variations of .1 dB is described for this purpose. An adaquate bench alignment system that eliminates all response bumps attributed to the bench set up is absolutely necessary if the cascade is to be prealigned accurately. The procedure requires a sweep system with a digitized sweep reference and it must be logrithmic in its screen display inorder to produce a minimum resolution of .2 dB/per division

After the bench alignment in a common fixture, the modules were checked in their final connector chassis (mother board) which will be used in the cascade. Each trunk was aligned for 26 dB of cable at 550 Mhz.

THE CASCADE

Upon installation into the cascade, additional mop-up was not attempted until all sixteen modules were installed. Final cascade alignment was required on some of the modules to allow for slight equalizer adjustment since the cable spaceings in the cascade are not always identical to those used on the bench setup. The system flatness was very easy to control with minor equalizer adjustment on a few of the 16 amplifiers.. The interstage equalizer was the only variable required. A combination equalizer/"mop-up" board was designed as a plug-in replacement for the interstage equalizer, but its use was not required.

CASCADE PERFORMANCE

The room temperature response achieved was a peak-to-valley of 1.72 db (fig. 4). The discontinuities at 67 and 500 Mhz are due to the presence of pilot carriers during the sweep display interval.

The 16 amplifier cascade response at -25 degress F resulted in a peak-to-valley of 2.46 dB (fig. 3) and the response at +134 degrees F. was the worst case peak-to-valley of 2.6 dB (fig. 5). The composite 2nd order, composite triple beat, carrier to noise, and crossmodulation as observed at these temperatures are given in table 1.

CONCLUSIONS

It appears that improved system performance will be obtained when the system flatness is improved. If the peak-to-valley performance improves over temperature then the carrier-to-noise ratio will be smoother over the entire band Other system parameters are also affected and they improve directly as the response becomes flatter.

As the system response flatens we see less change in the critical parameters which affect the overall dynamic performance throughout the operating temperature range. Valuable experience has been gained concerning component size and layout considerations as they apply to bandwidths in excess of 550Mhz. The technology exists now to reduce system maintenance costs by improving the product.

We may now save valuable time and improve system performance through the use of accurate sweep methods, surface mounted components, superflat feedforward stages, and prealigned subassemblies. Together they may be combined into a "super-flat" trunk amplifier which approaches the theoritical limits in state of the art performance capability.

ACKNOWLEDGEMENTS

I would like to thank Mark Gibbons for his efforts in the cascade. Thanks to Ed Mitchell and Vic Tarbutton for their support and belief that these goals could somehow be acheived. Admiration for my fat Mac computer on which this paper was prepared.

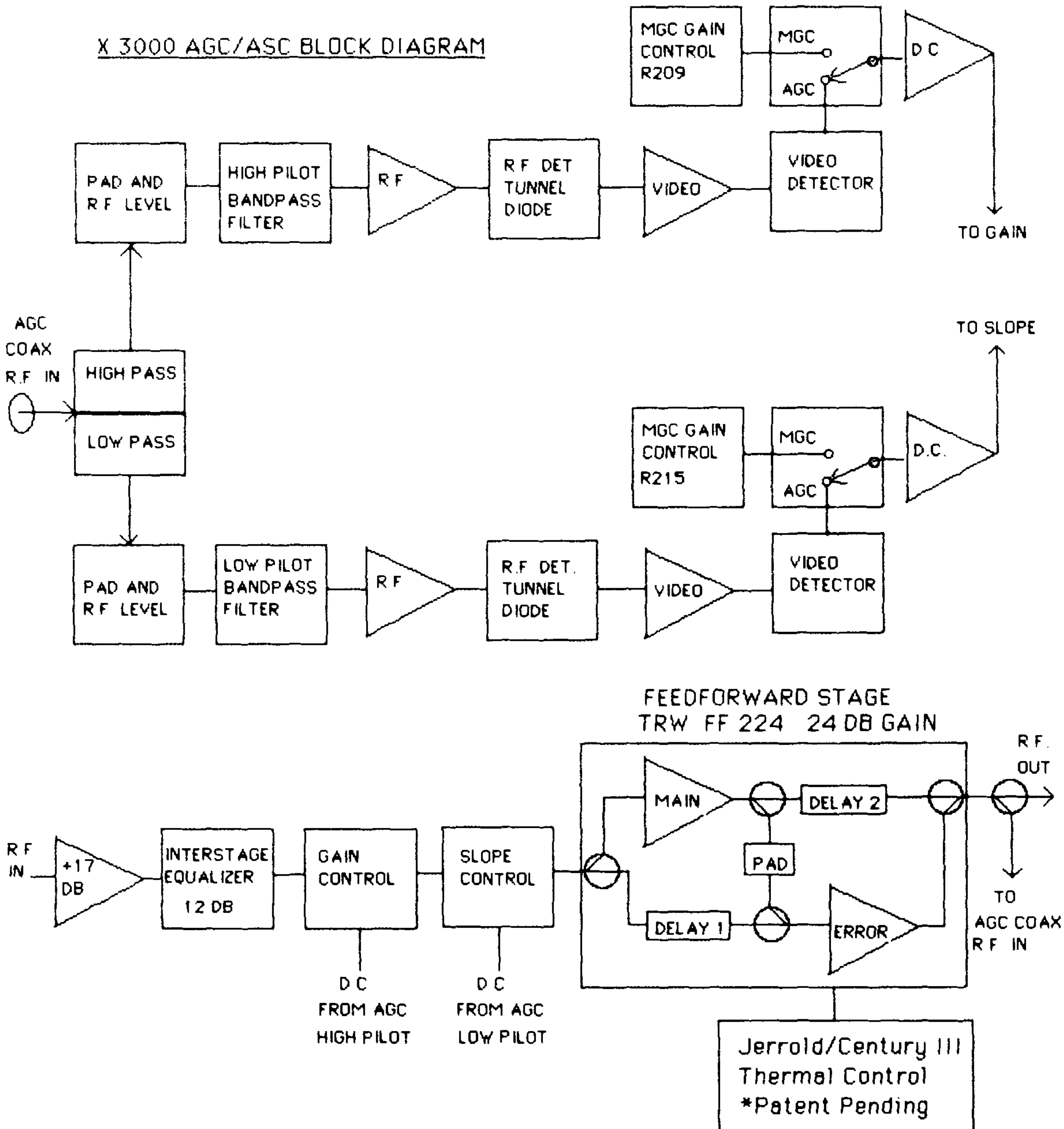

X 3000 AGC/ASC BLOCK DIAGRAM
MGC GAIN CONTROL R209
MGC
AGC
D C
PAD AND R F LEVEL
HIGH PILOT BANDPASS FILTER
R F
R F DET TUNNEL DIODE
VIDEO
VIDEO DETECTOR
TO GAIN
AGC COAX R.F IN
HIGH PASS
LOW PASS
TO SLOPE
MGC GAIN CONTROL R215
MGC
AGC
D.C.
PAD AND R F LEVEL
LOW PILOT BANDPASS FILTER
R F
R.F DET. TUNNEL DIODE
VIDEO
VIDEO DETECTOR
FEEDFORWARD STAGE
TRW FF 224 24 DB GAIN
R F IN
+17 DB
INTERSTAGE EQUALIZER 12 DB
GAIN CONTROL
SLOPE CONTROL
MAIN
DELAY 2
PAD
DELAY 1
ERROR
R F. OUT
TO AGC COAX R F IN
D C FROM AGC HIGH PILOT
D C FROM AGC LOW PILOT
Jerrold/Century III
Thermal Control
*Patent Pending

FIG. 1

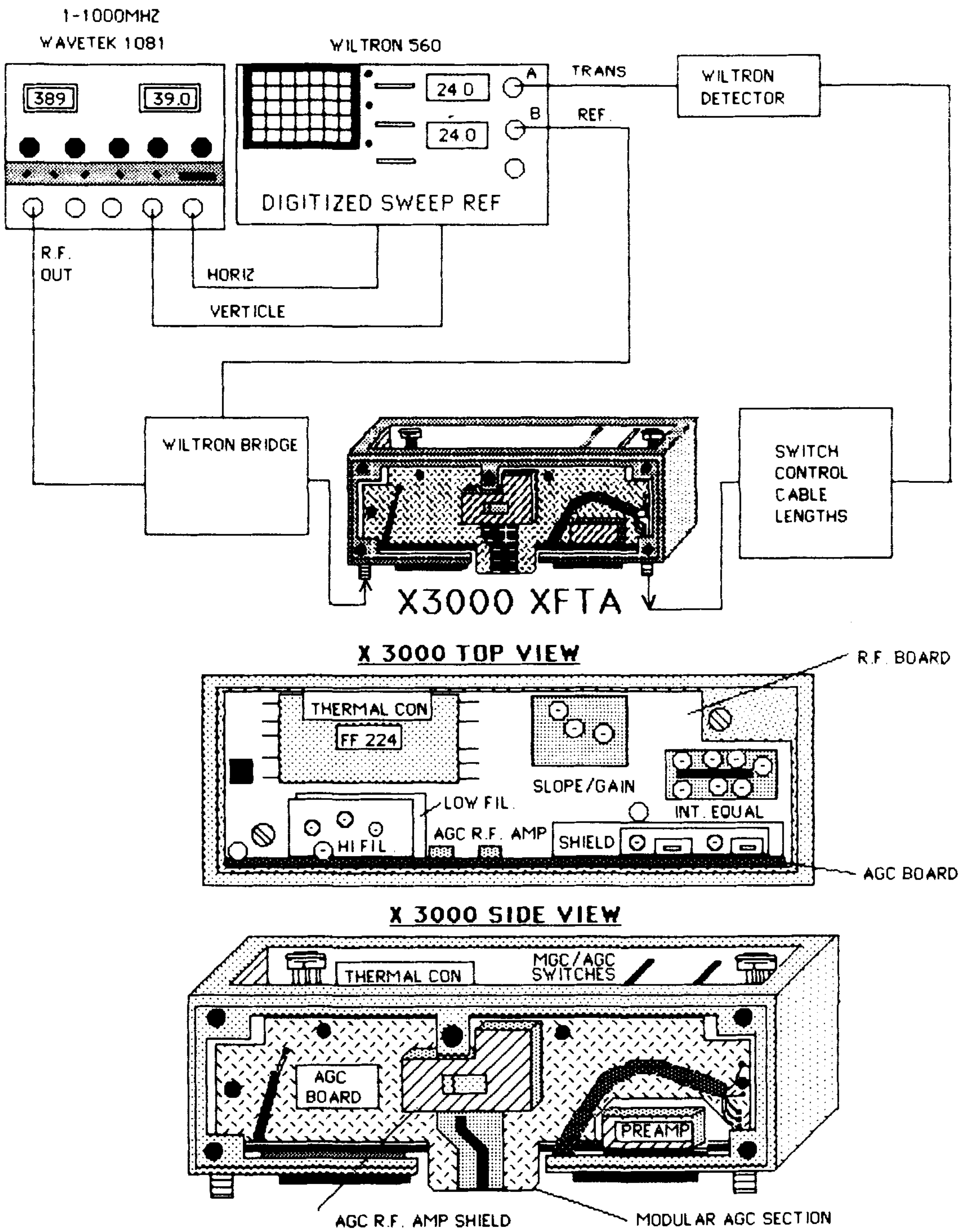

1-1000MHZ
WAVETEK 1081
389
39.0
R.F. OUT
WILTRON 560
24.0
24.0
DIGITIZED SWEEP REF
A
B
TRANS
REF.
WILTRON DETECTOR
HORIZ
VERTICLE
WILTRON BRIDGE
SWITCH CONTROL CABLE LENGTHS
X3000 XFTA
X 3000 TOP VIEW
R.F. BOARD
THERMAL CON
FF 224
SLOPE/GAIN
LOW FIL.
INT. EQUAL
HI FIL.
AGC R.F. AMP
SHIELD
AGC BOARD
X 3000 SIDE VIEW
THERMAL CON
MGC/AGC SWITCHES
AGC BOARD
PREAMP
AGC R.F. AMP SHIELD
MODULAR AGC SECTION

FIG. 2

TABLE 1

X3000-550 MHZ
TEMPERATURE TEST 3/21/85
LEVEL +39 DBMV TILT 6 DB
TEMPERATURE -25 F.

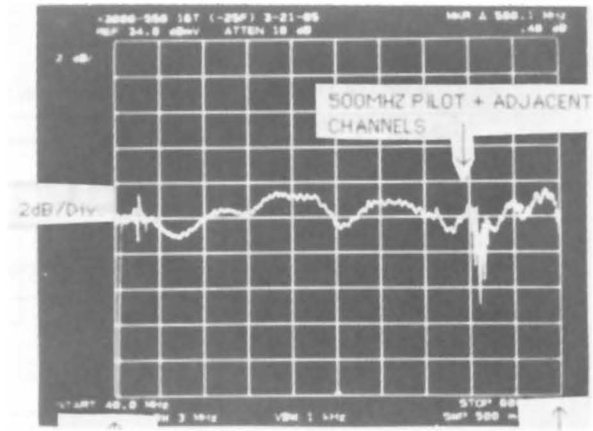
FREQ	C2ND	CTB	C/N	XML	XMH
55.25	70.5	71.9	51.0	59.9	60.1
175.25	71.2	64.5	51.1	60.8	61.0
211.25	67.2	63.3	51.5	61.5	60.7
295.25	70.4	61.9	52.5	61.4	62.2
343.25	69.8	60.0	51.5	62.4	62.0
397.25	66.1	58.2	51.7	63.5	62.9
445.25	65.4	57.3	51.1	64	63.5
487.25	72.0	57.3	52.3	64	64.5
547.25	65.3	61.4	52.6	62.3	62.9

TEMPERATURE +70 F.

FREQ	C2ND	CTB	C/N	XML	XMH
55.25	71.8	72.4	50.6	74.8	74.9
175.25	72.0	68.7	50.9	75.3	75.2
211.25	66.1	67.2	51.3	74.8	74.9
295.25	71.7	66.7	51.3	77.6	77.1
343.25	71.9	64.6	50.8	75.4	75.7
397.25	66.3	62.6	50.7	73.9	73.8
445.25	65.4	62.1	50.0	73.8	72.4
487.25	72.7	62.6	51.3	72.3	73.0
547.25	64.9	67.3	50.7	76.2	76.3

TEMPERATURE + 134 F.

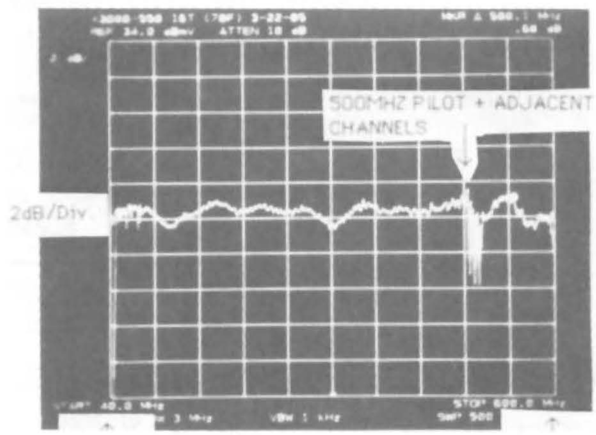
FREQ	C2ND	CTB	C/N	XML	XMH
55.25	70.8	72.3	50.3	72.6	72.4
175.25	65.9	67.0	50.4	71.0	70.9
211.25	67.0	66.4	50.3	70.8	70.5
295.25	71.5	65.3	50.4	71.2	71.4
343.25	71.8	63.8	50.4	68.8	68.6
397.25	67.6	61.8	50.0	67.0	66.7
445.25	66.8	61.3	50.0	65.8	65.7
487.25	72.4	61.5	50.8	65.3	65.2
547.25	65.0	63.4	49.3	63.9	63.9



50 Mhz 600 Mhz

FIG. 3

-25 DEGREES F 2.46 DB P/V



50 Mhz 600 Mhz

FIG. 4

+70 DEGREES F 1.72 DB P/V

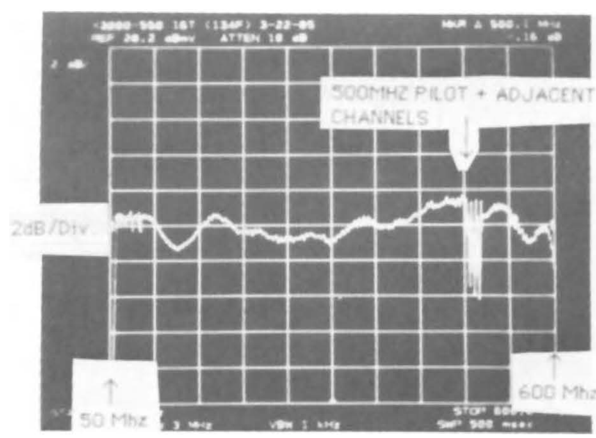


FIG. 5 +134 DEGREES F 2.6 DB P/V

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Mr. Blumenkranz was born in Miami Beach, Florida on March 21, 1944. He received the Bachelor of Science degree in Electronics Engineering from the University of Miami, Coral Gables, Florida in 1967. While attending college he was employed at Communications Company (COMCO) and WTVJ-TV(CBS).

From 1967-1970 he designed Broadcasting facilities for severasl South Florida Radio and T.V. Stations, and acted as Chief Engineer and Technical Director of several.stations.

During 1970-1972 , he was Technical Director of Tel Car Corp. a Radio Common Carrier consisting of computerized pocket paging,mobile two-way , and communications systems.

In 1973 as senior design engineer he devoloped a scanning mobile telephone control head while working at Glenayre Electronics Ltd. North Vancouver, B.C.In 1974 he assisted in the construction of a 22 Mhz Radio Telescope at the Herzberg Institute of Astrophysics near Penticton, B.C. The following year he designed interactive two-way Pay Television systems for Vancouver and Toronto hotels with Mediatronics Ltd. Vancouver, B.C.

From 1976 to the present he has been with Jerrold/Century III Electronics, Inc. (formerly Anaconda CATV Ltd) as design Engineer Consultant He has developed and patented the Feedforward and other Trunk Amplifier Associated Systems.

Mr. Blumenkranz holds an F.C.C Radio Telephone First Class License and an Amateur Extra Class Amateur Radio License.