

A FREQUENCY MEASUREMENT TECHNIQUE FOR CATV

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THE REQUIREMENT TO MEASURE FREQUENCIES ACCURATELY IN THE CATV FIELD IS ONLY NOW BECOMING RECOGNIZED AND RECEIVING ITS PROPER PLACE IN THE TECHNOLOGY OF THE INDUSTRY. THIS TOPIC IS BROUGHT INTO FOCUS BY EXAMINING SOME EXAMPLES OF THE REQUIRED ORDER OF MAGNITUDE FREQUENCY MEASUREMENT PRECISION REQUIRED FOR CERTAIN APPLICATIONS. FIRST, EXAMINE THE ALIGNMENT OF HEAD END PROCESSING EQUIPMENT. IN THIS CASE THE SHOULDER OF THE RESPONSE CURVE IS TO BE ACCURATELY PLACED AT A POINT BELOW (AND ABOVE) THE CARRIER, AS SHOWN IN FIGURE 1. THE RECOVERED VIDEO RESPONSE OF THE SYSTEM IS DEPENDENT UPON THE PHASE CHARACTERISTICS, AND IN TURN THIS IS DEPENDENT UPON THE AMPLITUDE CHARACTERISTICS,¹ PARTICULARLY IN THE VICINITY OF THE VISUAL CARRIER AND THE CHROMINANCE SUB-CARRIER. THEREFORE, IT IS QUITE IMPORTANT THAT THE LOCATION OF THESE RESPONSE SHOULDERS BE ALIGNED WITH AN ACCURACY OF ± 25 KHZ (MINIMUM!). THE REQUIRED ACCURACY IS 25 KHZ OUT OF 200 MHZ OR APPROXIMATELY 1 PART IN 10^{-4} . IF IT IS ASSUMED THAT THE MARKER SOURCE IS A VARIABLE TUNED OSCILLATOR, ITS SCALE ACCURACY WOULD HAVE TO BE AT LEAST 4 TIMES THIS GOOD, I.E., ITS RESETTABILITY AND SCALE ACCURACY WOULD HAVE TO BE AT LEAST 2 PARTS IN 10^{-5} , TO BE ABSOLUTELY SURE THE MARKER WAS IN THE PROPER POSITION. IT IS UNFORTUNATELY TRUE THAT MOST MARKER GENERATORS AVAILABLE TODAY SIMPLY DO NOT HAVE THIS ORDER OF ACCURACY. THE DIFFICULTY ARISES, NOT FROM THE ABILITY TO GENERATE FREQUENCIES TO THIS ACCURACY, BUT RATHER THE PROBLEM INVOLVED IN CALIBRATION. THEREFORE, IF THE ALIGNMENT OF A HEAD END SIGNAL PROCESSOR IS ATTEMPTED, ONE MUST HAVE SOME MEANS OF MEASURING THE MARKER FREQUENCY TO THIS ORDER OF ACCURACY. THE WR-99-A MARKER GENERATOR, WIDELY USED IN THE INDUSTRY, IS marginally acceptable for this use, IN THE HANDS OF A SKILLED OPERATOR, PROVIDED THAT THE MARKER GENERATOR IS ALLOWED TO WARM UP OVER A CONSIDERABLE PERIOD OF TIME (SEVERAL HOURS) PRIOR TO ALIGNMENT. EVEN THEN IT WILL BE NECESSARY TO RE-CHECK THE MARKER FREQUENCY BY THE COMPLETE CALIBRATION PROCEDURE SEVERAL TIMES DURING THE ALIGNMENT, TO BE ABSOLUTELY SURE THAT THIS FREQUENCY TOLERANCE HAS BEEN ACHIEVED.

¹DIRECTLY RELATED FOR MINIMUM PHASE SHIFT NETWORKS; INDIRECTLY RELATED FOR NON-MINIMUM RELATED BIFILAR OR BRIDGED "T" NETWORKS.

A BETTER METHOD OF DETERMINING THE FREQUENCY WITH THE SAME MARKER GENERATOR WOULD BE TO UTILIZE A FREQUENCY COUNTER (AND SCALER IF NECESSARY) CONNECTED TO THE MARKER GENERATOR TO DETERMINE ITS FREQUENCY CONTINUOUSLY DURING USE. BY THIS TECHNIQUE, IT IS POSSIBLE TO MONITOR THE OUTPUT FREQUENCY TO THE ACCURACY REQUIRED FOR THIS MEASUREMENT.

A SECOND SERIES OF MEASUREMENTS AND FREQUENCY TOLERANCES INVOLVE ANOTHER CRITICAL ADJUSTMENT ON THE HEAD END PROCESSOR, THE ADJUSTMENT OF THE SOUND TRAP. SINCE THE SOUND TRAP IS IN CLOSE PROXIMITY TO CHROMINANCE SUB-CARRIER, AND SINCE ANY ATTENUATION OF THE CHROMINANCE SUB-CARRIER CREATES AN ATTENDANT PHASE SHIFT, IT IS EXTREMELY IMPORTANT THAT THE MARKER FREQUENCY FOR THIS APPLICATION BE VERY ACCURATELY IDENTIFIED. THE ORDER OF ACCURACY FOR THIS MEASUREMENT WOULD BE ± 5 KHZ OR APPROXIMATELY 5 TIMES TIGHTER TOLERANCE THAN THE PREVIOUS MEASUREMENT. IT IS MARGINALLY POSSIBLE THAT A VERY SKILLED OPERATOR COULD USE THE MARKER GENERATOR DESCRIBED PREVIOUSLY FOR THE APPLICATION, BUT IT IS DOUBTFUL THAT THIS MEASUREMENT COULD BE MADE WITH THE INTERNAL CALIBRATION MEASUREMENT WITH SUFFICIENT ACCURACY TO ASSURE THE DEGREE OF ALIGNMENT PRECISION DESIRABLE IN THIS HEAD END PROCESSING EQUIPMENT. THEREFORE, THIS SHOULD NOT BE ATTEMPTED UNLESS ONE OF TWO CALIBRATION SOURCES ARE AVAILABLE:

- A) A DIRECT COMPARISON OF THE MARKER FREQUENCY TO THE ACTUAL AIR SIGNAL (SOUND CARRIER).
- B) OR THE USE OF A COUNTER SCALER AS HAS BEEN PREVIOUSLY DESCRIBED.

A NATURAL QUESTION ARISES AS TO HOW ONE CAN MAINTAIN THE PRECISION OF ADJUSTMENT REQUIRED IN THE HEAD END PROCESSORS TO ASSURE THIS DEGREE OF COMPLIANCE, WHEN IN FACT, IN MOST CASES THE EQUIVALENT Q AND STABILITY OVER A LARGE TEMPERATURE RANGE SIMPLY DOES NOT PERMIT SUCH RETRACE CHARACTERISTICS. IT HAS BEEN ADEQUATELY STATED BY THE MANUFACTURERS OF HEAD END EQUIPMENT, THAT THE TEMPERATURE TOLERANCE OF HEAD END EQUIPMENT IS REALLY QUITE SMALL, AND THE CONCEPT OF ENVIRONMENTAL CONTROL FOR THE HEAD END EQUIPMENT IS NOT ONLY JUSTIFIED, BUT MANDATORY. NOT ONLY WILL IT PROVIDE FOR LONGER LIFE OF THE TECHNICAL EQUIPMENT, BUT IT WILL PERMIT A VAST DIFFERENCE BETWEEN THE ALIGNMENT CYCLES. (IF ONE REALLY CARES ABOUT THE PICTURE QUALITY AT THE HEAD END). THE MECHANISM OF THIS DETERIORATION IS QUITE SIMPLE. IF THE

HEAD END TEMPERATURES VARY OVER A PRESCRIBED TEMPERATURE LIMIT, THE EXPANSION AND CONTRACTION OF THE DEVICES USED IN THE VARIOUS RESONANT CIRCUITS EXPAND AND CONTRACT ALSO, WITH THE RETRACE CHARACTERISTICS OF THE MECHANICAL ADJUSTMENTS NOT BEING PERFECT. THIS IS THE MAJOR SOURCE OF LONG TERM SHIFTS IN ALIGNMENT (ASIDE FROM COMPONENT FAILURES OR DETERIORATION). OBVIOUSLY, IF THE TEMPERATURE CONTROL IS TIGHT ($\pm 100^{\circ}\text{F}$) THERE WILL BE LESS NEED FOR ALIGNMENT, OR TO PUT IT ANOTHER WAY, THE ALIGNMENT CYCLES WILL BE FURTHER APART. THE NEXT EXAMPLE OF MEASUREMENT PRECISION REQUIRED IN CATV EQUIPMENT DEALS ALSO WITH HEAD END EQUIPMENT, HOWEVER, IN THIS CASE, CONSIDER THE SYSTEM WHERE THE DEMODULATION/REMODULATION IS EMPLOYED. SPLIT THIS AGAIN INTO THESE CATEGORIES:

- 1) THE SYSTEM WHERE THE 4.5 MHZ SOUND CARRIER IS RETAINED IN THE DEMODULATION PROCESS.
- 2) WHERE THE AUDIO INFORMATION IS RECOVERED AND REMODULATED. (THIS APPLIES TO LOCAL ORIGINATION ALSO).

IN THE FIRST CASE, THE TOLERANCE BETWEEN THE AURAL AND VISUAL CARRIER IS MAINTAINED AS IT WAS AT THE TELEVISION STATION, AND THERE IS NO PROBLEM MEASURING THE FREQUENCY SEPARATION AS THIS WILL NOT BE DISTURBED IN THE REMODULATION PROCESS. THE ONLY FREQUENCY TOLERANCE ATTENDANT WITH ALIGNMENT OF THIS EQUIPMENT IS THE PLACEMENT OF THE BAND EDGE OF THE BAND PASS, AND ALIGNMENT OF THE MODULATOR VESTIGAL SIDE BAND FILTER. THE FCC STANDARDS PRESCRIBE A SPECIFIC AMPLITUDE VERSUS FREQUENCY RESPONSE, AND TELEVISION RECEIVERS HAVE BEEN DESIGNED TO COMPLEMENT THESE CHARACTERISTICS, WHILE AT THE SAME TIME PROVIDING THE BEST POSSIBLE PHASE CHARACTERISTICS ASSOCIATED WITH THIS VESTIGAL ATTENUATION, THIS MEANS THAT THE CATV OPERATOR MUST DUPLICATE THIS "TRANSMITTER CURVE"² AS CLOSELY AS POSSIBLE TO ASSURE IDENTICAL PHASE CHARACTERISTICS³. THE FCC AMPLITUDE RESPONSE CURVE IS SHOWN ON FIGURE 11. IT IS NECESSARY TO MAINTAIN THE SHOULDERS OF THE FREQUENCY RESPONSE TO WITHIN ± 25 KHZ, AND AGAIN, THIS REQUIRES THE SAME FREQUENCY TOLERANCE ASSOCIATED WITH THE PREVIOUSLY DESCRIBED MEASUREMENTS, AND CAN BE DONE WITH

²IN ADDITION, IT IS NECESSARY TO UTILIZE THE SAME PHASE PREDISTORTION CHARACTERISTICS THAT HAVE BEEN INSTALLED IN A TYPICAL TV STATION, BUT THIS IS ANOTHER MATTER FOR ANOTHER PAPER.

³THIS PHASE CURVE IS GIVEN IN FCC RULES 73.687 (5).

A CONVENTIONAL TYPE MARKER GENERATOR WITH SKILL AND EXPERIENCE.

ADDRESSING THE SECOND CASE OF HEAD END PROCESSING EQUIPMENT UTILIZATION, WHERE THE AUDIO HAS BEEN DEMODULATED TO BE SUBSEQUENTLY REMODULATED WITH A MODULATOR, OR WHERE AN AUDIO CARRIER IS ORIGINATED (AS WITH LOCAL ORIGINATION) THE SAME TYPE FREQUENCY MEASUREMENT IS INVOLVED, I.E., THE EXACT CARRIER FREQUENCY OF THE VISUAL CARRIER MUST BE ESTABLISHED ACCURATELY AND THE FREQUENCY SEPARATION OF THE AURAL CARRIER AND VISUAL CARRIER MUST BE DETERMINED. THE MEASUREMENT OF THE VISUAL CARRIER, CAN BE DONE WITHIN THE REQUIRED ACCURACY BY USING A MARKER GENERATOR, WHEN DONE BY A PERSON WHO HAS THE SKILL AND EXPERT KNOWLEDGE TO USE THIS DEVICE PROPERLY WITHIN ITS LIMITATIONS (AGAIN WITH A COUNTER). THE SECOND MEASUREMENT, THE INTERCARRIER DIFFERENCE FREQUENCY BETWEEN THE VISUAL CARRIER AND AURAL CARRIER MUST BE MEASURED TO A TIGHTER TOLERANCE. TYPICALLY, TELEVISION RECEIVERS WILL PERFORM SATISFACTORILY WITH A ± 5 KHZ DEVIATION OF THE AURAL CARRIER WITH VERY LITTLE SOUND DETERIORATION. AS HAS BEEN PREVIOUSLY SHOWN, THIS IS AT THE BARE LIMITS OF THE MARKER GENERATOR TECHNIQUE WHEN USED WITH A COUNTER.

ANOTHER METHOD TO ESTABLISH THE AURAL CARRIER FREQUENCY WOULD ESTABLISH THE VISUAL AND AURAL CARRIERS AND THEN MEASURE THE DIFFERENCE FREQUENCY BETWEEN THE TWO CARRIERS. THIS METHOD IS NOW WITHIN THE MEASUREMENT TOLERANCE OF A MILITARY SURPLUS METER, KNOWN AS THE "BC 221 SERIES." WITH THIS HETERODYNE TYPE DEVICE, IT IS POSSIBLE TO MEASURE THE FREQUENCY DIFFERENCE WITH SUFFICIENT ACCURACY TO BE ABLE TO SET FOR THE CORRECT INTERCARRIER FREQUENCY.

THERE ARE OTHER TECHNIQUES FOR MEASURING THE FREQUENCIES INVOLVED IN CATV TO THIS ORDER OF ACCURACY, HOWEVER, MOST OF THEM WILL BE MORE EXPENSIVE THAN THE TECHNIQUES DISCUSSED.

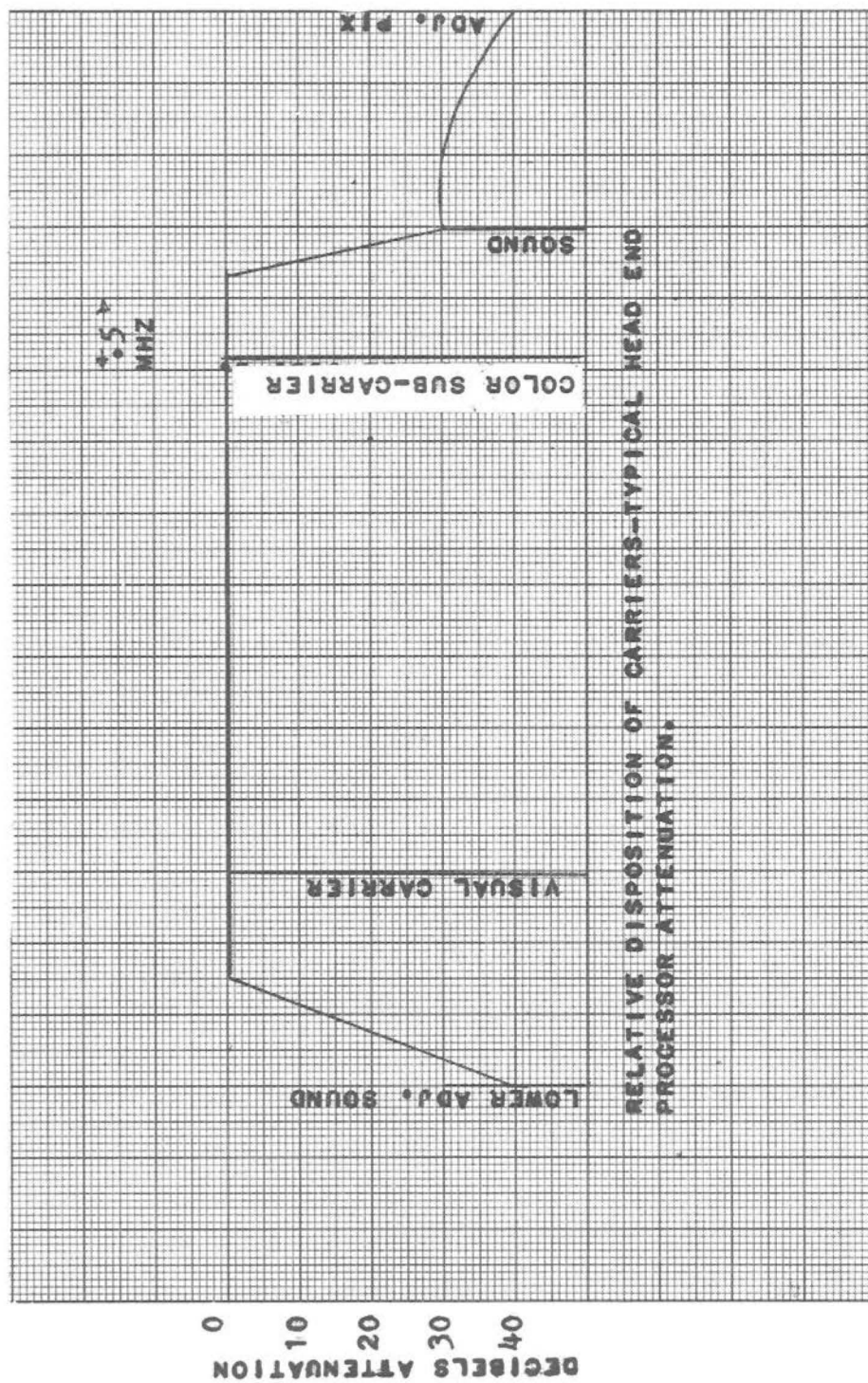
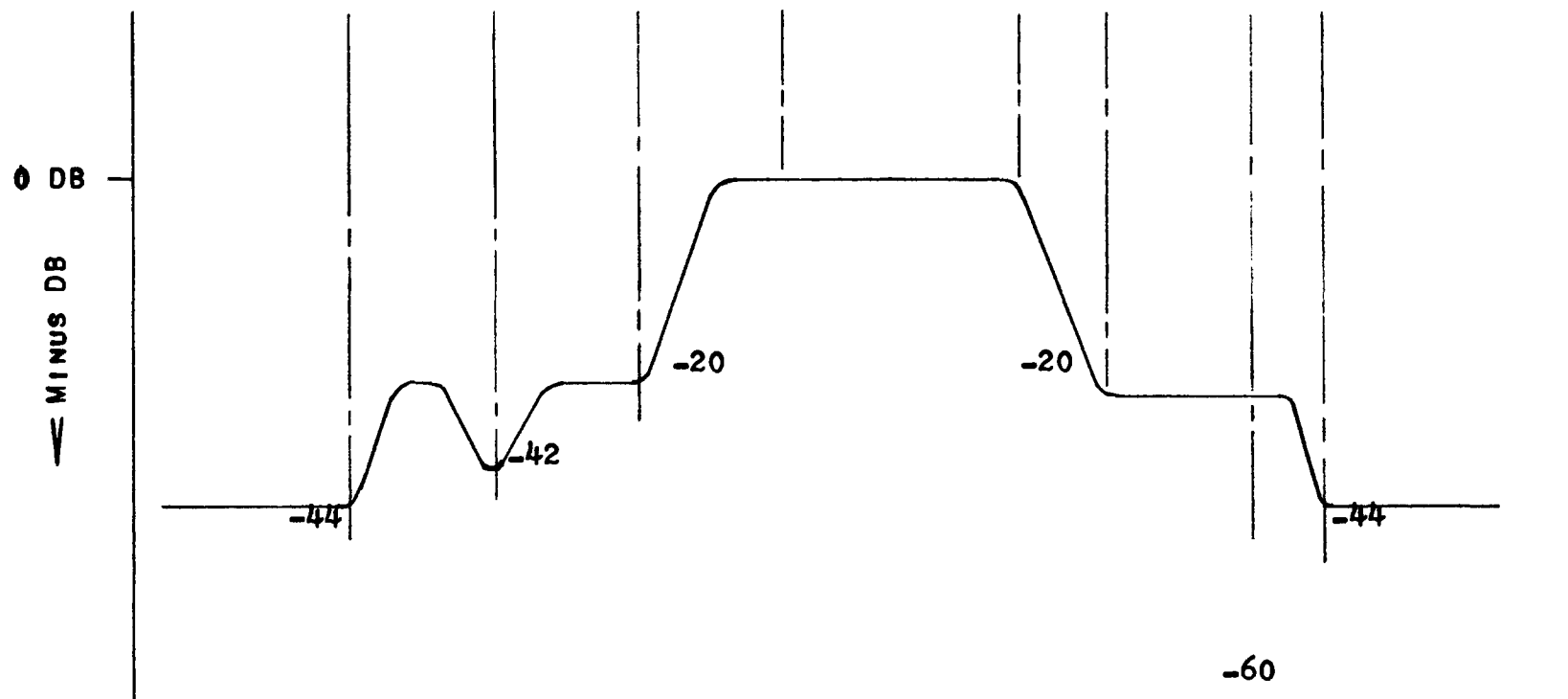
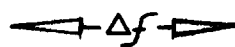


FIG. 1

BAND EDGE →	-3	-2.33						
REFERENCE			B.E.		B.E.		B.E. +3	
VIDEO CARRIER →	-4.25	-3.58	-1.25	V.C.	+4.18	+4.75	+6	+7.75
REFERENCE								



REFERENCE:
1. REF. DATA FOR RADIO ENG., ITT
Pgs. 797, 798



FCC SPEC _____

FIG. 2

AT ADJ.
V.C.