| BO & E TECH QC REPORTS | THE PEAK PROGRAM METER AND THE VU METER IN BROADCASTING | TQR 101 1/11 OCT 79 |
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Organization of Content



## Introduction

In September 79, ABC put into operation its new New York studio. Throughout its control rooms some 40 PPMs are employed (Fig. 1). All new ABC installations (e.g. the new Washington News Bureau) will be equipped with PPMs.

At the SMPTE Toronto Section Meeting in February 78, the Canadian Broadcasting Corp. (CBC) reported that the CBC Vancouver plant employs 30 to 40 PPMs; only 1 to 2 VU meters are kept to settle Telco disputes (Fig. 2).

Clearly, the Peak Program Meter is here to stay!

In this report, I wish to sum up the present "Peak Program Meter situation" and discuss some practical operational problems that exist when VU meters and Peak Program Meters (PPMs) are used together in a broadcast plant. Anyone wishing to know more details of our investigations may refer to my papers in the IEEE Transactions on Broadcasting of MAR 77, the BME magazines of JUN and SEP 77 and the SMPTE Journal of JAN 76.

The oral presentation of this report has a slightly different format. This is mainly because a TV monitor (from a video cassette) displays both meters side by side showing the meter deflections of the audio signal that one hears.

## Characteristics of VU meter, PPM, FCC Modulation Monitor and Chart recordings

### The VU Meter

The VU Meter (per IEEE Std. 152) is an averaging meter with a response time of 300 ms (to reach 99% of its final value) and an identical fall-back time. It can be demonstrated that the integration time is $\sim$170 ms. To avoid misunderstandings, I must point out the obvious. Program levels are expressed absolutely: for example an 8 VU level reading actually represents the sum of the meter's attenuator setting (+8, even if the attenuator is fixed and hidden) and the meter deflection of zero (per IEEE Std. 152 as "the greatest deflection occurring in a period of about 1 minute for program waves ..... excluding not more than 1 or 2 deflections of unusual amplitude").

Our investigations are based on the Weston Model 862 meter as standard. VU meters from various reputable manufacturers exhibit ±1 dB deflection discrepancies with tone burst signals.

### The PPM

The PPM on which our experiences are based is a quasi-peak-reading meter with an integration time of 10 ms (to reach -2 dB, or 80% of the final value). This PPM is sometimes referred to as the EBU meter since it is based on the European Broadcasting Union Standard Tech. 3205-E. ABC has found the modified A-scale version (see Fig. 3) of the EBU meter to be most appropriate since it lets operators use their usual jargon such as "Zero Level" etc. And like with the VU meter the level is expressed absolutely, i.e. it is the sum of the meter deflection and the attenuator setting.

The FCC Audio Modulation Monitor

The semi-peak indicator of modulation monitors for AM, FM and TV audio (FCC 73.50, .332, .694) has a response time of 40 - 90 ms to reach 90% of its final value and a fallback time of 500-800 ms to return to 20 dB below the final value. It can be estimated that the integration time will be on the order of 25 to 55 ms.

The FCC Audio Modulation Monitor is mentioned here for completeness sake. It was not investigated in detail but deflection discrepancies of several dB can be expected with short ($\sim$30 ms) tone burst signals.

The Strip Chart Recordings

In the oral presentation of this paper the VU meter and the PPM are shown side by side on a TV monitor. Thus the viewer can see the actual deflection differences between both meters. Dual Strip Chart Recordings provide a permanent record of these differences. Since these charts have been misunderstood by many, let me hasten to say that they are <u>not</u> recordings of the audio signal (e.g. when viewed on an oscilloscope). The recordings are the representation of the actual meter deflections (much like as if a pen were mounted on the tip of the meter needle and the pen writing the needle deflections on chart paper that moves upward over the meter). For the PPM the chart recorder is fed from a slave-meter output of the standard EBU meter. For the VU meter the electrical equivalent of its ballistics (including the rectifier) is fed to the chart recorder.

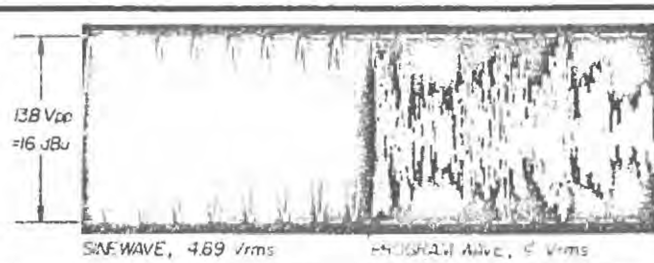
## The Meters and Program Level

The VU meter is an averaging type voltmeter with a dynamic response such that it registers typical program voltage peaks at 8-12 dB below their actual amplitude. This VU meter lag has been standardized in the EIA Standard RS-219 (par. 5.1.2.a) as 10 dB. Thus in a Broadcast plant the standard program level is 8 VU which corresponds to a steady-state EIA standard output level of 18 dBm. (Yes, at this level the VU meter is off-sale!). The PPM has no meter lag, hence it will register program voltage peaks at their actual amplitude.

When both PPMs and VU meters are used in actual Broadcast operation, it is essential that for a given program level both the PPM and the VU meter deflect to their respective Zero Reference points. To meet this condition it has been found that a VU meter lag of 8 dB is more realistic than 10 dB. Rather than decrease the sensitivity of all the VU meters in a plant by 2 dB, ABC has chosen to lower its steady-state standard output level by 2 dB. Thus ABC's new steady-state standard level is 16 dBm while the standard program level is still 8 VU. It is interesting to note that CBC independently arrived at the same "16 dBm" conclusion and their PPMs are actually so calibrated (Fig. 4).

However, the term dBm is only correct for steady-state sine wave signals. For fluctuating program signals the power concept (dBm) is meaningless and ABC has therefore adopted the EBU recommended voltage concept. Adopting the voltage concept in a broadcast plant makes for some great advantages that will be discussed below.

0 dBu = .775 Vrms = 2.2 Vpp (VOLTAGE ON 600Ω AT 1 mW = 0 dBm)
16 dBu = 4.89 Vrms = 13.8 Vpp ( " " " 39.8 mW = 16 dBm)




DEFINITION OF VOLTAGE LEVEL

Meter calibration and deflections

Fig. 5 (and the TV monitor) shows that on a PPM a level of 16 dBu registers equally for steady-state sine waves and tone bursts. On a VU meter an 8 dBu steady-state signal registers at 8 dBm, a 16 dBu tone burst signal (63 ms duration) registers at 8 VU and a 16 dBu steady-state signal is off-scale.

The audio/video distribution system at ABC NY provides an Audio Level Test Signal (ATS). This ATS is a continuously repeating 440 Hz signal that alternates between an 8 dBu steady-state signal ("0" on VU meter and "-8" on PPM) and 16 dBu tone bursts ("0" on both VU meter and PPM).

Fig. 6 shows that on a PPM 16 dBu tone bursts with varying durations register equally for all practical purposes. On a VU meter 16 dBu tone bursts with varying durations register unequally. Fig. 6 also shows that these conditions are not frequency dependent.

A musical program, for instance, contains sounds as short as a 1/64 note (about the shortest that can be performed) to as long as sustained notes. The duration of a 1/64 note at an allegro (brisk) tempo is on the order of 25 ms, the duration of a sustained note can certainly be longer than 300 ms.

For this range of tone durations the VU meter will exhibit a $\sim$15 dB level discrepancy, while the PPM shows none.

For the next figures (and for the TV monitor) we recorded several musical pieces played by a cellist. In all cases the playback level was adjusted for 16 dBu maximum on the PPM.

Fig. 7 shows the level readings of the music scale played at slow and fast tempi. The VU meter exhibits a level discrepancy of $\sim$4 dB between slow and fast tempi. The scales and the largo piece of Fig. 8 would cause an operator with a VU meter to make level adjustments resulting in a dynamic range that is different from what the cellist had intended. In the scherzo and tocatta pieces of Figs.9 and 10, little or no adjustments would be made.

The PPM and some Implications

Adopting the voltage concept for a broadcast plant permits us to abandon the constant-power principle (with its necessary impedance matches) and instead employ the constant-voltage principle (with its low sending and high receiving impedances), thus gaining large equipment advantages and system simplicity, e.g.:

1. Console outputs don't need the 6 dB meter isolation and even with a clipp-level margin of 5 dB (21 dBu output) the output amplifier and transformer will be much smaller and cooler than those of the customary 30 dBm (1W) amplifier.
2. Audio distribution amplifiers will be much smaller than the customary 10-20W amplifiers.
3. Standard AC volt meters with "dBm on 600 Ω" scales can be used for trouble shooting.
4. Levels other than 16 dBu can be accommodated since the PPM amplifier is adjustable.

Using the PPM as a modulation monitor at transmitters will reduce if not eliminate licencees' problems with the FCC regards over-modulation.

Harmonic distortions will be lower than customary because transformers do not transform power but voltage.

VU meters can still be used in places other than program integration points such as Telco plants.

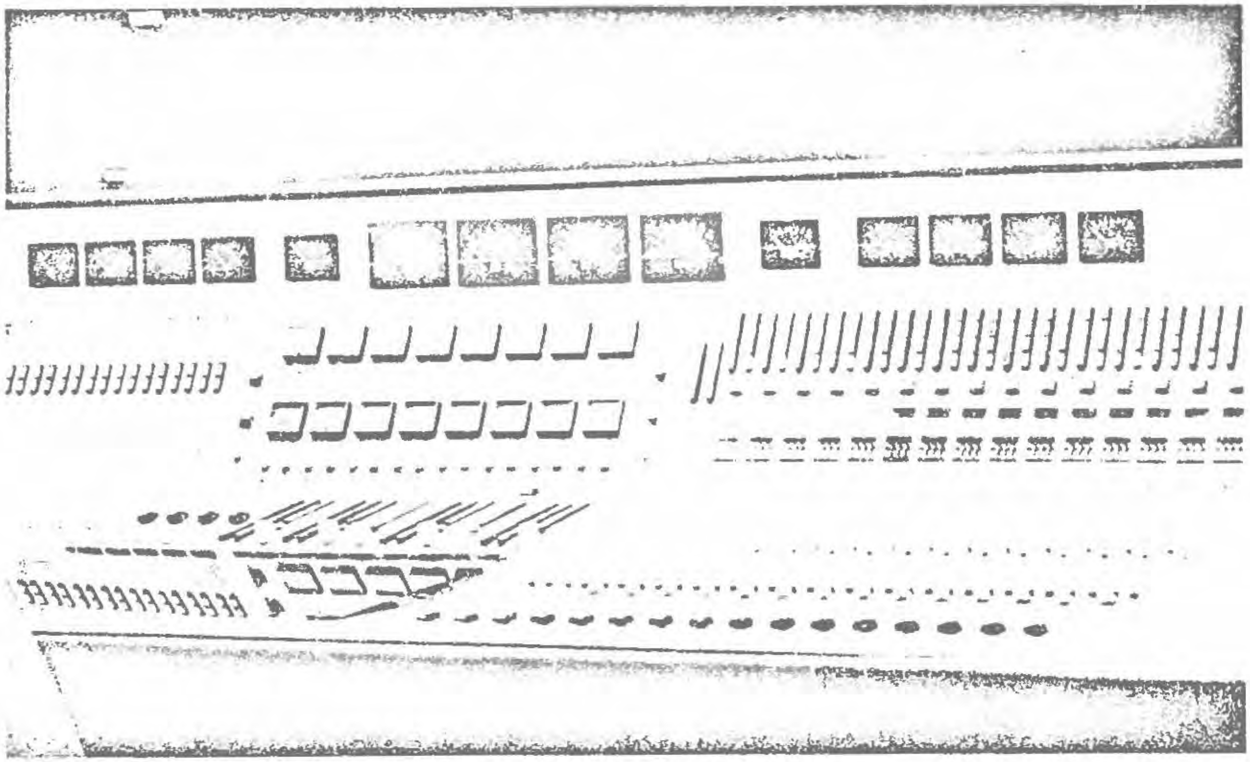
These are only the most obvious implications of using the PPM and the constant-voltage principle. Others will be found in time and with widespread usage.

## Conclusion

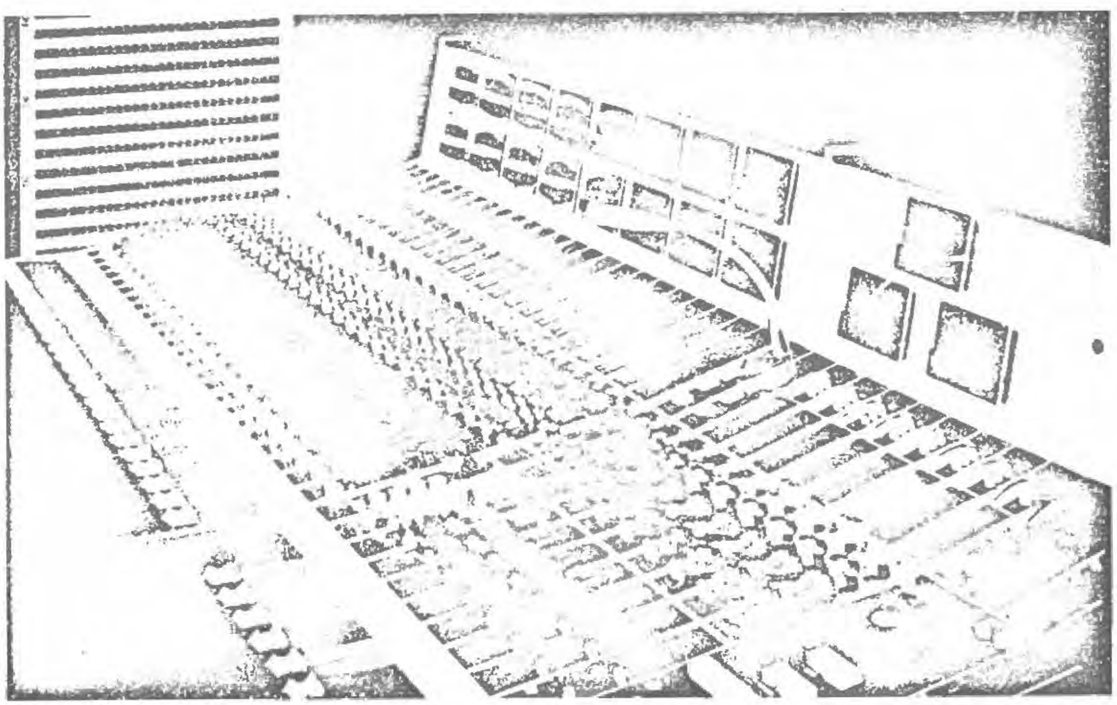
The PPM's time has come!
I hope that industry organizations such as IEEE, NAB, SMPTE, etc. will endorse the EBU meter, rather than reinvent the wheel and that the PPM will not be the victim of the NIH (not invented here) syndrome. I also hope that a reputable instrument manufacturer will develop a chip for the PPM amplifier.

## Acknowledgment

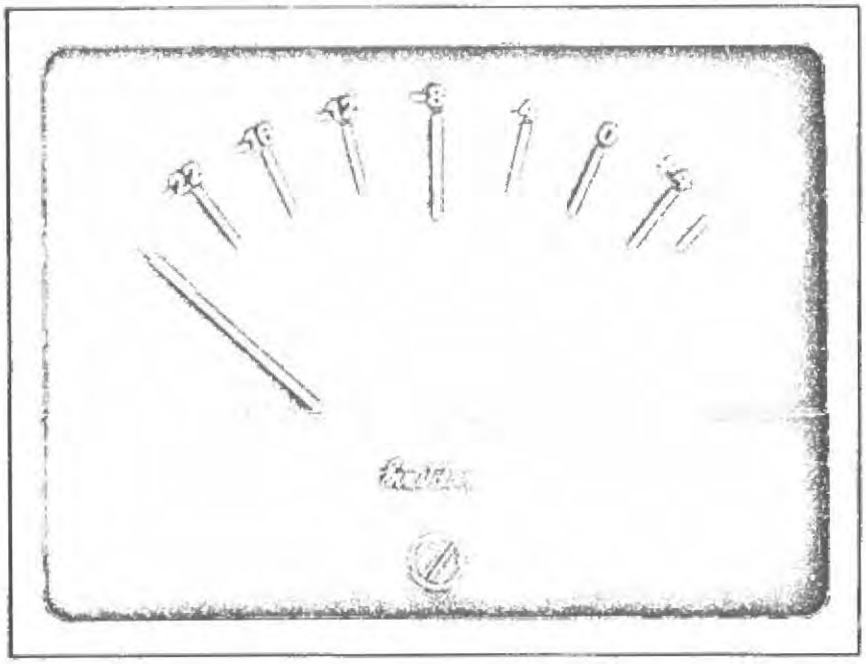
Over the years of experimenting and investigating that preceeded this report, the author had the help of many too numerous to mention individually. Some have been mentioned in earlier papers. However, my special thanks for their assistance and contributions to this report must go to D. Cahn and C. Pantuso of ABC's Engineering Lab. Last, but not least, my heartfelt thanks to my friend Jascha Silberstein, the Principal Cellist of the New York Metropolitan Opera for giving Kultur to this report.



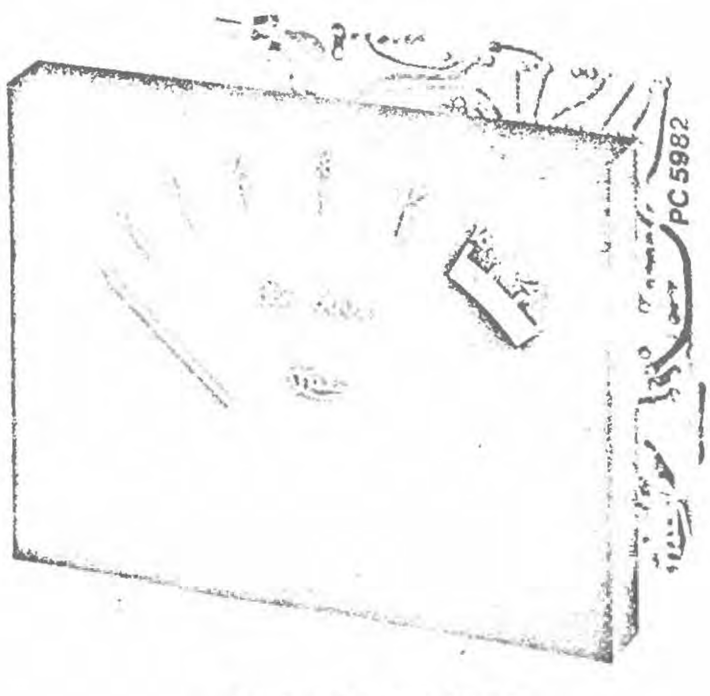
1 ABC CONSOLE WITH PPMs



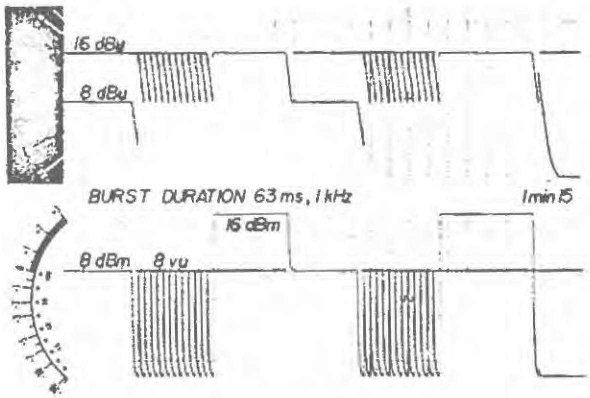
2 CBC CONSOLE WITH PPMs



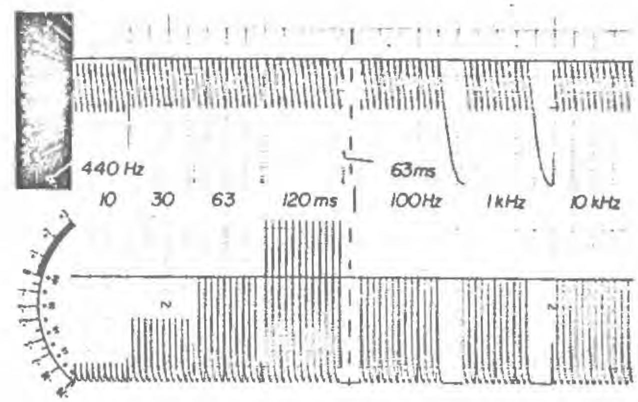
3 PPM WITH ABC SCALE



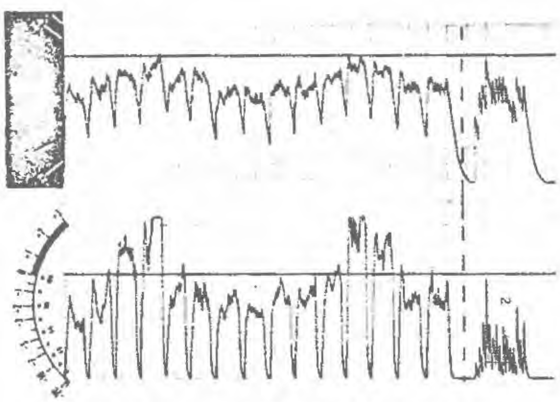

4 PPM WITH CBC SCALE



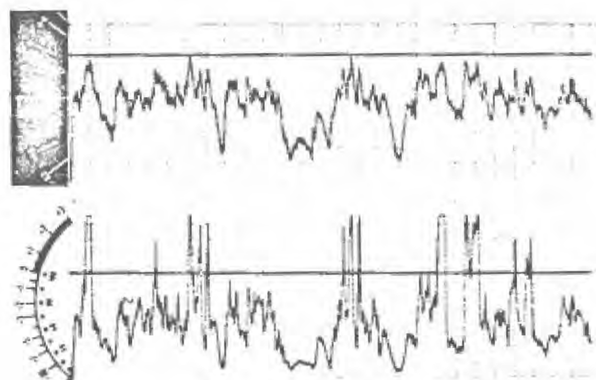

5 CALIBRATION OF PPM & VU METER



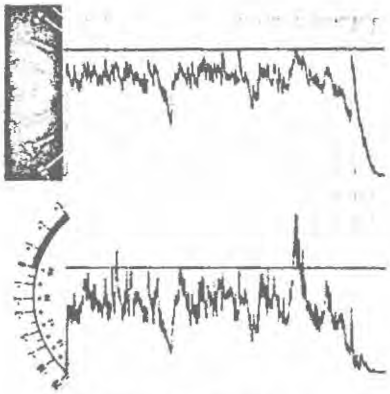

6 TONE BURST RESPONSE OF PPM & VU METER



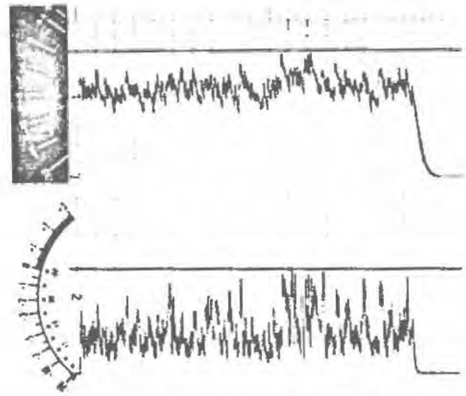
7 THE MUSIC SCALE AT SLOW & FAST TEMPI



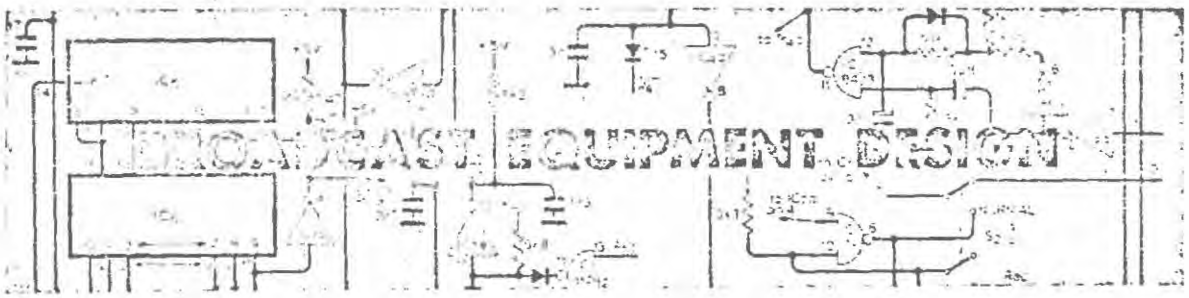
8 HANDEL, LARGO



9 DAVIDOFF, SCHERZO



10 FRESCOBALDI, TOCCATA




*Many broadcasting organisations design and produce professional equipment to meet the needs of their facilities. Often the equipment produced is less expensive than those available from the market, but they adequately serve a similar purpose. Readers are invited to submit suitable designs for publication where it is considered that these would be of benefit to other broadcasting organisations.*

## A SIMPLE LOW COST VU TO PPM CONVERTER

The Peak Programme Meter (p.p.m.) provides an accurate indication of audio programme peaks on an easily read dB scale range which may be wide and linear. It can be used with lower signal levels than the v.u. meter and it can be designed with a high input impedance. In view of these relative merits of using a p.p.m. to monitor audio programme levels, the Australian Broadcasting Commission (ABC) sought a means of converting the existing v.u. meters to p.p.m.'s in its studios. To permit a programme of quick conversion at low cost, the best approach was considered to be the conversion of existing v.u. meters with an externally mounted printed circuit board rather than replacing each meter with a new p.p.m. Using this technique, two minor compromises were accepted: since the scale of the existing meters was left untouched the converted meter does not provide the linear 30 or 40 dB of scale typical of p.p.m.'s and, in some meters a tracking error of 0.5 dB maximum could occur at indications of −10 dB. These problems could be overcome if the meter case were opened, the scale changed and the internal diode bridge removed, however this would compromise the objective of a simple conversion.

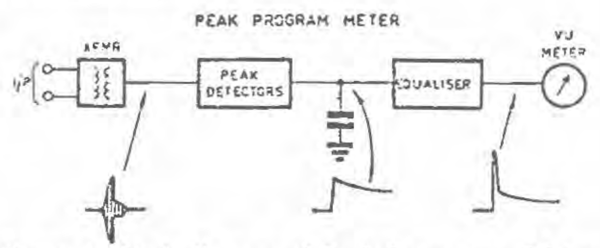



*Figure 1. Block diagram of Peak Programme Meter.*

A simplified block diagram of the converter is shown in Figure 1 and a detailed circuit in Figure 2. Referring to Figure 2, the input signal is fed to two peak detectors (X1 and X2) from either side of transformer T1. Thus one detector responds to positive programme peaks and the other to negative peaks. They provide a low output impedance when charging C4, allowing a fast rise time to the voltage on this capacitor. When the output voltage of either X1 or X2 falls below that on C4, diodes D2 and D3 are reversed biased providing only a high impedance discharge path for this capacitor. Thus the voltage on C4 will rise quickly with programme peaks, but decay slowly when they have passed. Typical waveforms are shown on Figure 1. Capacitors C2 and C3 are included to limit the rise time for peaks less than 10 milliseconds in duration. The equalizer X3 is necessary since the v.u. meter has a slower response time than that required for the rise time of a p.p.m. It provides new time constants for the moving coil meter to give the required rise time specifications. Resistors R6 and R8 have been included in the design so that the circuit can be used for lower signal levels in the future. The removal of these resistors gives an 8 dB increase in gain. In limited operational tests, the converted meter has proved most satisfactory and the ABC plans to convert all its radio and television studio centres to p.p.m.'s in the next few years if the pilot conversion programme at one centre proves successful.

**Specification**

| | | | |
|---|---|---|---|
| Frequency Response | 30 Hz to 15 kHz (±0.3 dB) | Fall Back Time | 20 dB in 1.5 seconds |
| Rise Time | 10 ms burst reads −1 dB (±0.25 dB) | Overswing | <1 dB |
| | 1 ms burst reads −8 dB (±1 dB) | Supply Current | .5 mA |
| | | Supply Voltage | 8 to 50 volts |
| | | Input Impedance | 36 k Ω |
| | | Bridging Distortion | < −70 dB |

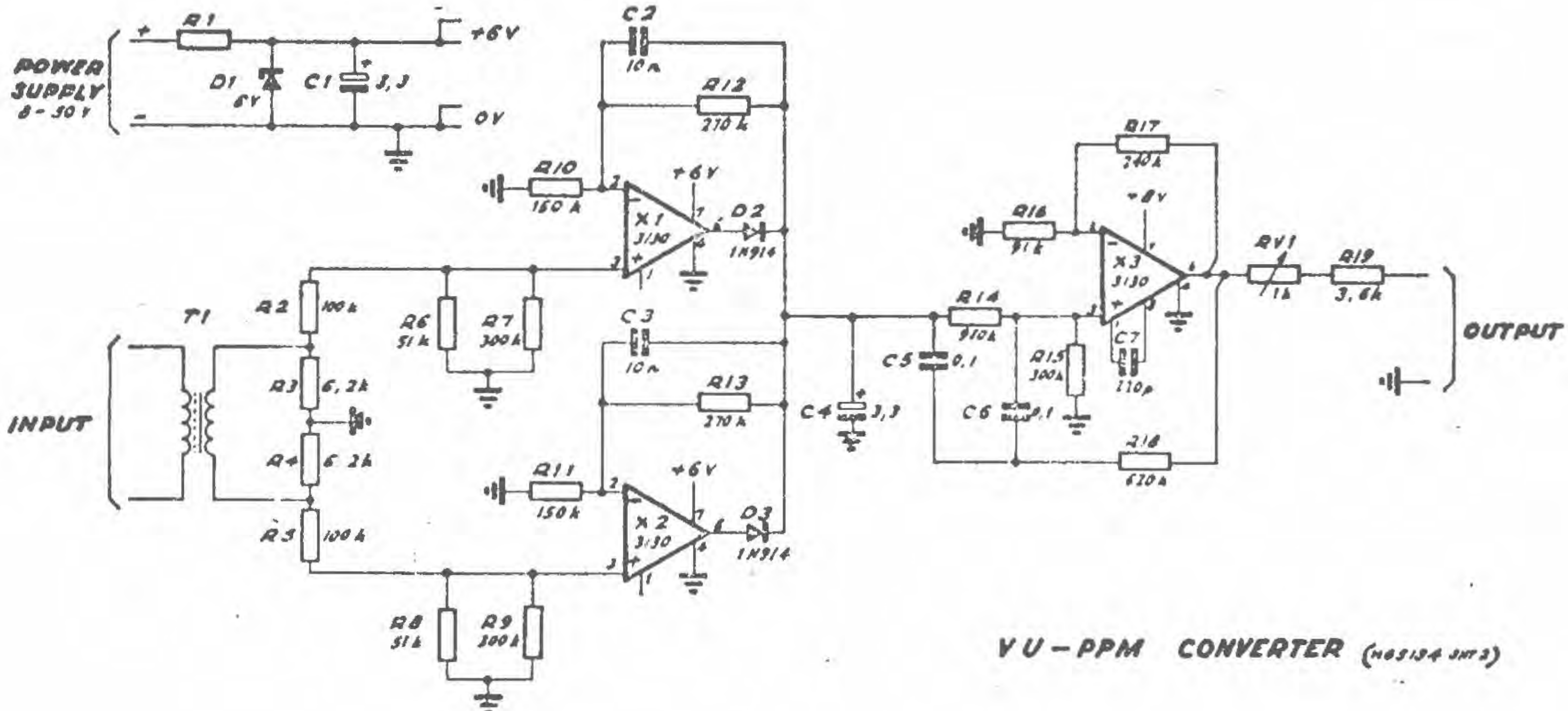



*Figure 2. Circuit diagram of vu to ppm converter.*