Colour Television in Australia

Simon Moorhead
Ericsson Australia and New Zealand

Abstract
A historic paper from the Journal in 1976 regarding the colour conversion of transmitters in the National Television Service by Telecom Australia (now Telstra).

Introduction
The National Television Systems Committee was formed in the United States in 1950 to research the problems associated with colour television. The Radio Corporation of America (RCA) played a large part in development of a compatible system adopted by the committee called the NTSC system. (Hutson 1971 [5]) The United States commenced regular colour television broadcasts in January 1954 and well before the introduction of monochrome television in Australia in 1956 and in time for the Olympic Games in Melbourne.

The new colour system was compatible in both directions, meaning an existing monochrome receiver was able to display a monochrome picture with a colour broadcast and a colour receiver was able to display a monochrome picture with a monochrome broadcast. The NTSC system however had some drawbacks such as phase distortion which caused hue or colour errors. This led to the NTSC system being referred to as ?Never Twice the Same Colour? by broadcast engineers. In 1958, Graham Kennedy of Channel 9 fame, visited the United States and witnessed a number of colour television broadcasts. He was impressed but only saw the system on expertly-tuned studio monitor sets. Kennedy said of the NTSC system, "I believe however it can be a tricky business for the viewer with a clutch of knobs to twiddle on your set and if you are not too expert you get green cows, white grass and purple people eaters would probably come out tartan" (Blundell 2003 [6])

Whilst Australia was far behind the United States in the race to introduce colour television, we eventually chose a variant to the NTSC system called PAL which was developed at the Telefunken Laboratories in the German Federal Republic. The system was designed to reduce the effects of phase distortion on the colour signal. (Hutson 1971 [5])

In 1967 the PAL system was adopted by the German Federal Republic and the United Kingdom.

The local broadcast industry had been lobbying the Australian Government since the 1960?s to introduce colour television. In 1966 Hansard records the Postmaster-General being asked which of the three colour television standards (NTSC, PAL & SECAM) would be used in Australia? The answer given was ?No decision has been made regarding the introduction of colour television in Australia. An essential pre-requisite for a colour television service in Australia is the determination of technical standards. Following recent failure to reach international agreement on a common colour television standard for Europe at a meeting of the International Radio Consultative
Committee (C.C.I.R.) of the International Telecommunications Union, it is apparent that the most advantageous course for Australia will be to await further developments in the introduction of colour television services in Europe, particularly in Britain, so that the merits of competing technical systems may be assessed on the basis of the practical operation of comprehensive colour television services in those countries?.

?The timing of the introduction of colour television into Australia is a matter for decision by the Government at the appropriate time. Consideration of all the factors relevant to the matter including the experience of overseas countries in colour television suggests the desirability of a cautious approach. The matter of colour television, having regard to its complexities, is unlikely to be considered and decided in a way which would not leave manufacturing interests ample time to prepare themselves before final Government decisions are made. The Australian Broadcasting Control Board recently obtained the views of industry in this country on the question of technical standards considered appropriate for Australia? (Hansard 1966 [7]).

On 15 February 1972, the Prime Minister William McMahon announced that colour television would be introduced on 1 March 1975, allowing the local broadcast industry three years to convert to the PAL standard that had been adopted by the Australian Broadcasting Control Board (PM Transcripts 1972 [8]). The National Television Service would be updated to colour on a phased basis due to financial constraints brought about by Australia?s continued participation in the Vietnam War (Gyngell 1998 [9]).

The historic paper (Lees & Hodgson 1976 [10]) details the significant challenges and solutions employed to convert the National Television Service transmitters to colour operation. Telecom Australia?s approach was to modify the existing transmitter equipment wherever possible to minimise the capital expenditure. This presented unique challenges given the equipment had to be operational during the day for monochrome transmissions, then modified and tested during the night with colour and rolled-back by morning when monochrome transmissions resumed. Luckily there were no 24 hour, 7 day transmissions in those days.

Naturally the conversion to colour triggered a number of changes elsewhere in the Telecom?s network such as transmission, not to mention the significant changes at the studio end managed by the Australian Broadcasting Commission and the respective commercial broadcasters.

Additional information on the effects of colour television on Telecom?s network can be found in (Hatfield 1974 [11]) and the extensive modifications to the Melbourne Television Operating Centre in (Humberstone & Lock 1976 [12]).

References


Hansard. 1966. 15 September 1966 at http://parlinfo.aph.gov.au/parlInfo/search/display/display.w3p;adv=yes;orderBy=_.fragment_number,doc_date- rev;page=13;query=Dataset%3Ahansardr,hansardr80%20Decade%3A%221960s%22;rec=1;resCount=Default [13]


Hutson G. H. 1971. ?Colour Television Theory PAL-System Principles and Receiver Circuitry Preface Historical Notes


signal has increased susceptibility to level dependent or non-linear distortions, which affect the accuracy of the picture reproduction.

The excursion of picture information into the portion of the signal occupied only by synchronising information in a monochrome signal affects synchronising signal processing circuits normally used in monochrome equipment. It should be noted that the modulation levels apply to an ideal double sideband signal. In practice this is modified to a vestigial sideband signal in the transmitter prior to transmission, with the result that the amplitude of the high frequency colour or chrominance information is reduced to one half. In addition the synchronising portion of the colour signal includes the "colour burst" which is essential for decoding the colour information in the transmitted signal.

The distribution of spectral energy in colour and monochrome signals is represented in Fig. 3.

The increased level of high frequency energy is due to the inclusion of the colour information, in the form of a colour sub-carrier of approximately 4.43 MHz on to which the hue or colour itself is phase modulated and the saturation or strength of the colour is amplitude modulated. As a result the colour signal makes increased demands upon the frequency dependent performance characteristics of the transmitting equipment and also increases the frequency range over which level dependent distortions are significant. Deficiencies in these performance characteristics affect the accuracy of picture reproduction. In particular, the different time delays of the frequencies associated with colour information and the picture or luminance information affect the "registration" of the colour with the picture. The addition of the colour sub-carrier to the vision and sound carriers increases the likelihood of intermodulation and spurious radiation problems.

With the recognition of these characteristic differences between monochrome and colour television signals, the more important basic tests appropriate...

Fig. 3 — Frequency Spectra of Typical Signals.
transmitter was it necessary to overcome an output stage overheating problem by means of a replacement valve with increased dissipation rating. Achievement of modulation depths below 5%, of the carrier level at the peak of synchronising pulses is dependent on the condition of modulator valves and on careful setting up to prevent grid current caused by any excessive amplifier input voltages from introducing counter-acting black level shifts. The performance defects arising from being unable to modulate below 5%, are not frequent or serious enough to justify the more extensive modulator changes that would be required to ensure this could always be achieved, particularly in the case of the overseas transmitters.

The third deficiency in all the monochrome modulators used in the National Service was that the back porch clamping circuits caused interference to the colour synchronising burst which is located on the back porch of the colour signal. The most common method of avoiding this interference, and the method adopted by the main Australian supplier in their modulator modification, is the insertion of a rejection filter at colour sub-carrier frequency to isolate the effects of the clamp circuits at colour frequencies. This method does not entirely eliminate disturbance to the burst information and two alternative methods are being tested for use on other modulators. The first alternative method is the insertion of a resistor rather than a tuned filter in the clamp line. This removal of reactive elements minimizes disturbance to the burst information by only at the expense of clamp efficiency. The second alternative method is the clamping of the clamp on a small portion of the back porch not occupied by the burst. In concept this is the superior method as complete independence is possible, operation and the burst, but complex circuitry is required to ensure that the clamp pulse is correctly positioned, particularly during the field blanking interval, and to ensure continued correct operation of blanking level feedback systems.

The fourth deficiency requiring alteration in monochrome modulators was in the operation of signal processing circuits designed to compensate for non-linearity of the modulation characteristic and limiting circuits designed to prevent excessive signal amplitudes. Synchronising pulse stretching circuits operating on a “stretch and clip” basis interfere with chrominance information extending beyond the black level and they were modified so as to operate only at luminance frequencies. Peak white clipping circuits were similarly modified to avoid interference with chrominance information extending beyond white level. Other linearity correction circuits found in monochrome modulators do not provide adequate correction at chrominance frequencies over the increased range of picture information found in a colour signal, and they make provision for differential phase correction which is necessary with colour operation. Therefore they were supplemented at the modulator input by a colour correction unit providing a full range of signal processing facilities. There is evidence that in some monochrome modulators the existing correction circuits introduce differential phase errors or are difficult to set up in conjunction with the colour correction unit. If this is confirmed all signal processing circuits will be removed from operation and all correction performed by the colour correction unit.

This process of off-setting errors in one part of the equipment by introducing compensatory errors in another part directly affects the long term stability of the overall equipment performance and has implications for the operation and maintenance of the station. This aspect will be carefully watched as experience is gained with converted stations.

Filterplexer and Other Coaxial Components

All medium and high level modulated monochrome transmitters are equipped with filterplexers to provide vestigial sideband shaping and to combine the output of the vision transmitter with the associated sound transmitter. The outputs of each of the vision/sound transmitters are further combined and connected to the aerial system by various coaxial components such as diplexers and switching frames. The filterplexers supplied with the monochrome transmitters do not offer the same level and stability of performance of parameters such as in-band insertion loss and return loss as do more recently available filterplexers. In addition the design does not reflect such colour requirements as the suppression of the colour sub-carrier image frequency to avoid spurious out-of-band radiation, and adequate cross-insertion loss between the sound and vision input ports which guards against the production of a visible 1.07 MHz component in the transmitted signal from inter-modulation between the sound and colour sub-carrier. An evaluation program involving measurement of individual filterplexer characteristics was commenced which included measurements on the transmitter-filterplexer combination in those cases where the filterplexer characteristics varied from those obtainable from a replacement unit. The aim was to determine those transmitters where the filterplexer represented the limiting factor in achieving satisfactory stable colour performance. These measurements showed that the in-band insertion loss of the monochrome filterplexers does not vary outside 0.5 dB across the band and does not jeopardise the power-bandwidth performance of the transmitter-filterplexer combination. The out-of-
STATION EQUIPMENT CONFIGURATION

The increased availability of solid state equipment of high reliability has enabled the configuration of station facilities, particularly in the programme input equipment area, to be progressively simplified over a period of time from that adopted when the major stations were established. A simplified block diagram of the configuration now adopted at a typical converted station is shown in Fig. 5.

PROGRESS AT 1 MARCH, 1975

By 7 October, 1974, progress with conversion work had reached the stage where colour test transmissions were introduced from capital city stations.

These test transmissions were subsequently extended to all National television stations and associated translators. These test transmissions which involved test patterns and programme material, proved most effective in enabling available resources to be directed towards the conversion of those aspects of each item of equipment causing the most visible performance deficiencies. By this means it was possible for all National stations to commence regular colour services at a subjectively acceptable level on the official ‘C-Day’ of 1 March, 1975.

Following this date, the conversion work as planned continued at the majority of regional stations. Completion of this work ensures that the...
ers can be seen in Figure 7. On closer inspection, it was found that only the bottom pair of feeders would foul the air duct. The bottom two feeders are only used for testing either the sound or vision transmitters into dummy load, without the filter-plexer. Consequently removal of the bottom pair, during the final stages of installation, would only reduce the test facilities of the original transmitter for a short period.

**Sequence**

It was first necessary to clear the area that the new transmitters and associated equipment would finally occupy. A large portion was already clear as can be seen from Figure 7. However, it was necessary to relocate the original power supply components away from the area to be occupied by new frames. It was fortunate that most of the original power supply leads were too long and had been folded back in the cable trunking under the floor. This allowed transformers and chokes to be moved without extensive reconfiguring. The rearrangement was carried out after programme hours and the power requirements were checked and tested before programme the following morning.

Holes were cut in the floor prior to the delivery of the transmitter equipment. The floor thickness is 152 mm (6 inches) and diamond drills were employed. The inevitable hidden conduit was hit by the drilling, successfully extinguishing the whole of the basement lighting system.

It was decided that the new transmitter furthest from the original feeders would be installed first. The second one would then be put in position and when the time was reached for air to be supplied to the second unit the two lower feeders would be removed. This sequence provided a margin of safety in that if a failure in the original monochrome transmitter required it to be tested into dummy load, there would be one of the new transmitters that could be put to air with programme while the two test feeders were being replaced.

**Transmission**

At the correct stage in the installation, it was necessary to connect the new transmitters to the antenna system. The final arrangement was to connect the main external antenna feeders via suitable reducers to the 2½ in. rigid coaxial feeder used from the new switching frame. The mono-
chrome transmitter was connected by 3½ in. rigid feeder to the main external feeder via a switching frame, which contained several electrically operated coaxial switches. This arrangement enabled the output from the monochrome filterplexer to be connected to:

* Dummy Load
* Both halves of the antenna via a power divider.
* Upper antenna only
* Lower antenna only

The new switching frame provides the same facilities but was not brought into full use until the two transmitters had been completely tested and the main antenna feeders connected to the 2¾ in. feeder. It was however, advantageous to retain the antenna splitting facilities, in case of a fault. An electrically driven coaxial switch was located in series with the feed from the monochrome filterplexer, for use as a 'change over' switch between the monochrome and colour installations, whilst maintaining full antenna switching flexibility. The main purpose of the changeover facility was to enable the new colour installation, 10kW at first, to be put to air for test transmissions of colour test pattern. Normal monochrome programmes were then broadcast using the monochrome transmitter whilst work continued on the new colour transmitters. Finally when the colour installation was complete and the permanent connections made to the antenna feeders, the monochrome installation was removed completely, leaving the final arrangement as shown in Fig. 8.

CONCLUSIONS

The National Television Transmitting Stations have been converted to colour operation by the modification of those items of equipment unable to handle the increased transmission demands of colour signals. If the necessary modifications were expensive or the item was becoming a maintenance liability then the item was replaced. This engineering approach was aimed at providing a colour service in compliance with Australian Standards, at minimum cost. Experience with colour operations is expected to show the areas in which there is an opportunity to improve further the standard of the service in both quality and reliability and to reduce the maintenance costs.
R. P. LEES graduated B.E.E. from the University of Melbourne in 1958 and joined the Radio Section in the Victorian Administration of the APO. During the period 1962–1968 he worked on the establishment of regional television stations throughout Victoria and from 1968 onward he was responsible for the construction works associated with a major expansion of the Victorian microwave broadband bearer network.

In 1972 he transferred to Headquarters as Supervising Engineer, Television Services, and in this position he has been responsible for the colour conversion of National television transmitting stations throughout Australia.

J. D. HODGSON is an Engineer Class 2 in the Tasmanian Administration of Telecom Australia. Prior to joining the APO in 1971 he worked with the British Post Office. He obtained a B.Sc. degree from the University of Aston in Birmingham, U.K. Currently he is involved in the conversion of National TV stations to colour operation but has been involved in a wide range of installation projects including crossbar exchanges and subscriber’s radio systems. From 1972 to 1974 he was secretary of the Tasmanian Division of the Telecommunication Society and he is currently a committee member.