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Research Laboratories Report 7725

The Digital Network Synchronisation Field Trial — Transmission of Timing References Over the Analog Trunk Network

By R.B. Coxhill

Telecom Australia

Telecom Australia

Research Laboratories
770 Blackburn Road, Clayton, Victoria, Australia 3168

REPORT 7725

THE DIGITAL NETWORK SYNCHRONISATION FIELD TRIAL - TRANSMISSION OF TIMING REFERENCES OVER THE ANALOG TRUNK NETWORK

BY R.B. COXHILL

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REPORT 7725 - THE DIGITAL NETWORK SYNCHRONISATION FIELD TRIAL - TRANSMISSION OF TIMING REFERENCES OVER THE ANALOG TRUNK NETWORK.

BY R. COXHILL

Up until the latter part of 1983, the Telecom Australia Research Laboratories had been co-ordinating the development of a synchronisation plan for the emerging digital network. This plan was based on the use of the analog trunk network for the transmission of timing references to be used for network synchronisation purposes. A field trial was established to investigate various parameters associated with this proposed method of transmitting timing references. The field trial involved transmitting a typical timing reference and monitoring a variety of parameters on a computer based data acquisition system.

This report describes the method of transmitting this timing reference over the analog trunk network, and briefly describes the hardware constructed to provide the necessary interface to achieve this.

Since the establishment of this field trial, Telecom Australia has reviewed its plans with regard to digital network synchronisation, and the current proposal is that it will be implemented via digital bearers in conjunction with other mechanisms.

RESEARCH LABORATORIES REPORT 7725

THE DIGITAL NETWORK SYNCHRONISATION FIELD TRIAL - TRANSMISSION OF TIMING REFERENCES OVER THE ANALOG TRUNK NETWORK

1. INTRODUCTION

Up until the latter part of 1983, the Telecom Australia Research Laboratories had been co-ordinating the development of a synchronisation plan for the emerging digital network. This plan was based on the use of the analog trunk network for the transmission of timing references to be used for network synchronisation purposes. A field trial was established to investigate various parameters associated with this proposed method of transmitting timing references. The field trial involved transmitting a typical timing reference and monitoring a variety of parameters on a computer based data acquisition system.

This report describes the method of transmitting this timing reference over the analog trunk network, and briefly describes the hardware constructed to provide the necessary interface to achieve this.

Since the establishment of this field trial, Telecom Australia has reviewed its plans with regard to digital network synchronisation, and the current proposal is that it will be implemented via digital bearers in conjunction with other mechanisms.

However, by reconfiguring the scheme on a loop basis, useful information on the transmission characteristics of the analog trunk network can be obtained, and this information is currently being gathered.

The report is not intended to provide specific hardware details, but to present an appreciation of the techniques employed and an overview of the transmission arrangements required to facilitate the timing reference transmission.

With regard to more specific hardware details of the interface equipment constructed, the Line and Data Systems Section maintains a well documented register of "Experimental Models", in which further details can be found [1].

Information pertaining to the overall synchronisation field trial arrangement is given in [2].

Details of other equipment and associated software which are also part of the field trial are given in [3, 4 & 5].

2. OVERVIEW OF TRANSMISSION REQUIREMENTS

The Digital Network Synchronisation Field Trial requires the transmission of a 204.8 kHz timing reference over the Frequency Division Multiplexing network. This timing reference is transmitted between 770 Blackburn Rd., Clayton, Victoria, and Haymarket Carrier Terminal Centre, Sydney, and is used to phase lock a main clock at Haymarket to the national reference clock at Clayton.

The timing reference is transmitted by firstly generating two tones that have a frequency difference equal to the timing reference frequency, sending these two tones via the FDM network to the required location, and then determining the frequency difference between the two tones to reconstitute the timing reference.

It is imperative that the two tones maintain the same frequency difference over the transmission link. For this reason the two tones cannot be inserted into the FDM network at the standard channel or group multiplexing points because of carrier frequency errors affecting each tone differently. They must be added at the basic supergroup level or any higher point. Similarly, they must be filtered out at a point no lower than the basic supergroup. Any carrier frequency errors affecting the two tones at supergroup level, or any higher point, will affect the two tones equally, and thus still maintain the same frequency difference between the two tones.

Carrier frequency errors are inherent in the FDM network and are caused by frequency differences between carriers used for each modulation/demodulation step enountered over a transmission link.

Telecom Australia is currently implementing a plan to phase lock carrier frequencies on a national basis. At this stage some capital city and larger country terminal centres have phase locked carriers. When the full plan is implemented, carrier frequency errors will not be a problem.

The two tones that are transmitted over the FDM network are chosen such that they can be accomodated within a single supergroup by displacing two voice channels. In terms of the basic supergroup, the reference tones have the following frequencies:

333.333 kHz - occupies channel 6 of group 1
538.133 kHz - occupies channel 9 of group 5

To clear the two channels of normal traffic, they are declared as leased lines and terminated appropriately.

The final arrangement requires that the timing reference be transmitted simultaneously over two independent media (e.g. coax and radio), with provision for a possible third. This ensures a high degree of reliability. For testing purposes, one return path is required.

3. TRANSMISSION SCHEME.

As previously mentioned, the timing reference is to be transmitted between Clayton, Victoria, and Haymarket, NSW. This transmission link can be broken up into 3 stages:

(i) 770 Blackburn Rd., Clayton, to 22 Winterton Rd., Clayton Vic. via 2 km of unrepeatered coaxial cable.

(ii) 22 Winterton Rd., Clayton. to Lonsdale Carrier Terminal Centre Melbourne, via a tail 12 MHz FDM system over repeatered coaxial cable. This is a distance of around 25 km.

(iii) Lonsdale Carrier Terminal Centre (Melbourne) to Haymarket Carrier Terminal Centre (Sydney), via the high capacity FDM coaxial and radio links.

Three sets of interface equipment have been constructed and installed to interface with the FDM equipment and facilitate the two tone transmission. The interface equipment is installed at (1) 770 Blackburn Rd., Clayton, Vic., (2) Lonsdale Exchange, Melbourne, Vic. and (3) Haymarket Exchange, Sydney, NSW.

Fig. 1 illustrates the arrangement.

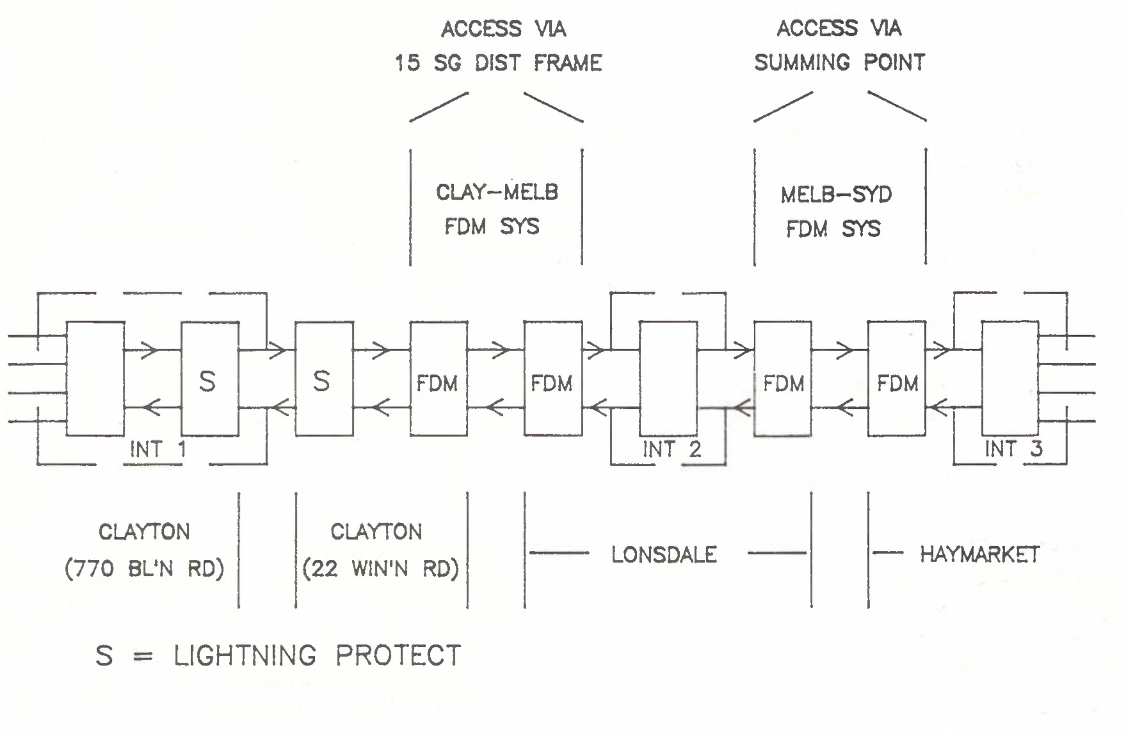

Fig 1. TRANSMISSION SCHEME

At Clayton, the tones can be interfaced with the FDM equipment at the 15 Supergroup assembly distribution frame access point. The link at this access point is broken and fed to the interface equipment. As the FDM system at Clayton is used only for experimental purposes and is not carrying live traffic, this link can be broken without disruption to other services. At Lonsdale and Haymarket however, the situation is different, and this is discussed in the next paragraph.

3.1 Tone Injection Methods

At Lonsdale and Haymarket carrier terminal centres, the tones must be interfaced to a supergroup with no disruption and as little as possible modification to existing services. To achieve this, two methods are possible, and these are discussed below. Either method displaces only two voice channels within a supergroup and is otherwise transparent to the FDM equipment.

(i) Method 1

Telecom's FDM network is based on the use of 15 (2-16) supergroup assemblies, whereas the hierarchy makes provision for 16. Telecom does not normally use supergroup 1 on intercapital bearers. However, as supergroup assemblies are purchased on the world market and invariably provide facilities for supergroup 1, rack space is provided for a supergroup 1 modem, although for some systems Telecom does not purchase this additional space. This vacant rack space (if provided) can be used to insert another supergroup modem. The tones could then be applied to this additional supergroup modem. However, this method requires an additional supergroup modem and cannot be employed on FDM equipment which does not have the required rack space or where the rack space is already utilised for other purposes.

(ii) Method 2

Whether or not the additional rack space is provided, it is generally possible to obtain direct access to the supergroup summing point via one or more methods. The supergroup summing point is the point where supergroups are electrically combined after being translated up or down to the next level in the hierachy. The methods for gaining direct access to this summing point include:

(a) Directly (jack provided).

(a) Via connectors at the rear of the supergroup 1 vacant rack space.

(c) Via pilot injection points.

In those systems that use resistors and/or hybrid transformers to sum supergroups, the tones can be injected directly into the supergroup summing point, and will displace the channels associated with the tone frequencies in the unmodulated supergroup (supergroup 2). This restricts the transmission of the tones to supergroup 2 (the only unmodulated supergroup), but is simple to implement and requires no additional equipment. This is the method adopted.

The use of supergroup 2 is preferable as it avoids bandwidth clashes with multi-supergroup modems. In addition, the use of groups 1 and 5 within the supergroup avoids clashes with those groups normally used for groupband data transmission.

4. INTERFACE EQUIPMENT HARDWARE DETAILS

As shown in Fig. 1, three sets of interface equipment are required to facilitate the timing reference transmission.

Each set of interface equipment consists of a rack width double height "eurocard" chassis, together with a selection of plug-in "modules". The chassis is designed to mount in a Telecom type 72 rack. The selection of modules for each set of interface equipment is determined by the functional requirements of the equipment at its particular location. Each module performs a distinct function (e.g. Filter, Attenuator), is fully screened, and has an input and output impedance of 75 ohms. The facility to plug in a selected attenuator, or a straight through connection is provided on some modules as a means of adjusting relative levels. Where used, the Lightning Protection module is permanently fastened into the interface equipment chassis to ensure good earthing arrangements. Coaxial cable is used to interconnect between modules within an interface chassis. The combination of screening and coaxial cable interconnections ensures a high level of noise immunity which is required due to the low signal levels in some paths. Considerable care has been taken in the design of active circuitry. In particular, noise levels, intermodulation distortion and gain variations have been kept to a minimum. Each set of interface equipment operates off a supply of -50 V dc.

4.1 Interface Chassis Descriptions

(i) Interface 1

This equipment is located at 770 Blackburn Rd., Clayton, Victoria. A block diagram is shown in Fig. 2.

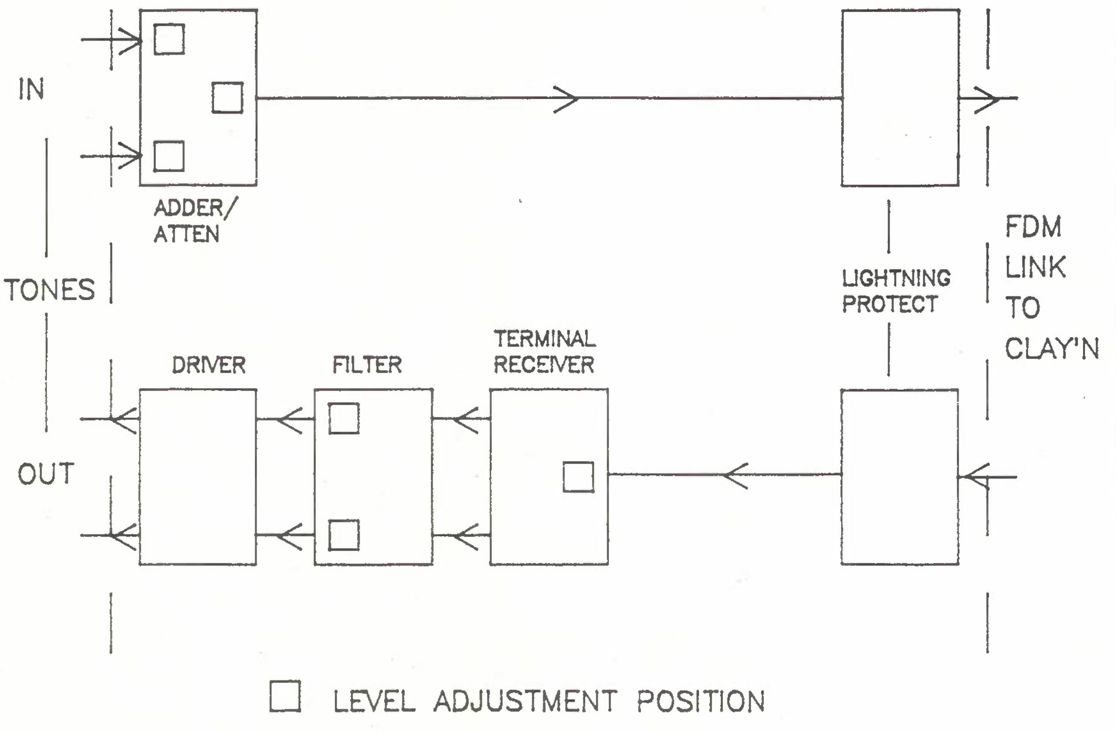

Fig 2. INTERFACE 1

In the send direction, the two tones are added and sent to 22 Winterton Rd., Clayton, via the Lightning Protection module.

In the receive direction, the two tones are accepted through a Lightning Protection module, and applied to the Terminal Receiver module. In the Terminal Receiver, a bandpass filter is used to reject any signals outside the frequency band containing the tone frequencies. The two tones are then sent to the Filter module via 2 equivalent paths.

The Filter module consists of two independent high quality crystal band pass filters with associated active buffering. One filter is centred on 333.333 kHz, and the other on 538.133 kHz. The filters have a bandwidth of about 500 Hz. Each tone is extracted and output via amplifiers located in the Driver module.

(ii) Interface 2

This equipment is located at Londale Exchange, Melbourne. A block diagram is shown in Fig. 3.

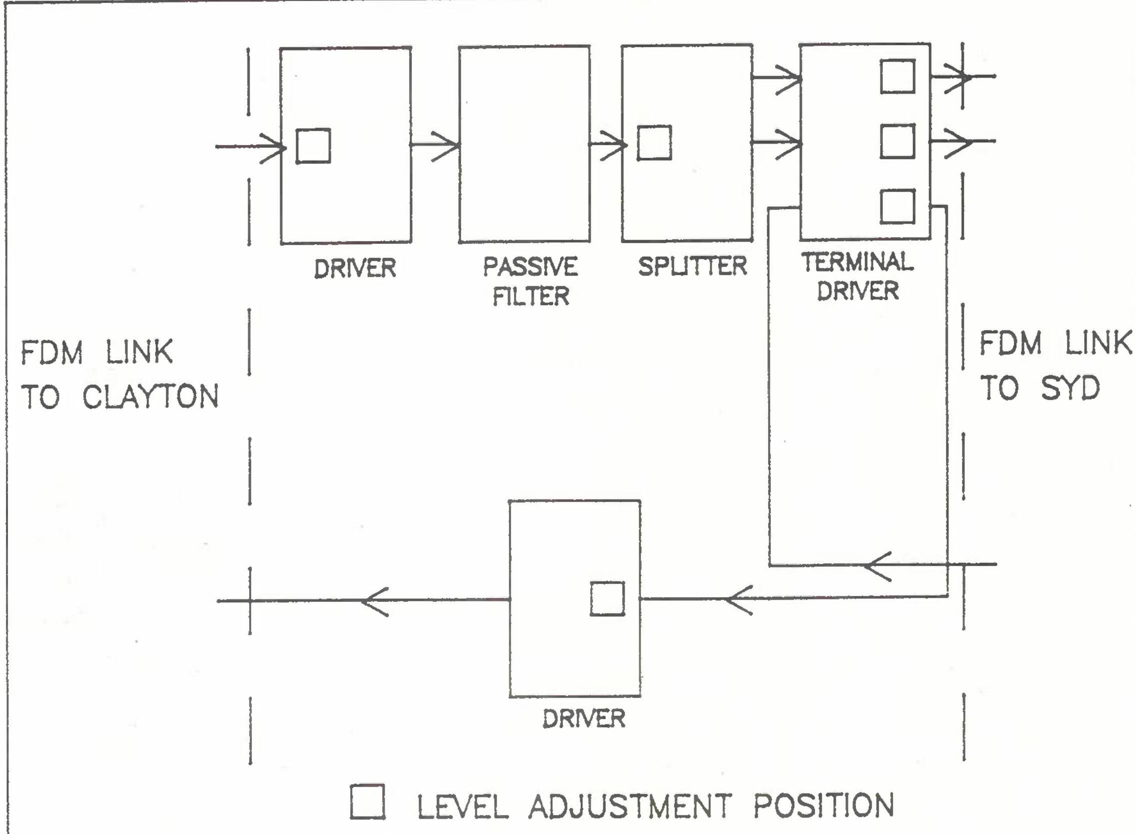

Fig 3. INTERFACE 2

In the send direction, the signal taken from the 15 supergroup distribution frame access point is applied to an amplifier. This signal contains the two tones in addition to other signals introduced by the FDM equipment. The signal passes through the amplifier and is appied to the Passive Filter module which passes the tones and rejects any other signals. This filter is functionally the same as the filter module described in Section 4.1(i). The Passive Filter also contains circuitry to prevent the passage of large signal levels. This protection is required in the case of a fault condition to prevent overloading the following FDM equipment which is carrying live traffic from Melbourne to Sydney. The two tones are then applied to the Terminal Driver module via the Splitter module. The Terminal Driver contains three independent bandpass filters and output attenuators corresponding to the three possible transmission media to be used in the experiment. The outputs from the Terminal Driver are applied to the supergroup summing points on the FDM equipment of the appropriate transmission medium. The bandpass filters are equivalent to that used in the Terminal Receiver module (see Section 4.1(i)).

In the receive direction, signals received from the FDM system are firstly filtered in the Terminal Driver module, then amplified via the Driver module and sent to 770 Blackburn Rd., via the Lightning Protection module. Care must be taken in the receive direction to ensure that no overloading occurs as the signal taken from the FDM system contains a complete spectrum of supermastergroup traffic.

(iii) Interface 3

This equipment is located at Haymarket Carrier Terminal Centre, Sydney. A block diagram is shown in Fig. 4.

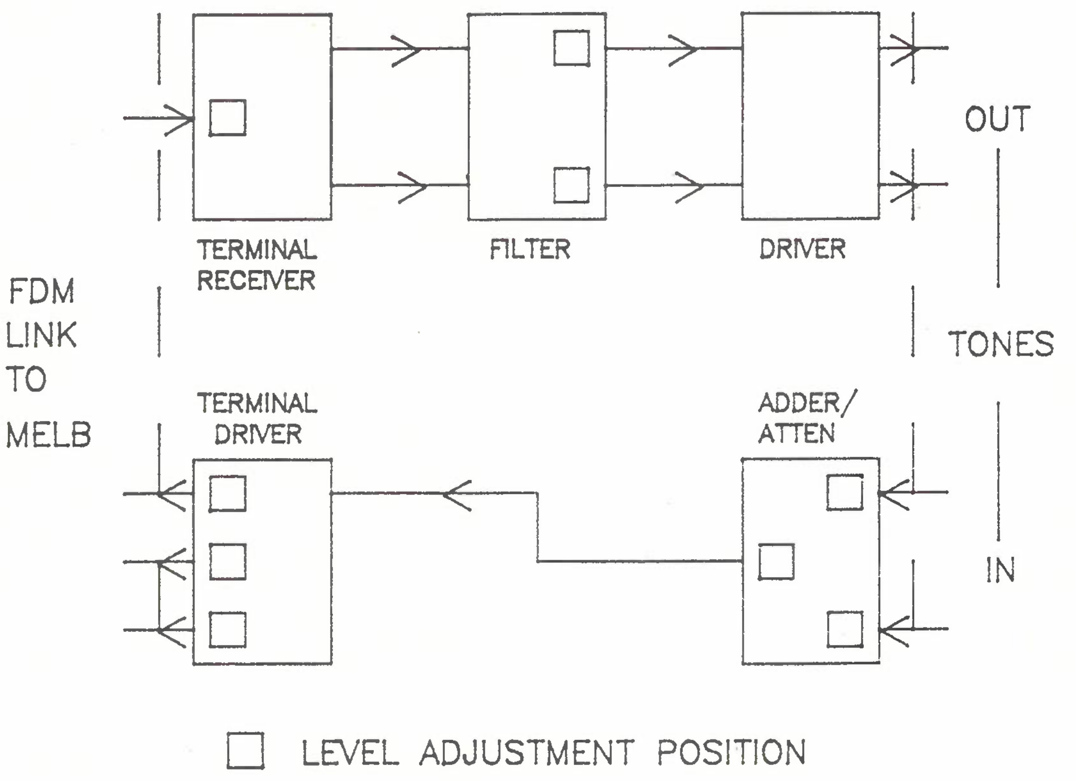

Fig 4. INTERFACE 3

In the send direction, signals received from the FDM system are processed in the same manner as described for the same modules in Interface 1.

In the receive direction, the two tones are added in the Adder/Attenuator module and sent to the FDM system via the Terminal Driver module. See Section 4.1 (ii) for a description of the Terminal Driver.

5. SOME INTERFACE EQUIPMENT SPECIFICATIONS AND PERFORMANCE DETAILS

5.1 Level Specifications

(i) Reference tones in and out: -6 dBm ±1 dB.

(ii) FDM equipment summing point (in): -15 dBm0 (-48 dBm) ±1 dB.

(iii) FDM equipment summing point (out): -15 dBm0 (-40 dBm) ±1 dB.

(iv) Coaxial cable interface points: -43 to -48 dBm.

All the above levels can be adjusted by selection and insertion of plug-in attenuators. Refer to [2] for further details.

5.2 Filter Frequency Responses

(i) Crystal Filters

Fig. 5 here shows a plot of loss vs. freq. for the 333.333 kHz crystal filter as used in the Filter module. The response for the 538.133 kHz filter is similar.

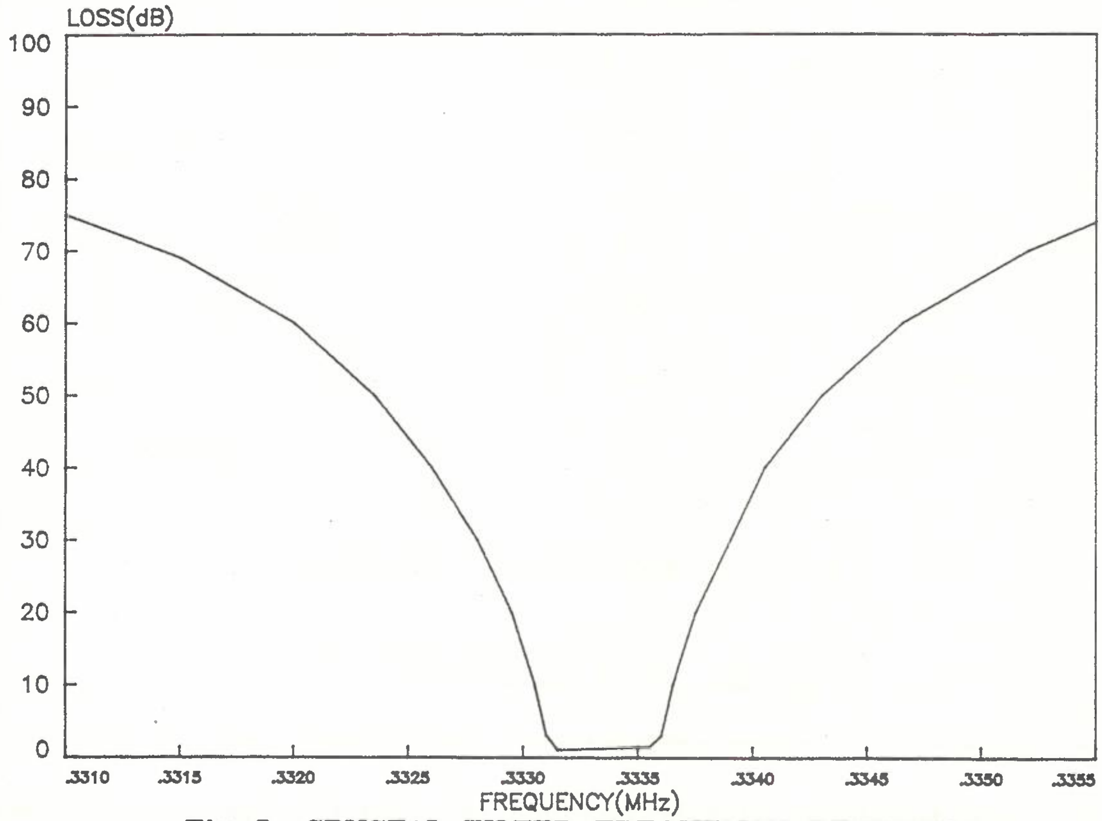

Fig 5. CRYSTAL FILTER FREQUENCY RESPONSE

(ii) Band Pass Filter

Fig 6 shows a plot of loss vs. freq. for the bandpass filter used in the Terminal Receiver and Terminal Driver modules.

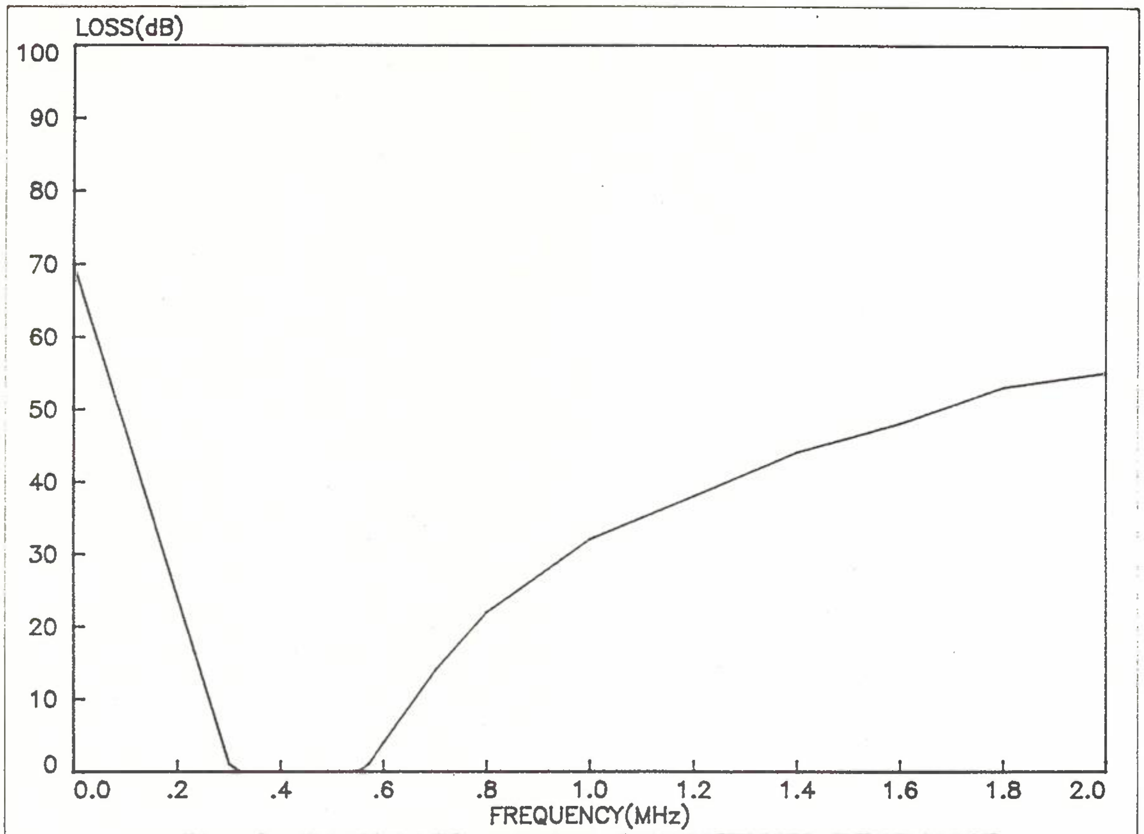

Fig 6. BANDPASS FILTER FREQUENCY RESPONSE

6. ACKNOWLEDGEMENTS

The author wishes to thank John Millott who initiated the scheme and designed sections of the interface circuitry. Also to Stephen Spicer and Fred Bullock who designed and/or modified sections of the interface circuitry. Rick Witham also assisted in setting up the equipment configuration.

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