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A Telephone-Conference Multiplex Switch for Radio Studio

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1 Introduction

Bertolt Brecht demanded that radio, working as a communicator being a one way communication medium, has to become a medium with «feedback». This can be achieved fairly well with the help of the telephone. It has been proved in many broadcastings in which the listener could participate by telephone. There is hardly a studio left that does not own the necessary equipment. The meaning of broadcastings like these is to motivate the listener to take part in the programme himself. Experience has shown that due to the anonymity and the limitation of the participant to a voice especially hot topics can be dealt with successfully. But the importance of choosing the right participants should not be overlooked.

For the recording or transmitting of telephone conversations, the PTT certified equipment is normally used. It is known as telephone balance unit or telephone-hybrid. *Figure 1* shows a much simplified block diagram. The two-wire telephone line to the subscriber (SL) is connected to the hybrid circuit. In the hybrid (HYB) a four-wire connection is produced in which the circuit LBO (Line Build-Out) serves for balancing the line impedance. The conversation in the direction subscriber to studio takes place over the receive amplifier path (RCV). The other direction takes the way over the transmit amplifier path (XMT). The isolation between the transmitting and receiving path has to be as good as possible. This is granted by the trans-hybrid loss obtained.

2 Development of Multiplex Switch for Telephone-Conference

In 1976 the Swiss Broadcasting Corporation started an evaluation programme with the aim of finding a replacement for an already existing telephone-hybrid. The device had to be easier to use and to have better qualities concerning the trans-hybrid loss. With the exception of the prototype presented by *Willi Studer* at Regensdorf (Zurich), all of the tested devices till 1978 showed no improvement in at least one parameter.

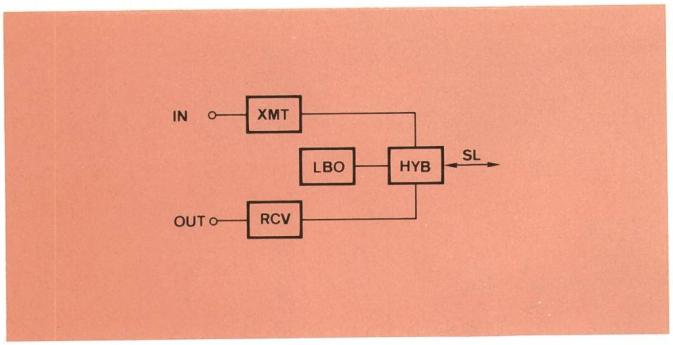


Fig. 1
Block diagram of the telephone hybrid circuit
SL Subscriber line
HYB Hybrid circuit
LBO Line build-out network
XMT Transmitting circuit
RCV Receiving circuit
IN Input
OUT Output

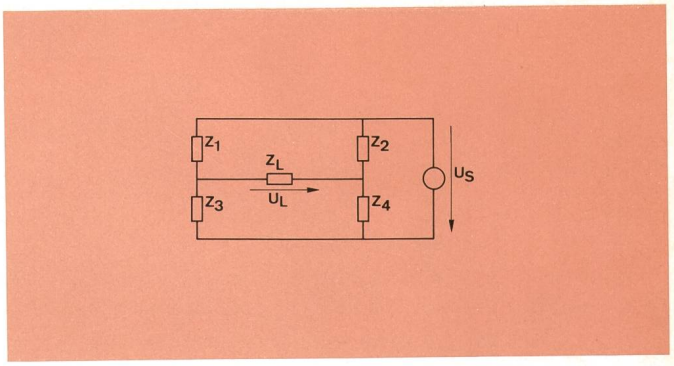


Fig. 2
Principle of the Wheatstone-bridge

When using the aforementioned equipment, only the speech level of the participating telephone subscriber has to be adjusted at the mixing console. The trans-hybrid loss being so high one could think of a conference connection. A corresponding order was sent out to the Standard Telephone & Radio Co to produce a telephone console together with partner firms.

The layout for a similar Studer device in a portable version is completed. It will be produced on sufficient demand.

3 The Hybrid Circuit

The hybrid circuit divides a two-wire into a four-wire line by using the *Wheatstone* bridge circuit *(Fig. 2)*. It is balanced when the conditions

$$Z1 \cdot Z4 = Z2 \cdot Z3 \text{ with } Z = |Z|e^{j\varphi}$$

is fulfilled, which means, if a signal produced by U_s does not appear over Z_L, Z_L and U_s can be exchanged. In *Figure 3* Z2 and Z4 have been connected by transformers, whereby for example Z2 is the two-wire line and Z4 an impedance, identical in amplitude and phase, if $Z1 = Z3$. With the aid of the transformers, Z2 can be electrically (d.c) insulated from the bridge circuit.

The trans-hybrid loss (THL) is indicated as the loss of U_s over Z_L between the four-wire connections. If $Z1 = Z3 = Z$ then

$$THL[dB] = 20 \log \frac{(Z+Z2)\,(Z+Z4)}{2Z(Z2-Z4)}$$

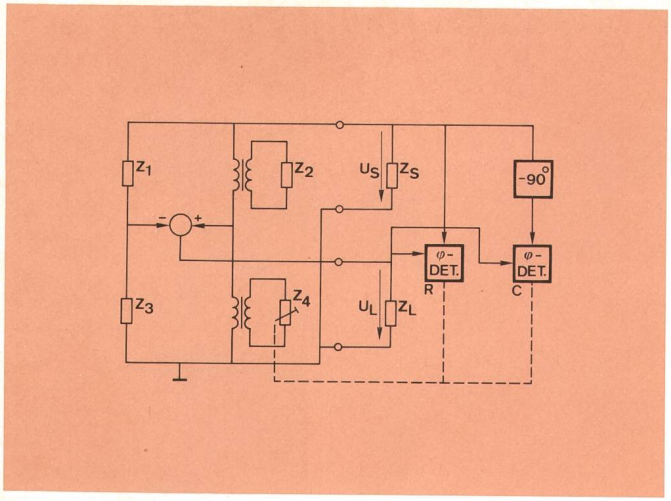


Fig. 3
Hybrid circuit with alignment
DET Detector

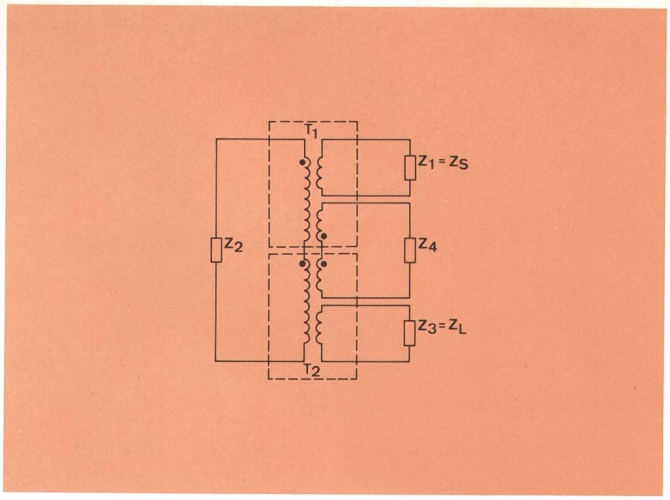


Fig. 4
Hybrid circuit with transformers

In telecommunications engineering one normally uses two transformers according to *Figure 4.* This gives us a floating connection of the four-wire circuits. The use of these transformers goes back to the year 1904 but the basics have been known since 1890 already.

As mentioned above in Figure 3, Z2 can be a two-wire line and Z4 an impedance which is similar to Z2 as close as possible. For this reason Z4 is called line build-out (LBO) and usually consists of an adjustable resistor in series with a capacitor. So, one usually reaches a trans-hybrid loss of 11 dB ± 3 dB. With complex network, balanced for certain lines, values up to 50 dB can be obtained.

4 The Telephone Hybrid

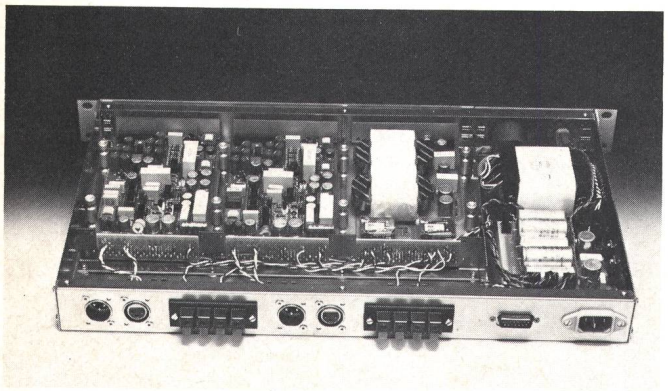
The great advantage of this device is that trans-hybrid losses of 20 to 40 dB can be achieved automatically. The balancing takes place as follows: if a signal U_s is introduced to the four-wire input over Z_s (Fig. 3), a fault signal appears if bridge over Z_L is not balanced. This signal together with the input signal U_s (speaker) is fed into a phase detector. The output signal of the detector drives a variable resistor until the fault signal is minimum. At the same time a second phase detector, which receives a signal with a phase lag of 90 degrees, generates a voltage for a variable capacitor (the variable impedances are realized by operational amplifiers). Thus it is possible, together with an inductance, which is set in a preadjustment, to reproduce very well the real as well as the imaginary part of the line. Besides, the transmitting and receiving parts of the telephone-hybrid are realized selectively (Fig. 1). *Figure 5* shows a plug-in unit for rack mounting equipped cabines with two telephone-hybrids, holding coils and power supply.

5 The Conference System

The telephone console *(Fig. 6)* contains four telephone-hybrids which feed a multiplex device. With these, up to four people can talk with the studio at the same time. It is possible to exchange the participants during broadcasting without any interferences. The audio output of the telephone console is switched to an input module of the mixing console, making it possible to balance the various speech levels of the calling participants.

During conference connection, up to three telephone-hybrids lie parallel to the input/output of a fourth. Due to the high rejection of unwanted signals of each hybrid circuit there is no instability.

The transmitting and receiving circuits have been adjusted for an average two-wire level of −15 dBm (dBm = absolute power level relative to 1 mW). A special auxiliary sum of the mixing console, on which all inputs



▲
Fig. 5
Studer telephone hybrid cabinet

▶
Fig. 6
View of the telephone console

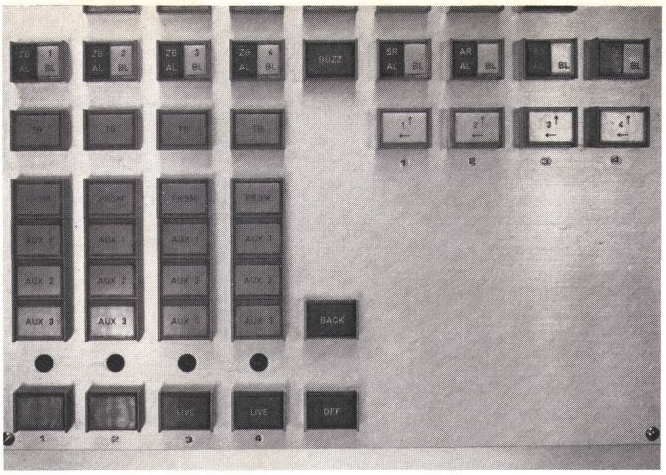


Fig. 7
View of the push button panel

except input «telephone console» work, feeds the fifth multiplex input. With the exception of the input fader on the mixing console no other setting devices are needed.

The mixing console is put beside the continuity console in the control room because in Swiss studios, the moderator works together with a technician who operates the equipment and does the balancing.

6 The Control

Figure 7 shows the push button panel. When a listener calls in, one of the bicoulored keys in the top row starts flashing.

By pressing a key of the next row TB (talk-back) it is possible to have a preliminary discussion. Afterwards the caller gets one of four arbitrary foldback signals (next four rows), for example the station identification or the programme just being broadcast. During this time the caller is not switched on air yet and the moderator to whom the respective operation conditions are signalled *(Fig. 8)* is able to make further arrangements selectively. Using one of the four bottom keys the caller is switched on air noiselessly. There are special precautions against faulty operation.

In each of the four telephone-hybrids a circuit has been built-in which shows whether the input signal exceeds a certain minimum level. Thus, it is possible immediately to localise if a caller has put down the phone before or during the broadcasting.

The whole rather complicated control procedure has been realized as software. For this reason, possible additional modifications require a new programming of ROMs.

The first telephone console of this kind has been in use since the middle of 1979 and has proved very effective.

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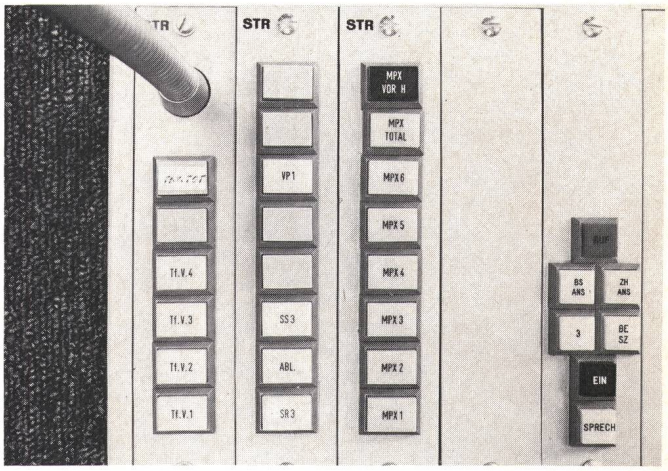

Fig. 8
View of the push button panel at the moderator. The push buttons at left indicate the operational status of the four telephone hybrid circuits. They can be used for selective preliminary discussion