Zeitschrift: Technische Mitteilungen / Schweizerische Post-, Telefon- und Telegrafenbetriebe = Bulletin technique / Entreprise des postes, téléphones et télégraphes suisses = Bollettino tecnico / Azienda delle poste, dei telefoni e dei telegrafi svizzeri

Herausgeber: Schweizerische Post-, Telefon- und Telegrafenbetriebe

Band: 50 (1972)

Heft: 3

Artikel: Automation and data processing at the telephone-cable test department

Autor: Kühne, H. / Schaudt, H.

DOI: https://doi.org/10.5169/seals-874651

Automation and Data Processing at the Telephone-cable Test Department

H. KÜHNE, Berne, H. SCHAUDT, Brugg

Die deutsche Version dieses Artikels ist bereits in den Technischen Mitteilungen PTT Nr. 1/1972 erschienen.

La version française de cet article a paru dans le Bulletin technique PTT No 1/1972.

Summary. *For some years Swiss cable manufacturers have been using automatic measuring equipment for electrical tests of telephone cables. Previously the many different routine tests of 2400-pair (1200-quad) cables involved considerable expenditure of time and personnel. Digital recording and processing of test results by a computer not only saves time, but also offers a number of other advantages. For quality control of their cables 'Kabelwerke Brugg Ltd' use a free-programmable computer which processes the test results from the automatic measuring equipment and calculates splicing tables on the basis of the individual cable data.*

Automatic Measuring of Telephone Cables

A variety of characteristics have to be measured by the manufacturers of local, junction and trunk cables. The limits to be adhered to are contained in the Swiss PTT specifications for the manufacture and supply of telephone cables [1]. Depending on the use of a cable, the following electrical characteristics of quads have to be measured:

$R_{1\text{-}2}$	Loop resistances in the quad: side-circuits 1 and 2
$\Delta R_{1\text{-}2}$	Resistance unbalance of side-circuits 1 and 2
ΔR_v	Resistance unbalance of the quad
$C_{1\text{-}2}$	Mutual capacitance of side-circuits 1 and 2
C_v	Mutual capacitance of the phantom
$k_{1\text{-}3}$	Intra-quad capacity unbalance
$k_{4\text{-}12}$	Adjacent quads capacity unbalances
$e_{1\text{-}3}$	Capacity unbalances to ground

If, as in the case of junction and trunk cables, all these characteristics have to be measured, there are 23 different values per quad.

As conventional measuring methods, i. e. balancing bridges manually and reconnecting the cable for each test, involved too much expenditure of time and personnel, new solutions were sought. By invitation of the Swiss cable industry, specialists of the PTT General Directorate have since 1961 been working on standard procedures for automatic measurement of telephone cables, including the recording and processing of test results for both quality control and the calculation of splicing tables.

The PTT discussed with various firms the possibility of manufacturing automatic measuring equipment meeting Swiss requirements, and on 25 October 1963 the first prototype was presented to the interested parties at Berne-Ostermundigen. In the meantime the following cable works have put into operation automatic test gear: Dätwyler Ltd [1], Brugg Ltd [2], Cortaillod Ltd [3] and Cossonay Ltd [4].

The first automatic tester in Switzerland was put into operation at Dätwyler Ltd, Altdorf, in mid-1967. The first tester with computer was supplied to Kabelwerke Brugg Ltd in early 1968. It is with this firm that the PTT have since continued their studies on the recording and evaluation of data obtained from automatic measuring equipment.

The automatic cable measuring equipment KMA-3b used by the test department of Kabelwerke Brugg Ltd, where over a million test results a month are recorded and evaluated, has been manufactured jointly by Felten & Guilleaume and Wandel & Goltermann. Wandel & Goltermann designed and made the digital equipment, while Felten & Guilleaume supplied the analog resistance and capacitance measuring apparatus. *(fig. 1).*

The measuring units for resistance, capacitance and capacity unbalance each supply a dc voltage which is proportional to the respective measurement. The analog/digital converter changes this dc voltage into digital signals, and the sorter, which is controlled by punched cards, selects the measuring range and determines the contract values as well as the tolerance limits. At the crossbar distributor of the measuring and control unit *(fig. 2)* certain recorder functions can be programmed (red print, symbols, recorder disconnection) which are triggered when a measured value exceeds the tolerance limits.

At the test point changeover switch *(fig. 3),* which is the central control device of the system, test programmes can be selected by means of push-buttons. The perforator converts the data received from the analog/digital unit into teleprinter signals.

By means of two clips an operator at each end of the cable connects the main and adjacent quad under test to the measuring equipment. The quantities resistance,

[1] Automatic tester by Felten & Guilleaume and Wandel & Goltermann

[2] Two automatic testers by Felten & Guilleaume and Wandel & Goltermann; free-programmable computer by Dietz

[3] Automatic tester manufactured by Cortaillod Ltd and developed by Lavanchy, Lausanne

[4] Automatic measuring and test equipment with computer by Siemens

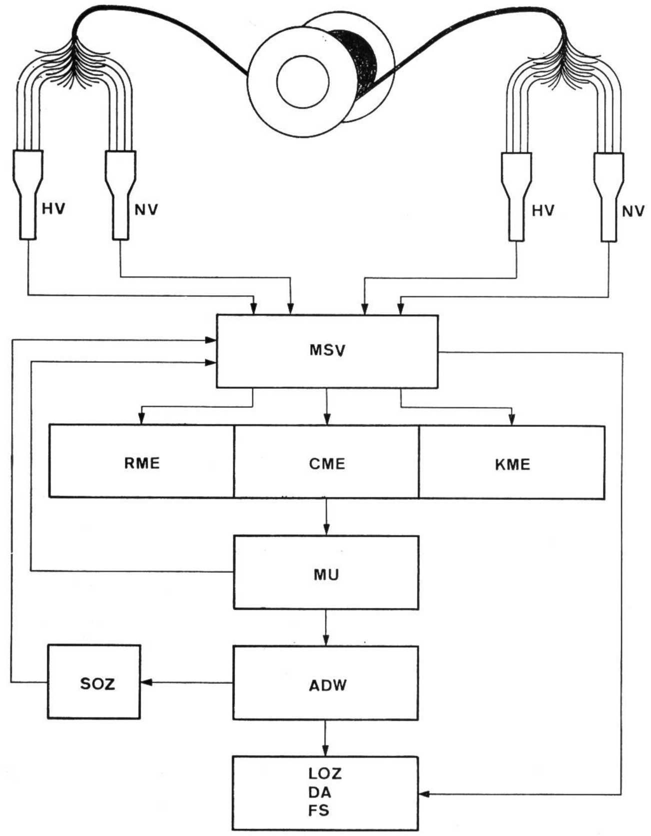

Fig. 1
Block diagram of the automatic cable measuring equipment KMA-3b

HV	Main quad	MU	Test point changeover switch
NV	Adjacent quad	ADW	Analog/digital converter
MSV	Measuring and control distributor	SOZ	Sorter
RME	Resistance measuring unit	LOZ	Perforator
CME	Capacitance measuring unit	DA	Digital display
KME	Capacity unbalance measuring unit	FS	Teleprinter

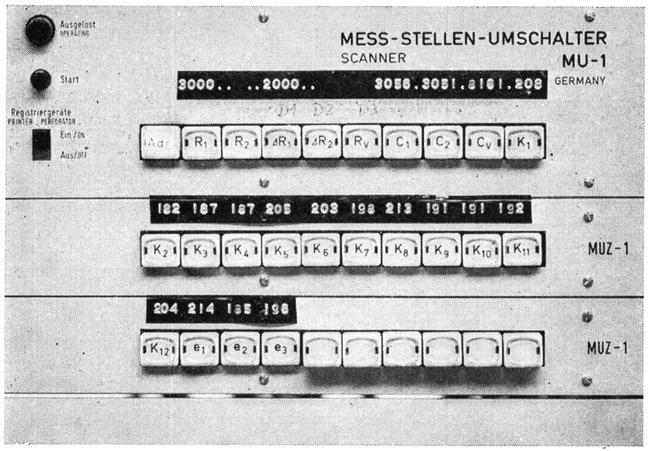

Fig. 3
Testpoint changeover switch

mutual capacitance and capacity unbalance are measured in a quick automatic sequence. During a test cycle 23 3-4-digit values and associated symbols can be recorded on the teleprinter within about 10 seconds. It is possible to select any form of abbreviated programme. Each individual measurement is preceded by a short-circuit and interruption test of the quad. As the operators self-check connections by making them simultaneously, the correct order of single wires and quads is ensured *(fig. 4)*.

Thanks to automation, Kabelwerke Brugg Ltd have been able to reduce substantially the number of test operators. While the manual method made it necessary to reconnect quads for each type of measurement (resistance, capacity unbalance, mutual capacitance), this is only done once for

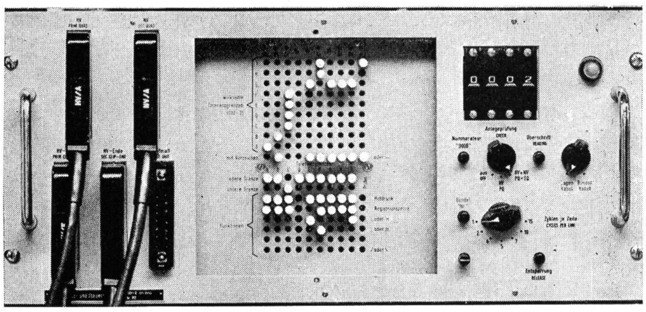

Fig. 2
Measuring and control distributor of the automatic cable tester at Kabelwerke Brugg Ltd

Fig. 4
Operators testing a factory length of cable by means of automatic tester KMA-3b

all automatic tests. Consequently, fewer testing positions are required and, since measurements also take up less time, space can be saved. The printed records, which contain no false readings or typing-errors, are an additional advantage.

Data Processing

The automatic cable testers at Kabelwerke Brugg Ltd are connected to the test department's own free-programmable Mincal 4 E computer by Dietz *(fig. 5)*. This computer processes the results of measurements in any desired form. The data obtained in this way is used for production checks and acceptance testing. Provision has been made for exchanging data with the firm's main computer system and for storing the test results on magnetic tape. The processor also calculates splicing tables for capacity balancing of junction and trunk cables (see section on splicing patterns).

Acceptance Requirements and Statistical Quality Control

The admissible electrical characteristics of cables are given in a PTT specification. It would hardly be possible to evaluate the test results and calculate the statistical data without a computer. The processor directly prints out the acceptance test report on a form that can also be used for statistical quality control. Kilometric values, mean and maximum values, the spread and quality figures are calculated automatically. At the same time each value is compared with the specification, and where tolerance limits are exceeded, the computer prints out the quad numbers. The results being available a few minutes after testing, the cables can immediately be released for delivery.

Fig. 5
Minical 4 E data processing system

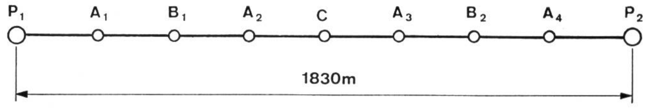

Fig. 6
Spliced joints in a loading-coil section

Splicing Patterns

Special capacity balancing methods are applied for the reduction of crosstalk on loaded lines. In particular, intra-quad capacity balancing and in some cases also balancing of capacity to ground is necessary to achieve the crosstalk quality required. Over the years two basic methods of balancing have been adopted: transposing wires in spliced joints on the basis of calculations; fitting loading-coil sections with balancing capacitors. In this way crosstalk interference can be kept within tolerable limits. Both methods have their advantages and disadvantages [2].

Until some years ago the Swiss PTT balanced their junction and trunk cables by transposing wires and by test-selected jointing of quads within layers. There are 8 possible transpositions for reducing couplings and unbalances. Each loading-coil section (which normally consists of 8 cable laying lengths) is balanced separately on the basis of measurements effected after the laying *(fig. 6)*.

The heavy demand for lines over the last few years made it necessary for the PTT to lay ever larger cables. As measuring the individual cable laying lengths and calculating splicing tables became more and more time-consuming, concentrated balancing of loading-coil sections was introduced [3]. The A and B joints are spliced according to a fixed pattern of cyclic quad change. At the C joint (middle sleeve of loading-coil section) the intra-quad couplings of both halves of the loading-coil section are measured, the most suitable splicing within a layer calculated, and residual couplings reduced by means of balancing capacitors. The capacitors for cables with a large number of quads are built into a separate balancing sleeve; those for cables with a small number of quads can usually be accommodated in the splicing sleeve.

As setting up C joints for concentrated balancing of cables with a large number of wires is rather time-consuming, further possibilities of rationalization have been sought.

From earlier tests it was known that the laying of cables did not affect couplings very much. This led to the idea of converting the coupling values available from factory testing into splicing tables by means of the computer.

Fig. 7
Splicing of a star-quad telephone cable with the aid of a computer-calculated table

In this way several lengths can be calculated in one operation *(fig. 7)*. The following combinations of transpositions are possible:

2 cable laying lengths = 1 transposition point = 8^1 = 8 combinations of transpositions
3 cable laying lengths = 2 transposition points = 8^2 = 64 combinations of transpositions
4 cable laying lengths = 3 transposition points = 8^3 = 512 combinations of transpositions

These figures show that optimum combinations of transpositions can only be calculated efficiently by means of a data processing system.

In cooperation with the PTT's Research and Development Department, Kabelwerke Brugg Ltd prepared programmes for the calculation of splicing tables. After satisfactory results had been obtained in various field tests, the new method became standard in 1970. However, the fixed pattern of cyclic quad change was maintained.

This method offers the following advantages:

a) As extensive coupling measurements in the field are no longer necessary, considerable savings in labour cost can be achieved, especially in the case of large cables (e.g. 2600 Swiss francs for a loading-coil section of a 312×4×0.6 mm side-circuit/phantom-loaded junction cable).

b) At A and B joints, couplings are no longer added through contingencies.

c) The number of coupling values to be balanced at the C joint is much smaller. As capacitors, which are needed for about 15–25% of the quads only, can in most cases be accommodated in the connecting sleeve, it is no longer necessary to provide a separate balancing sleeve.

Computer Balancing of Test-selected Quads

A coupling can be fully compensated only at its source. In a cable of small wire diameter (0.6 mm) phase shift over the entire loading-coil section is relatively high. If systematic jointing is used, couplings may not, in extreme cases, be sufficiently reduced by means of balancing capacitors at the C joint.

Tests have shown that, with test-selected jointing, the dispersion 's' (standard deviation) at point C is less than half the value resulting from systematic jointing *(fig. 8)*.

Example:

	$k_{2\text{-}3}$ Residual coupling at point C	
	Test-selected jointing	Systematic jointing
$\bar{x}$ (pF)	±5	±5
s (pF)	20	50

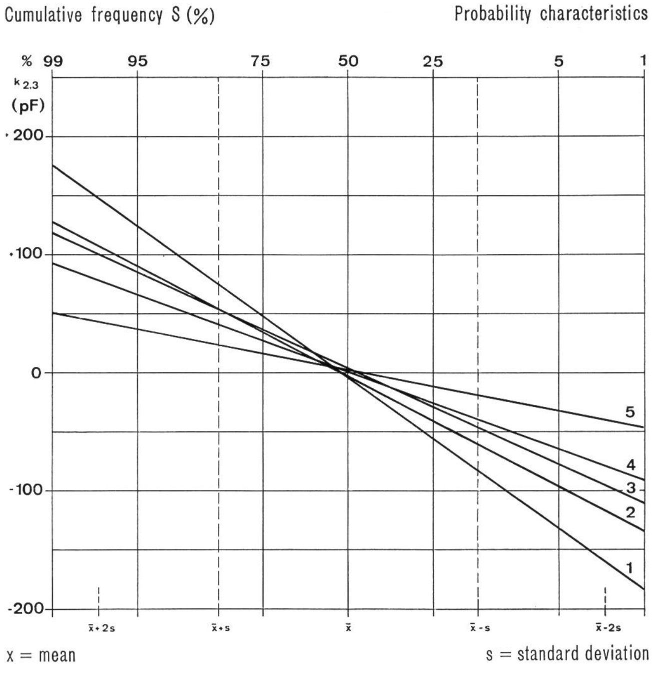

Fig. 8
Cumulative frequencies of intra-quad couplings $K_{2,3}$

1 230 m single lengths
2 B points with systematic joints
3 C points with systematic joints
4 B points with test-selected joints
5 C points with test-selected joints

In future an increasing number of circuits for PCM systems will have to be provided. Here concentrated capacitances (balancing capacitors at the C joint) lead to a considerable deterioration of crosstalk quality, while systematically distributed couplings hardly improve transmission characteristics. PCM lines should therefore not be capacitor balanced.

The quality of new cables is such that test-selected jointing of quads within layers (corresponding to the previous system of transposing wires) makes balancing capacitors at the C joint superfluous.

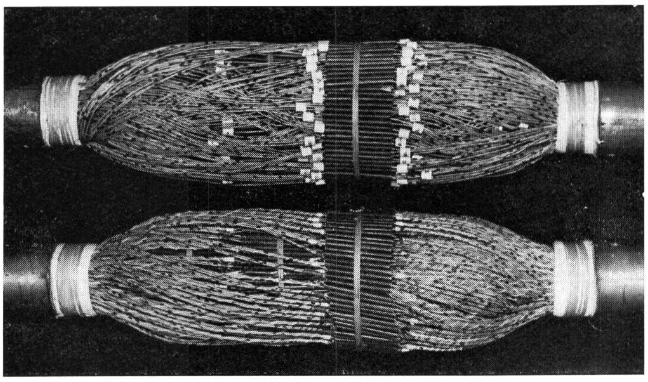

Fig. 9
312×4×0.6 mm spliced cable
Top: Test selected quad jointing
Bottom: Systematic quad jointing

In addition to improved electrical characteristics, considerable savings can be achieved by the omission of capacitor balancing; they amount to about 3800 Swiss francs for a loading-coil section of a 312×4×0.6 mm cable.

In the field *(fig. 9)* no difficulties should be experienced with test-selected quad jointing, for which a programme is now being prepared by Kabelwerke Brugg Ltd. As the computer is equipped with a 5-channel reader for direct processing of tapes from the telex network, it will be possible to convert field measurements into optimum splicing tables within a relatively short time. Resistance differences, which are of importance especially in the case of loaded cables, can be included in the calculations.

In the light of all the advantages it is clear that full use should be made of computer facilities in conjunction with automatic measuring equipment as a means of reducing the installation costs, yet at the same improving the quality of performance of the plant.

Literature

[1] Pflichtenheft für die Fabrikation und Lieferung von Telephonkabeln mit Papierluftraumisolation – Cahier des charges pour la fabrication et la livraison des câbles téléphoniques à isolation papier/air.

[2] *H. Kühne, H. Ammann, W. Hosner.* Probleme des Nebensprechausgleichs bei pupinisierten Fernsprechkabeln. V-Bericht Nr. A 25. 1015 vom 16. Mai 1969 – Problèmes de l'équilibrage diaphonique sur les câbles téléphoniques interurbains pupinisés. Rapport V n° A 25.1015 du 16 mai 1969.

[3] GD PTT, Vorschrift L-103.044. Kopplungsausgleich mit Kondensatoren – DG PTT, Prescriptions L-103.044. Equilibrage des couplages à l'aide de condensateurs.