[Mansoura Engineering Journal](https://mej.researchcommons.org/home)

Volume 9 | Issue 2 Article 2

2-7-2022

Transient Voltages and Currents Subsequent To Fault Initiation on Overhead Transmission Lines.

Reda M. K. El-Dewieny
Electrical Engineering Department, Faculty of Engineering, Mansoura University, Mansoura, Egypt.

Mansour H. Abdel-Rahman
Electrical Engineering Department, Faculty of Engineering, Mansoura University, Mansoura, Egypt.

Recommended Citation

M. K. El-Dewieny, Reda and H. Abdel-Rahman, Mansour (2022) "Transient Voltages and Currents Subsequent To Fault Initiation on Overhead Transmission Lines.," *Mansoura Engineering Journal*: Vol. 9 : Iss. 2 , Article 2.
Available at: https://doi.org/10.21608/bfemu.2022.217779

Mansoura Bulletin Vol.9, No.2, December 1984 E. 9

TRANSIENT VOLTAGES AND CURRENTS SUBSEQUENT TO FAULT INITIATION ON OVERHEAD TRANSMISSION LINES

Reda M. K. El-Dewieny and Mansour H. Abdel-Rahman

University of El-Mansoura, El-Mansoura, Egypt.

Abstract- The continuous increase in transmission voltages has led to a situation in which overvoltages due to fault initiation may become the determining factor in the assessment of the insulation level of future overhead transmission lines.

This paper reports the results of a study aimed at determining the transient voltages and currents due to fault initiations on transmission lines. Developing faults and simultaneous faults are considered and the results show that overvoltages due to fault initiation exceed those obtained by controlled switching operations.

1. INTRODUCTION

The continuous increase in the operating voltages of power transmission systems over the past two decades has resulted in a situation in which external overvoltages caused by lightning strokes are no longer of the same significance. Instead, internal overvoltages caused by switching operations[1,2] have been the most important factors for determining the insulation level of EHV systems. Under these conditions, a new generation of highly developed circuit breakers and arrestors have been created. In practice, synchronous closing of the circuit breaker, by controlling the timing of the breaker contacts or by inserting one or more resistors across the breaker contacts, or even more a combination of these methods have led to obtain switching overvoltages of the order of 1.5 pu or less[3,4,5].

Consequently, other sources of internal overvoltages which were discarded in the past, are brought back into consideration. Most important of these are the overvoltages due to fault initiation and fault clearing. Overvoltages due to fault clearing are however among those belonging to switching category overvoltages which can be controlled in value by means of low resistors inserted across the breaker contacts during the opening sequence[5]. It is therefore clear that there is nothing to be gained in trying to improve the circuit breakers to obtain switching overvoltages less than, for example, 1.5 pu, if the surges due fault initiation can have higher values.

It should also be recognised that, in order to determine correctly the insulation level of a system the maximum value of overvoltages is not the only important factor. The spectrum of the transient voltages and currents during the fault should also be taken into account since the response of a protective relay to the fault-generated transient waveform is of graet concern in determining its reliability for a given application.

From the forgoing it is obvious that, determination of the level and waveforms of the transient voltages and currents, due to faults in transmission systems, must be carried out in order to assess clearly the minimum insulation level and the adequate protective scheme considered as economically and operationally reasonable. It should also be kept in mind that, although some proposals have been done to reduce transient voltages due to fault initiation to a very low value[3], at the present state of technology these would be difficult to implement and even more costly[6]. So transient voltages due to fault initiation are nowadays out of any control and may determine the insulation level of future UHV systems.

The present work is concerned with the determination of transient voltages and currents produced by different types of fault initiation, using a digital computer program based on the lattice-diagram method[7]. Two line lengths, namely 20 km and 190 km, having same construction and tower configuration, are considered. The line is initially unloaded but charged from a 15000-MVA fault-level source[1] and the fault is initiated at the receiving end of the line.

2. DEVELOPING FAULT

In practice, more than 90% of the faults occuring in power systems are single phase-to-ground faults. The fault on one phase can however produce overvoltages in the other two phases. If ionisation occurs, or if the insulation is too low, the fault may degenerate rapidly to a double phase-to-ground fault before the circuit breaker comes into operation. The situation where a single phase-to-ground fault develops into a double phase-to-ground fault is illustrated by the sending and receiving end voltages and currents of Figs. 1 and 2. Initially, the single phase-to-ground fault occurs on phase one at a peak of the voltage wave. It then develops into a double phase-to-ground fault after 3.5 ms. For both line lengths, a noticeable change in the waveforms of phases one and two occurs at 3.5 ms when phase is faulted, and an increase in both frequency and amplitude of the transient components may be observed.

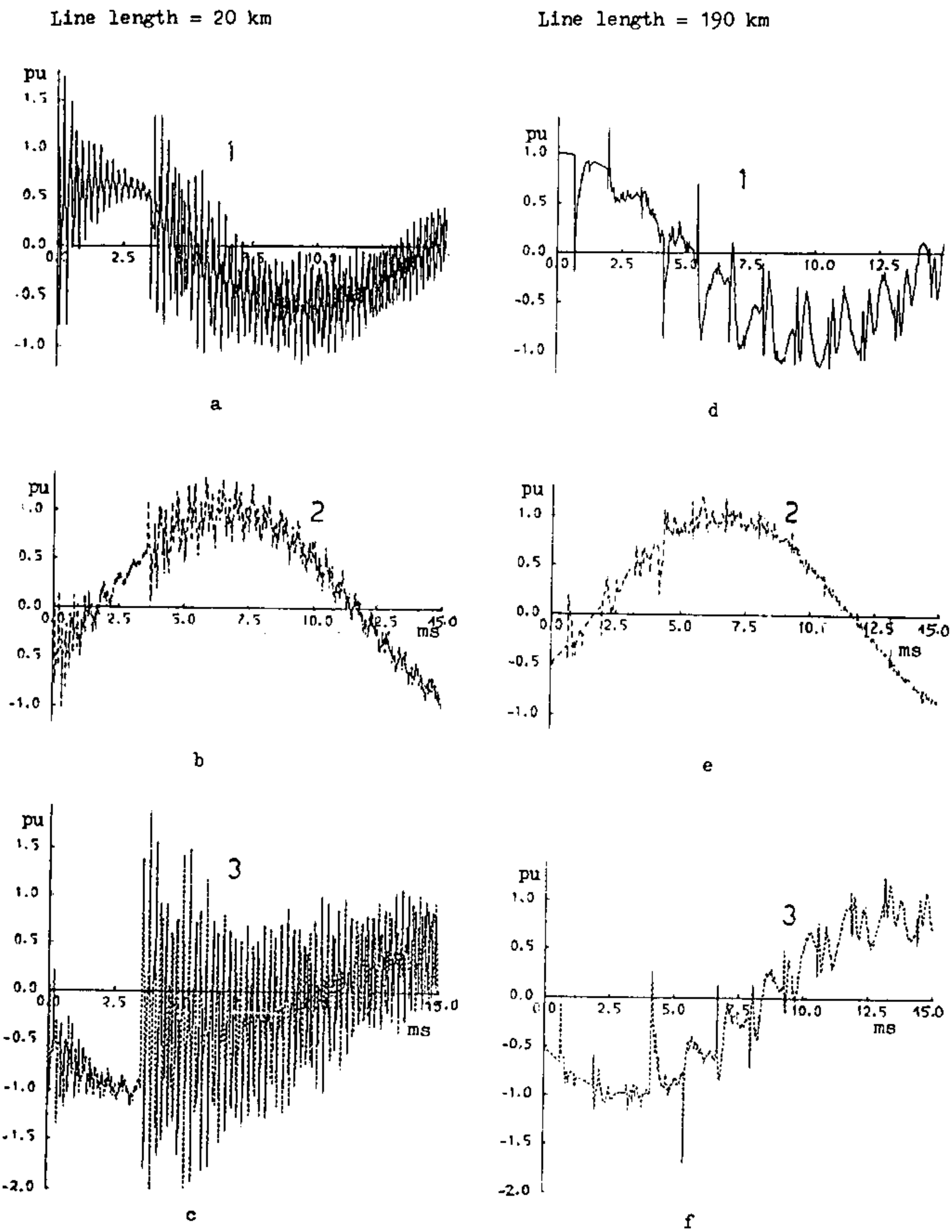

Fig. 1. Sending-end voltage waveforms for a developing double phase-to-ground fault. 1,2,3 are phase numbers for each line. 1 pu voltage represents zero-to-peak voltage of one phase.

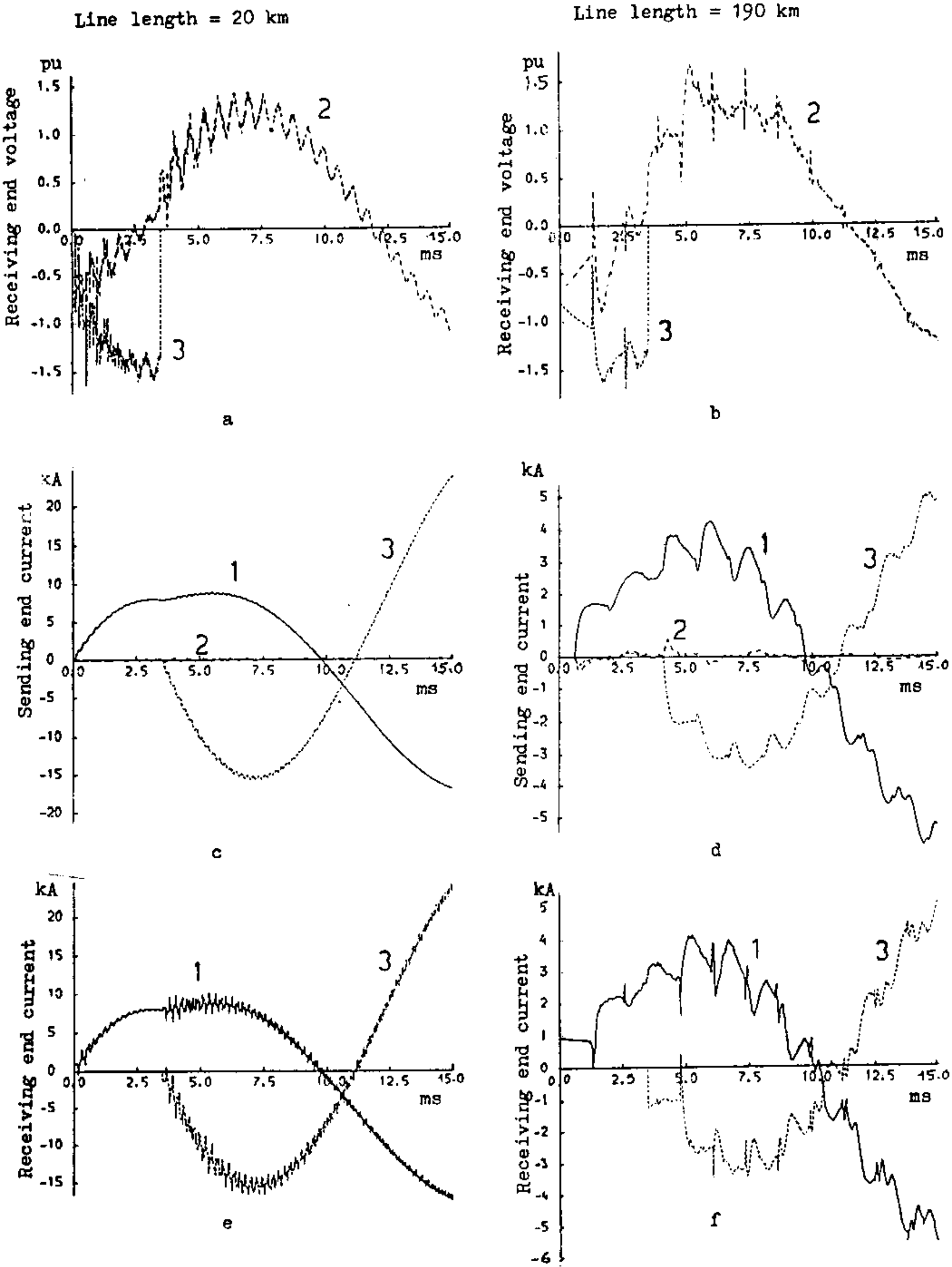

Fig. 2. Transient waveforms for a developing double phase-to-ground fault on phases one and three.

Comparison of the corresponding results for both line lengths would indicate higher amplitudes and frequency of oscillation for the transient components of the 20-km line than those obtained for the 190-km line. In particular, the transients obtained for the short line experience severe frequency of oscillations and much higher fault currents. These unfavourable conditions can be attributed to the much smaller wave travel-time and series impedance of the short line. Also, it can be seen from Fig.1 that voltages in excess of the 1.5 pu margin can be obtained, particularly at the sending end of the line. In this case, the highest overvoltage value reaches 2 pu and occurs on phase three of the 20-km line.

Conditions may become even worse if the fault is further developed into a full three phase-to-ground fault before the circuit breaker begins its clearing operation. Such conditions are illustrated by the diagrams of Fig.3 which gives the transient components for the 20-km line when phase two is faulted 3.5 ms after the initiation of the fault on phase three. Similar conditions are experienced for the 190-km line[7].

In these and the following results, the losses in the source and along the line are negleted. Their effect in practice, however, will be to cause some reduction in the magnitude of the high frequency spikes appearing in the transient waveforms.

3. SIMULTANEOUS FAULTS

The occurance of simultaneous two phase-to-ground or three phase-to-ground faults is rare in practice, specially in the case of the latter. These types of faults are however considered here for the sake of completeness.

Fig.4 gives the sending-end voltage waveforms for both line lengths when a simultaneous double phase-to-ground fault occurs on phases one and three. The diagrams of Fig.5 illustrate the corresponding receiving-end voltage waveforms and the sending and receiving-end current waveforms, respectively. The fault is initiated at the receiving ends of the lines when the voltage of phase one is at its positive peak, as for the previous cases. Maximum overvoltage values are seen to exceed the 1.5 pu margin and approach 2 pu on phase three for both line lengths. Again, the frequency of oscillation is more severe in the case of the shorter line.

Regarding the fault currents, it can be seen from the current waveforms of the 20-km line given in Figs.2 and 5 that a simultaneous fault may result in a higher maximum current than that obtained with the corresponding developing fault.

Extending the study to cover the full three phase-to-ground fault will result in the transient waveforms of Fig.6, which gives the transient components for both

Line length = 20 km

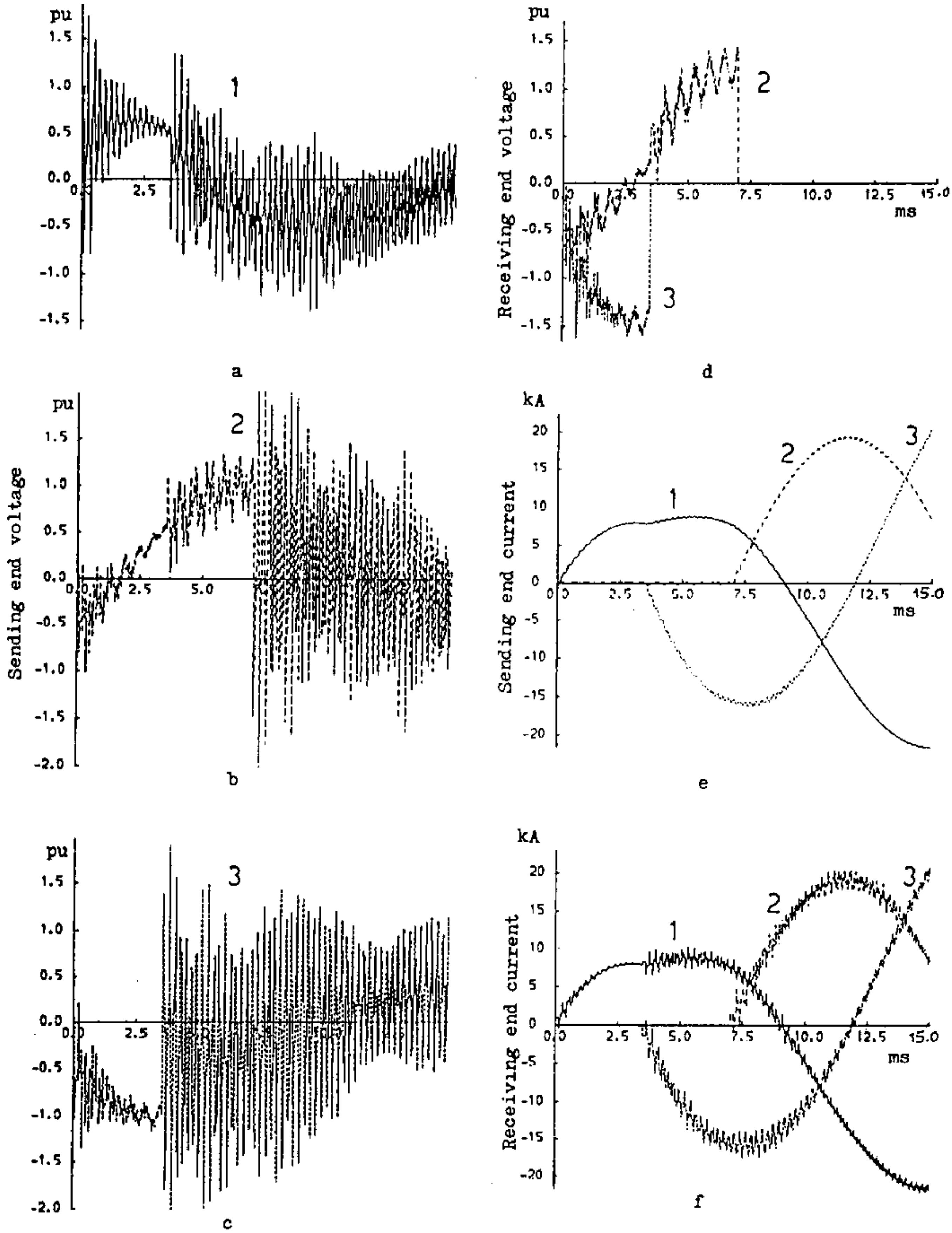

Fig. 3. Transient waveforms resulting from a developing three phase-to-ground fault.

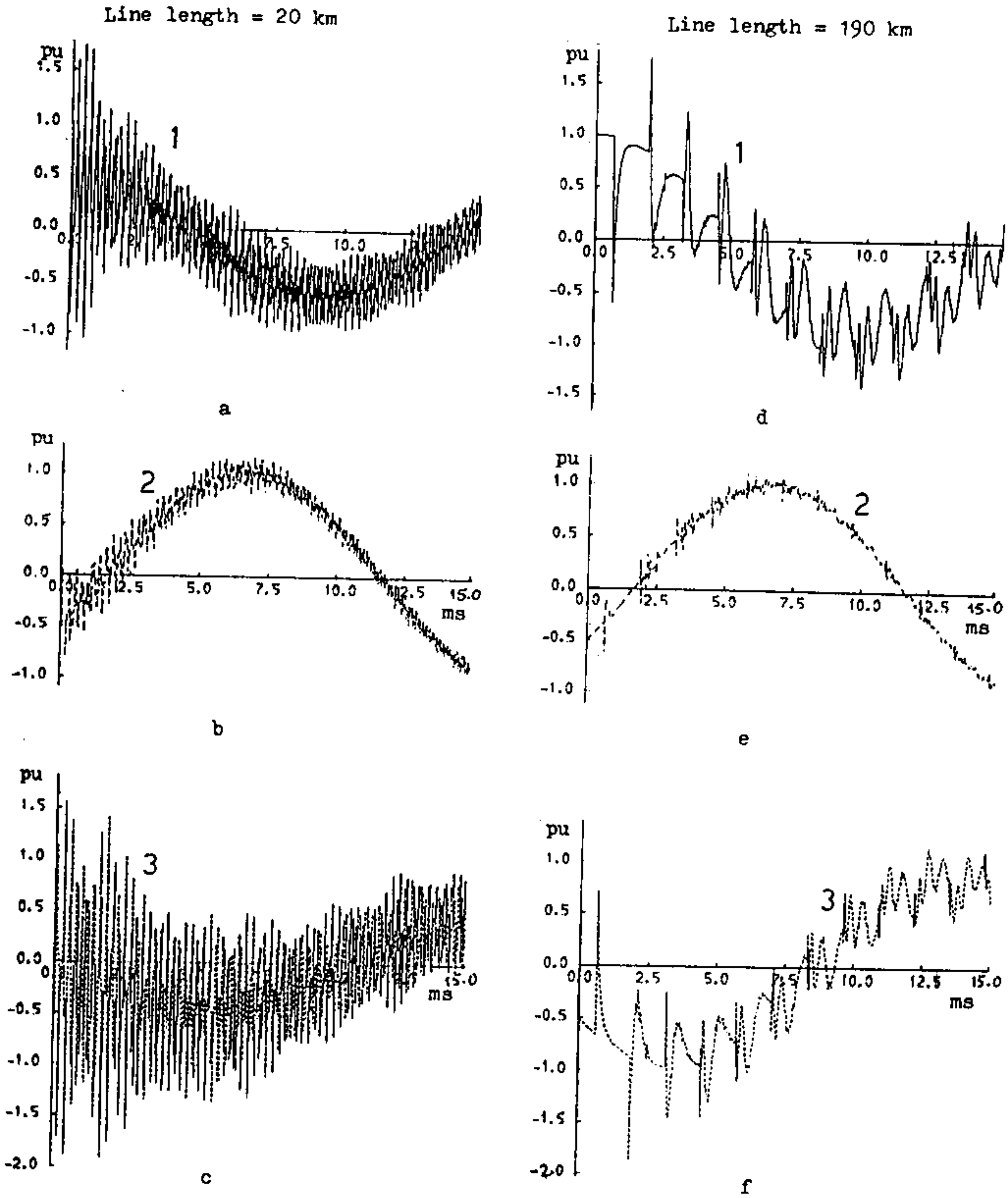

Fig. 4. Sending-end voltage waveforms for a simultaneous double phase-to-ground fault on phases one and three.

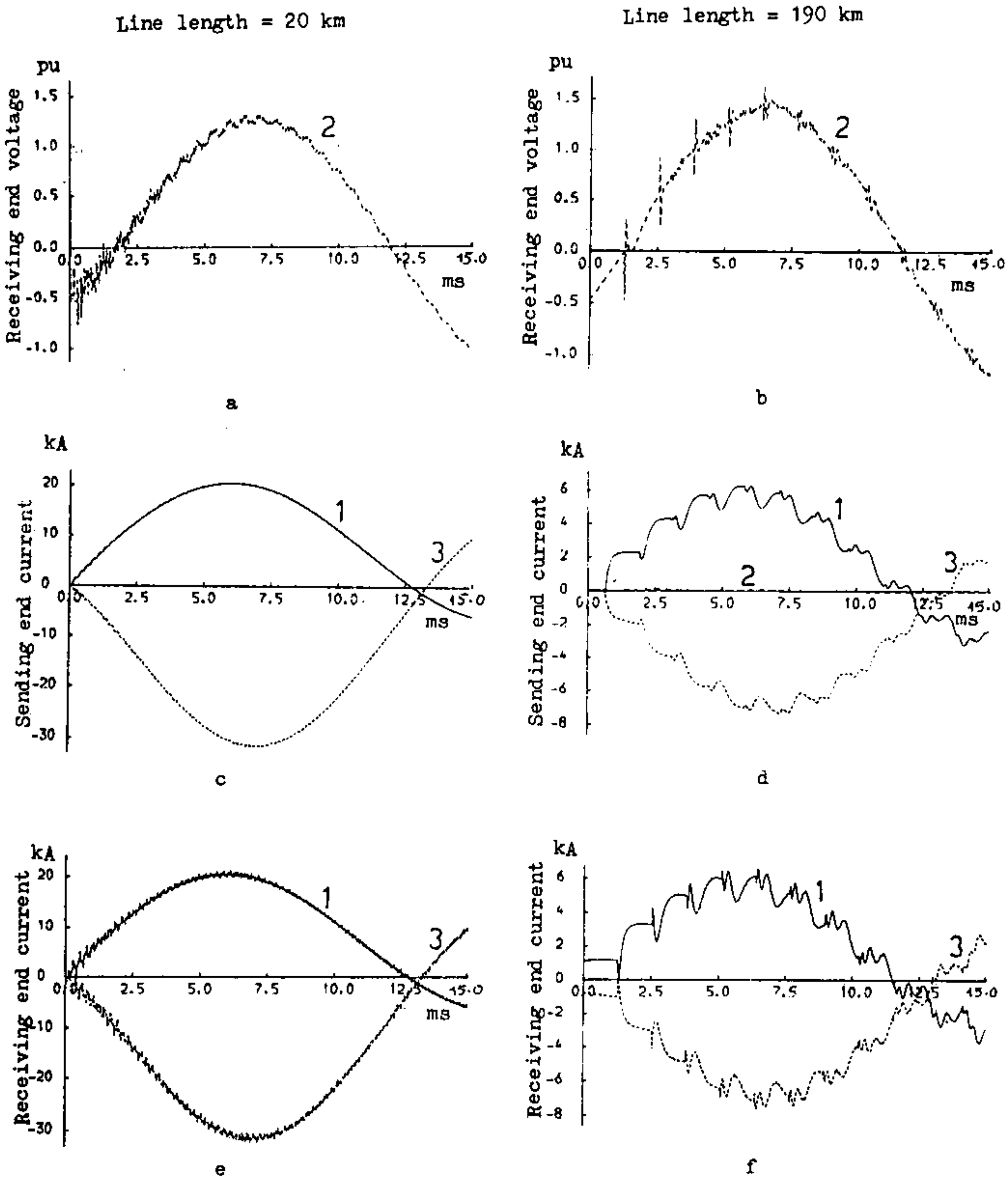

Fig. 5. Transient waveforms for a simultaneous double phase-to-ground fault on phases one and three.

ends of the 20-km length of line. Under these conditions, the receiving end voltages will have zero values on the three phases and need therefore not illustrated here.

The maximum transient voltage also reaches a value of 2 pu on phase one and this type of fault appear to produce a maximum current value which exceeds by far those obtained in the corresponding developing fault of Fig.3.

Applying this type of fault to the 190-km line was found to produce similar results concerning the maximum values of voltages and currents.

4. CONCLUSIONS

The paper reports the results of a study carried out on a digital computer to determine transient voltages and currents due to the initiation of various types of fault on overhead lines. Line lengths of 20 and 190 km are considered, and the faults are initiated at the receiving end of each line.

The results show that overvoltages due to fault initiation may exceed in value the basic insulation level of 1.5 pu currently used in EHV systems. Such overvoltages may for this reason determine the basic insulation level for future UHV transmission systems.

The results also indicate the importance of fault position where it is found that the nearer the fault to the source of energy or, more generally, to a discontinuety in the system, the more severe frequency of oscillation will result. In addition to the high stress which such high frequency causes to the insulation of the line, the reliability of the protective relays may be affected and suitable countermeasures may need be considered.

5. REFERENCES

1. R.M.K. El-Dewieny and M.H. Abdel-Rahman,"Transient voltages and currents due to energisation of series-compensated prefaulted transmission lines", Proc. of 19th UPEC Conference, Paper 12.4, Dundee, U.K., 10 - 12 April, 1984.

2. C.J. Traux, J.D. Broun, and W. Neugebauer,"TNA study of reclosing transients on a 765 kV shunt compensated transmission line", IEEE Trans. Power APP. Syst., vol. PAS-97, pp 1447-1457, July/Aug. 1978.

3. E.W. Kimbark and A.C. Legate,"Fault surge versus switching surge, a study of transient overvoltages caused by line-to-ground faults", IEEE Trans. Power App. Syst., vol. PAS-87, pp 1762-1769, 1968.

4. C.H. Boonyubol, C. Calabrese, and J.R. Tudor,"A mathematical analysis of transmission transients related to fault surges",IEEE Trans.Power App. Syst., vol. PAS-89, pp 1207-1215, 1970.

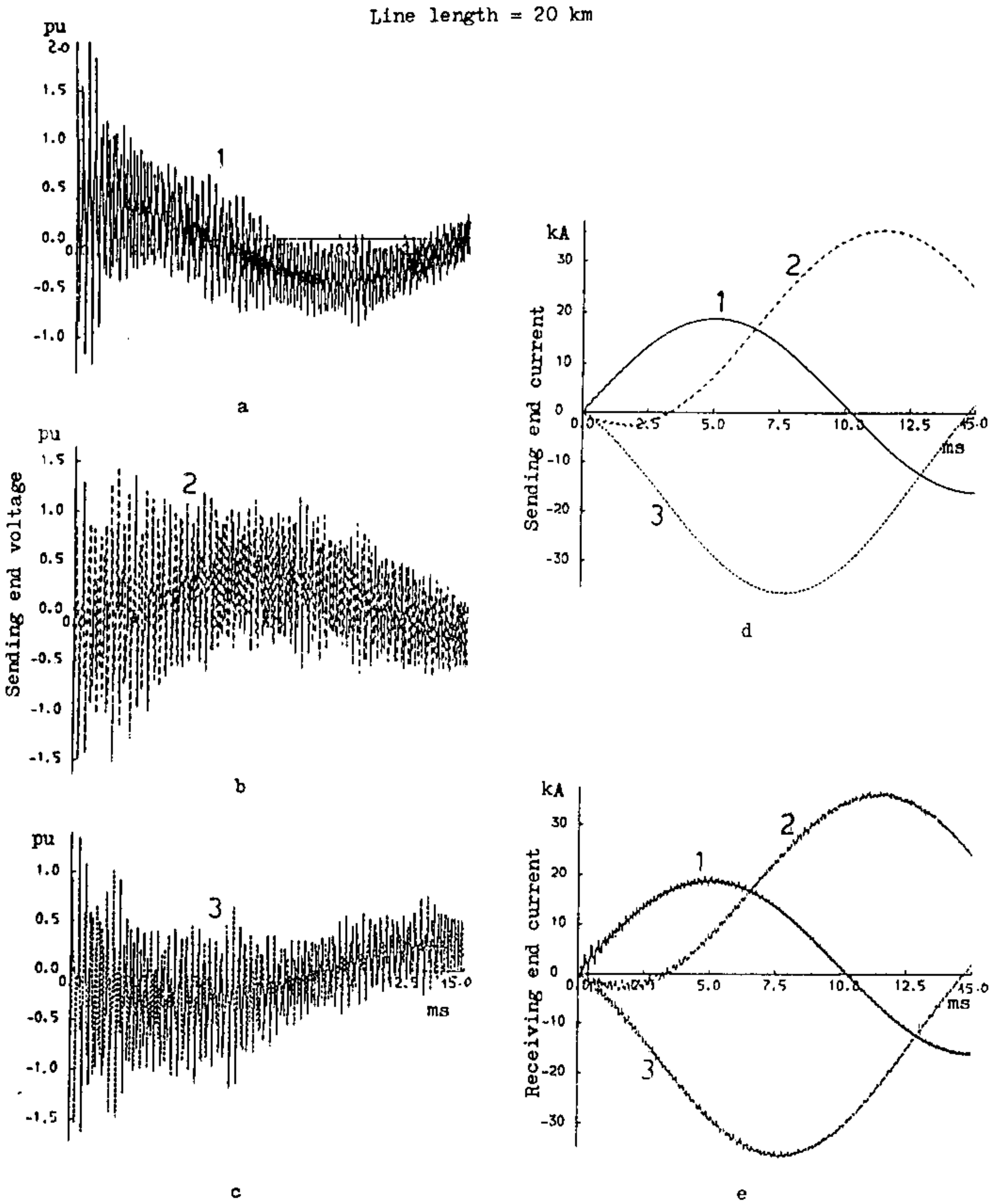

Fig. 6. Transient waveforms resulting from a simultaneous full three phase-to-ground fault.

5. A. Clerici and A. Taschini,"Overvoltages due to line energisation and reenergisation versus overvoltages caused by fault clearing in EHV systems", IEEE Trans. Power App. Syst., vol. PAS-89, pp 932-941, 1970.

6. J. K. Pinter,"Influence of system parameters on the transient overvoltages due to fault initiation", M. Sc. Thesis, Vectoria University of Manchester, U. K., 1978.

7. M. H. Abdel-Rahman,"Calculation of transient voltages and currents in power system networks", Ph. D. Thesis, Vectoria University of Manchester, U. K., 1979.

8. J. P. Bickford, J. V. H. Sanderson, M. M. Abdelsalam, S. E. T. Mohamed, S. A. Morais, and O. Olipade,"Developments in the calculation of waveforms and frequency spectra for transient fault currents and voltages", Proc. IEE, vol. 127, Pt. C, pp 145-152, 1980.