



Device for detecting defects of electric cable with disturbance stability

Serghei Tincovan

This paper deals with the analyses of realization ways of such a low cost device which is resistant to electromagnetic interference and has the improved user service. When repairs are carried out, it is necessary to localize and identify defects in electrical power cables. Most of the known devices for localization and detection of defects in electrical cables are vulnerable to industrial interference, which limits effectiveness and field of application.

***Keywords:** transmitter, receiver, electric cable, defects, electromagnetic interference*

1. Introduction

The operation of most household and semi-professional devices for localizing and detecting defects in a cable is based on a comparative analysis of the intensity level of the electric field emitted by a cable under voltage.

Cable localization is determined by the maximum value of the intensity level of the electromagnetic field, where the user can track it by the level of the acoustic signal or the optical indicator of the receiver. Detection of a defect in an open-circuit or short-circuit cable is monitored by a sharp decrease of in the electromagnetic field intensity level in the defect area.

If during the process of defect localization and detection electromagnetic interference is effected, then the real place of the defect in the cable is masked with a inducted or reflected signal, that create some problems. As an active source of interference can be used a switching power supply, the converter for the electric welding apparatus. The iron armature of a concrete wall, from which electromagnetic waves are reflected, can serve as a passive source of interference.

2. Solved problems

In this paper is discussed a device that allows to identify a defect (damage) in conditions with high levels electromagnetic interference, which are radiated by various devices or are reflected from metal obstacles.

Requirements for this device:

- 1) The ability to localize the cable in off mode;
- 2) Be portable;
- 3) The error of cable location determining must be within 0,05 ... 0,25 m, including the possibility of location in the reinforced concrete wall at a depth of 0,2 m.

For problem solving, it is necessary the device to consist of a transmitter and a receiver, to determine the location and defects in the disconnected cable and in the cable under voltage. As an additional option it is necessary to provide the possibility to determine the location and defects in low-current cables, such as a phone line, antenna cable, etc. Also it is necessary to provide protection from electromagnetic interference from active and passive devices.

3. Solutions and implementations

Determination of the location and defect in the cable can be done as follows:

- 1) By changing the intensity level of the electric field of the cable under voltage 380V/220V, 50Hz;
- 2) By changing the intensity level of the electromagnetic field of the cable under high frequency voltage of the transmitter and the tested cable must be disconnected from the voltage 380V/220V, 50Hz.
- 3) By the principle of a metal detector, for example, by the beats of the frequency difference;
- 4) By the principle of ultra shortwave or microwave radar.

From the above mentioned methods, the most acceptable is method 2, the others are refused because of the low localization efficiency and the high cost of devices (devices operating on the principle of a metal detector and ultra shortwave or microwave radar).

The operation of the device is based on the principle of transmission-reception, where the tested cable performs the function of a radiating antenna. For the case when the test of cable disconnect from voltage, the transmitter is connected to it directly, if the tested cable under voltage, the transmitter is connected via a coupling capacitor. For safety cable test defect localization in the cable under voltage should be carried out only for low-current cables, for example, a phone line.

In the transmitter it is amplitude modulation as it provides a clear dependence of the level of the received signal on the distance, while frequency modulation can not provide a similar dependence. As a modulating is chosen the one of the acous-

tic range of 400 Hz for the case of increased level of electromagnetic interference and 1000 Hz for their reduced level as is known the transmitter contains high and low frequency generators, an amplitude modulator and an output amplifier (Figure 3) [1, 2, 3]. However because of scheme simplicity, such generators have very high level of harmonics in the spectrum of output signal. In elaborated transmitter, some measures were taken to stabilize the high frequency carrier and to reduce the level of harmonics.

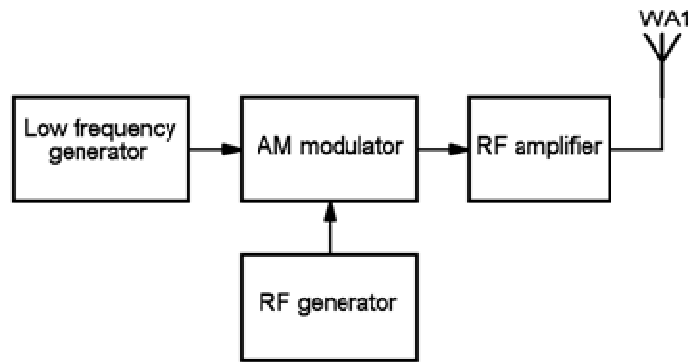
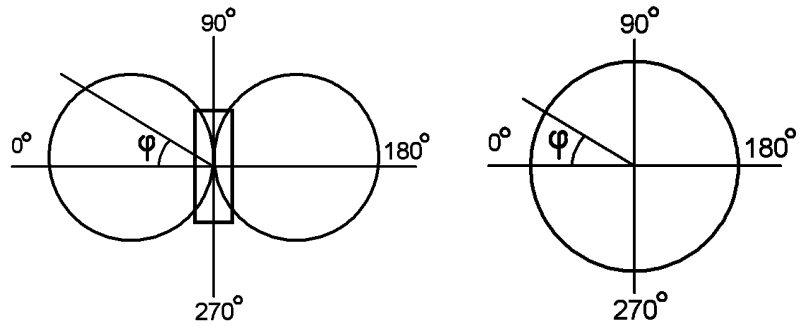


Figure 1. Block diagram of the AM transmitter.

The receiver device can be realized in several modes: a) on the structure of the receiver with direct amplification, b) on the super heterodyne receiver with a single frequency conversion, c) on the super heterodyne receiver with double frequency conversion, d) on the receiver with direct frequency conversion. For given task, in the transmitter and receiver of the device, the frequency bands of the LW and MW are used. Another condition for the receiver is its antenna pattern and the minimum number of spurious receive channels. A direct amplification receiver with modified input circuits that provide a cardioid-type radiation pattern meets these conditions.

To obtain a cardioid-type radiation pattern, it is necessary to use two types of antennas with different radiation patterns. As a rule, one of the antennas is chosen of the frame type or as ferrite one with the radiation pattern in the form of the digit "8", the second one is whip antenna, with a circular radiation pattern (Figure 2a, 2b). When adding their radiation patterns, a cardioid type diagram is obtained (Figure 3). A typical example of the implementation of such a combination of antennas is used in the direction finder receiver for the competition "Fox Hunting" (Figure 4). To reduce the antennas size and improve the signal/noise ratio, it is proposed to use two ferrite antennas located at an angle of 90 degrees, which are tuned to the transmitter frequency. As a receiver, a standard receiver was used with LW and MW bands, where changes were made to the input circuit (Figure 5, 6).



a) ferrite antenna b) whip antenna
Figure 2. Radiation patterns of typical antennas

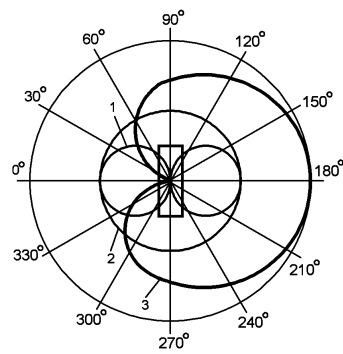


Figure 3. Radiation pattern of combined antenna.



Figure 4. An example of implementation of the direction finder receiver antenna

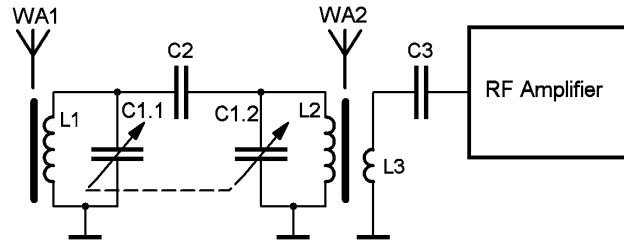


Figure 5. The electrical scheme of the input circuit of the receiver.

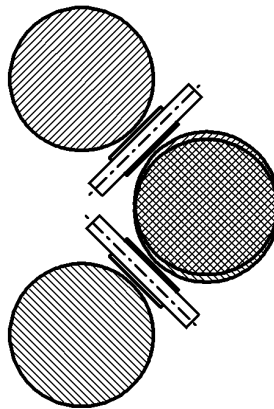


Figure 6. Summary radiation pattern of proposed antenna

The test of the experimental model of the device in real conditions confirmed the correctness of the decision of the receiver antenna implementation. It should be noted that the level of electromagnetic interference in the LW range was higher than in the MW range.

4. Conclusion

As a result, a device for localizing and detecting defects in the power cable was elaborated, which have the following advantages:

1) Allows to determine the localization of the cable with an error of 0,05 ... 0,15 m and of the defect position with an error of 0,05 ... 0,18 m in a reinforced concrete wall at a depth of 0,2 m;

2) Determines the localization and defects of the power cable and low-current cable under voltage;

3) In addition to the mentioned advantages, several limitations were noticed:

1) The need to increase the transmitter power in the upper part of the LW range for reliable signal reception;

- 2) The modified ferrite antenna depends on the stability of the settings and thermal compensation is needed;
- 3) The electrical part of the transmitter is critical to the voltage drop;
- 4) In standard receivers with LW and MW ranges, it is necessary to turn off the automatic amplifier adjustment, otherwise the cable localization error increases to 0,2 ... 0,4 m.

To eliminate the above-mentioned limitations, it is necessary to modernize the receiver's block diagram, improve the receiver antenna parameters and apply the synchronous AM detector. These ways of improvement are to be used in further researches. In the upper part of the MW range, a decrease in the level of reflected electromagnetic waves is observed, which improves the accuracy of cable localization.

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Address:

- Lect. Eng. Serghei Tincovan, Technical University of Moldova, Ștefan cel Mare, nr. 168, MD 2004, Chișinău serghei.tincovan@sde.utm.md
s_tincovan@mail.ru