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The Use of Electric Power Solar Sources in Rural Optical Telecommunication Networks

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ABSTRACT: The article provides analytically: an overview of the methods of power supply of ONT (Optical Network Termination) PON subscriber devices, it is proposed to use solar power sources to power these devices.

KEY WORDS: optical fiber, OLT (Optical Line Termination), SP – splitter, ONT (Optical Network Termination) - subscriber device, RRL - radio relay line, ATE - automatic telephone exchange.

I.INTRODUCTION

Currently, in rural areas there is an increase in demand for various telecommunication services (high-speed Internet access, digital television, interactive services, etc.). Since the telecommunications network (RTN) existing in rural areas provides mainly telephone communications, it becomes necessary to modernize it using promising technologies. In this regard, a number of technologies designed to build access networks were analyzed: xDSL, Metro Ethernet, DOCSIS, PON, wireless networks (in the areas where wired communication is difficult to imply) Wi-Fi, Wi: MAX, etc. A similar analysis was done in the article [1]. The choice of technology was carried out taking into account the following factors: the needs of the subscriber, technical conditions and the economic feasibility of implementing access from the provider.

II. RELATED WORK

As a result, PON (Passive Optical Network) technology was preferred for use in sparsely populated rural areas. In addition to satisfying these factors, this technology possesses more reliability due to the absence of active elements on the line, great flexibility in route planning and lower cost of servicing fiber-optic communication lines compared to copper lines. Figure 1 shows a model of a fragment of a rural (RTN) built on the basis of PON technology.

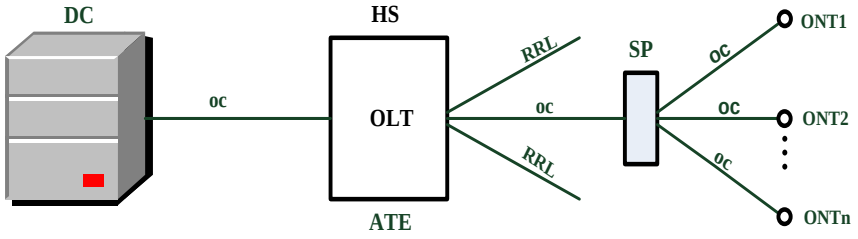

Fig 1.Model of a fragment of a rural (RTN) built on the basis of PON technology.

This figure depicts the following: DC - district center, OC - optical cable, HS - human settlement, OLT (Optical Line Termination), SP - splitter, ONT (Optical Network Termination) - subscriber device, RRL - radio relay line (for communication with distant subscribers, n is the number of ONT), ATE is an automatic telephone exchange.

When using PON technology, the problem of power supply of ONT subscriber devices (see Fig. 1) arises during periods of lack of power supply from the power supply network [2] [4], [5]. This is due to the fact that the PON scheme does not technically provide the possibility of remote power supply of subscriber devices from the battery of the telephone exchange of a settlement, just as it is implemented in traditional subscriber access networks. As a result, ONT subscriber units are not provided with power in the event of the power supply network malfunction which they

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were powered from. This leads to downtime, i.e. to the loss of communication, while according to the requirements of [3], the access network availability factor should be 0.9999, i.e. downtime should be 52.6 minutes during the year. Therefore, communication should be provided to subscribers at any time of the day. To meet these requirements, subscriber devices (ONT) of some manufacturers [2], [6], [7] are equipped with an integrated uninterruptible power supply (UPS), which can be used only for short-term power outages. With long network outages, it is useless.

IV. METHODOLOGY

The organization of guaranteed remote power supply of ONT subscriber devices is associated with a number of technical and technical-economic difficulties, as noted in the article [2], [8], [9]. Key challenges include:

- significant technical and technical and economic difficulties in the transmission of electricity through optical fiber (the presence of splitters on the line), which makes remote power supply of ONT devices via optical cables so far practically impossible;
- the need for organization and technical operation in the communication center of the settlement of power supply workshops with remote power installations of high power [10], [11]. The fact is that when using PON technology, the required energy consumption is determined according to the recommendations of ITU-T Y. 3022, according to which optical fibers and optical splitters are passive and are not taken into account when assessing energy consumption [12]. Electricity consumed by the PON network is the sum of the energy consumption of the OLT and ONT equipment included in the network:

$$E_{PON} = \sum_{OLT} + \sum_{i-1}^{n} E_{ONT_i},$$

where E_{OLT} is the power consumption of OLT equipment, E_{ONT} is the power consumption of i of ONT, n is the number of ONT.

Therefore, the power of electricity generated in the communication center of the settlement should be large:
- a significant increase in operator expenses for electricity payments;
-increase in operating costs of linear cable infrastructure and remote power equipment.

To date, several methods for organizing power supply of ONT subscriber devices have been proposed [2]:
1-organization of guaranteed remote power supply of ONT subscriber devices using an additional subscriber line with metal conductors included in a traditional telephone exchange;
2 - when modernizing existing rural access networks to provide power to ONT devices, the idea was proposed to use decommissioned copper subscriber wiring;
3- for power supply of ONT devices it is proposed to use a standard computer uninterruptible power supply with a built-in rechargeable battery. In the event of an emergency associated with a prolonged power outage, a small emergency generator with an internal combustion engine may be provided as part of the ONT equipment;
4-article [2] proposes three scenarios for providing power to ONT devices during periods of lack of energy conservation from the network:
a) centralized remote power supply at the access node level of the settlement. It is noted that this option is the most expensive and difficult to implement, but it provides for the presence of only one central battery of high power and one powerful emergency generator having an internal combustion engine;
b) a decrease in the degree of centralization of remote power supply (partial decentralization). This option is also not cheap and not easily implemented;
c) decentralization of the guaranteed power supply of ONT devices. This option is intended for use in cottage villages and other similar objects (Fig. 2)

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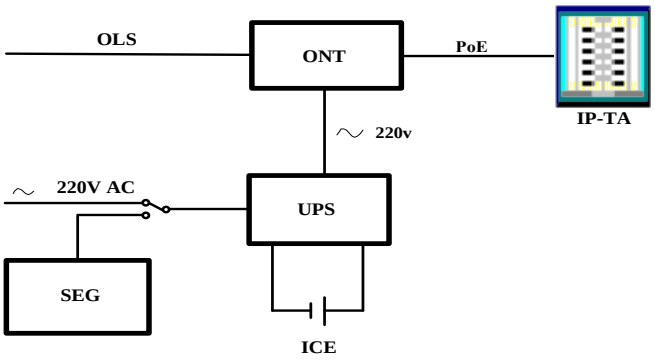

Fig 2. Organization of uninterrupted power supply at the subscriber level

The figure depicts the following: electrical network OLS -optical line of the subscriber; OC - optical cable, UPS - uninterruptible power supply, battery - SEG - small emergency generator, ICE - internal combustion engine, PoE (Power over Ethernet).

In this figure, the subscriber line (SL) is connected to the traditional ONT. One or more IP Telephone (Telephony IPs) are connected to this ONT that supports the Ethernet Remote Power Transmission (PoE) function.

From the above list of power methods for ONT devices it follows that for some of them (1,2,4a, 4b) separate power transmission lines are required, and on the access node (OLT) a powerful generator containing an internal combustion engine (ICE) is required. As is well known, devices containing moving elements are not very reliable. Therefore, the application of these methods significantly increases the complexity of maintenance, which leads to an increase in the cost of maintenance.

Methods 3 and 4c, proposed for powering ONT devices, also provide for the use of generators with internal combustion engines in case of prolonged absence of power supply from the power supply network. Therefore, they are also not free from the disadvantages that methods 1,2,4a, 4b possess.

V. EXPERIMENTAL RESULTS

In this regard, as an alternative, it is proposed to use solar power sources (SPR) for power supply of ONT subscriber devices. Such sources are widely used for powering spacecraft devices, small automatic telephone exchanges, household appliances, etc. The main advantages of SPR are simplicity of the device, reliable operation, and high specific energy indices.Figure 3 shows a diagram of the organization of autonomous power supply of ONT subscriber devices.

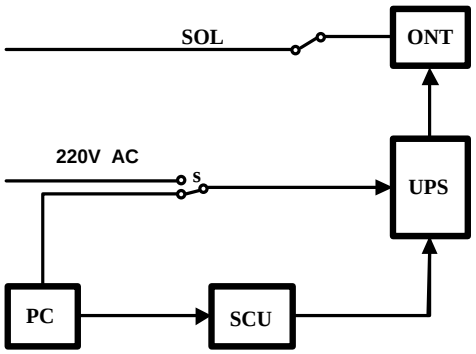

Fig 3. Autonomous power supply of ONT subscriber devices

(In this figure they mean: SOL - the subscriber's optical line, PC - photo converters (solar battery), S - switch, SCU - switch control unit, UPS - uninterruptible power supply with battery).

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Note that in Uzbekistan there are more than 300 sunny days in a year. FIE produces electricity only in the daytime. Therefore, when using a UPS (battery), which is able to accumulate the necessary amount of energy to power ONT devices for one day or, if needed, for 2 or 3 days, it is possible to use SIE as an autonomous source of electricity.

If, for some reason, the power supply of ONT devices from the PC is suspended for a long time (more than 2-3 days), then the BCM will turn on the power supply of ONT devices from the power supply network.

As a drawback of FIE, the necessity to clean the surface of photoconverters (PC) from contamination by various components of the air, and in winter from snow is considered.

The advantages of SEE include:
-the insignificant laboriousness of maintenance (cleaning the surface of the PC once every 2-3 months) for the subscriber
- there is no need for an electricity charge that the ONT devices would power.

If necessary, you can automate the process of cleaning the surface of the PC from dirt and use devices to heat the surface of the PC in winter.

VI.CONCLUSION AND FUTURE WORK

Today's solar systems are already cost-effective, due to their reliability, it is possible to use them to achieve guaranteed electricity supply of ONT-subscriberdevices of rural telecommunication networks. It is known that the most simple and affordable way to provide subscriberdevices with electricity is to power it like a simple telephone line. Taking into account the above methods, the use of solar energy sources as a reserve power source can be the most effective method in providing ONT-subscriber devices with guaranteed electricity supply. As a result, it is possible to bring the process of exploiting the winter to the level of international requirements and ensure that its readiness coefficient is 0.9999.

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