Two Realizations of Active Transmitting Station at 13GHz Frequency Range

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Abstract: **The paper discusses possible solutions for radio relay links without direct visibility between terminal stations. Instead of expensive passive reflectors, two realizations of active transmitting stations is proposed, described in detail and realized. In one of the presented cases a special attention is paid to power consumption reduction in order to enable powering from solar panel and wind power generators.**

Keywords – **Microwave links, Radio relay networks design Power consumption,**

I. Introduction

There are few solutions for cases when the RF signal has to be transmitted over some obstacle that prevents direct visibility between two terminal stations, or when it is necessary to redirect the signal path, where all of them can be classified in two major groups: passive and active:

A. Passive transmitters

1) Passive signal repeaters or RF mirrors. This is the traditional method that is relatively demanding and expensive because the required mirror size is usually from 16 to 64 m^2. Such a repeater has to withstand the maximum wind force for the given area which is a demand that increases the cost of its construction. Moreover, this class of repeaters can't be realized for all possible angles between the repeating post and terminal stations.

2.) Passive repeater consisting of two back to back antennas. This solution is possible for relatively short distances only because free space attenuation and losses in the connecting waveguide cannot be overcome by antenna gains with margin large enough to ensure uninterrupted transmission if fading occurs. The transmitting power increase of the terminal stations can help in a limited number of cases. Because of that this solution is very rare in practice and is applicable for short distances only.

B. Active transmitters

3) RF signal transmission with two radio-relay links in back to back configuration. This solution requires an uninterrupted power supply on the repeater's place. Also the price for this solution is relatively high because it requires the purchase of two additional links with antennas. This solution is possible for all angles between the repeating post and terminal stations. The only limiting factor regarding the angles can be the presence of other radio relay devices whose output signal can interfere with the transmitter operation. Such transmitting station permits transmitting frequency or channel change which is an option that allows much easier planning of the whole radio-relay network.

4) Active transmitter with diplexers and RF amplifiers. The advantage of this solution over the previous active solutions is lower power consumption and simple configuration. However since the input diplexer can't sufficiently suppress the near-channel interference, such a transmitter can be used only at the places without interfering signals. Another disadvantage of such transmitting stations is that they are prone to undesired oscillations especially when total RF amplification exceeds 50 dB.

5) Active Transmitting Station (ATS) that allows frequency changes, large gain, good selectivity and near-channel suppression. Its major advantage relative to solution No.3 is the much lower price. Also due to lower power consumption it is suitable for application on places outside the regular power network where the only possible powering solution is from solar panels or wind generators in combinations with batteries of sufficient capacity. IMTEL Communications produces two power supply options for DC voltage of 24 V and 48 V. The operation of this kind of transmitters can be monitored in the same manner as regular radio-relay links and incorporated into the network for remote monitoring.

II. Technical Solution Description

If the active transmitter is used in a radio relay network, then network planning is similar to the case when two complete back to back radio relay links are used for signal repetition. It is advisable to set-up both transmitters of the active transmitter to operate at the same sub-band. Otherwise the transmitters could easily interfere with the operation of each other's receiver and such interference is very hard to root-out once when it emerges.

Active transmitters presented in this paper are designed for IMTEL's digital radio relay link with a capacity of 4×2 MBit/s that operate at 13GHz frequency range. However presented solution can handle IMTEL's links with higher capacity as well as links made by other manufacturers and it is applicable for realization on other microwave frequency ranges.

One of the most important design requirements for the active transmitting station is power consumption lowering. Big power saving can be achieved by using the same local oscillator for both the receiver and the transmitter instead of having two independent oscillators. This was a general idea that affected the whole frequency plan of the presented active transmitter.

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TABLE I

FREQUENCIES OF OPERATING CHANNELS

Channel frequency [MHz] – lower subrange	Channel frequency [MHz] – upper subrange
12754,5	13020,5
12761,5	13027,5
12768,5	13034,5
12775,5	13041,5

The repeater preseneted in this paper is intended for a 4×2 MBit/s capasity channel operation. However, the presented solution is also appliable for other signal bit rates and frequency ranges. It is also applicable for devices of all manufacurers using FSK or PSK modulation procedures. One of the basic requirements in the designing of repeaters is to maintain minimal energy consumption. The frequency plan of the repeater includes one local oscillator for both transmitting and receiving branches. The local oscillator is placed above the receiving range in one device and below it in the other. So, we have the solution with two intermediate frequencies.

$$f_{IF1} = 1008 \text{ MHz} \quad \text{and} \quad f_{IF2} = 1274 \text{ MHz}$$

The basic difference in the two demonstrated solutions is that in the first solution synthesis of the local oscillator is used, as presented in Table I and Table II, working frequencies and in the second case the local oscillators are generated at subharmonic frequencies.

TABLE II

FREQUENCIES OF LOCAL OSCILLATORS–PLL SYNTHESIS FOR BOTH VERSIONS

frequency L.O. – lower [MHz]		frequency L.O. – upper [MHz]	
version A	version B	version A	version B
11746.5	5873.25	14028.5	7014.25
11753.5	5876.75	14035.5	7017.75
11760.5	5880.25	14042.5	7021.25
11067.5	5533.75	14049.5	7024.75

The existence of two intermedaite frequencies enables significant signal amplification without the problems of interference and oscillation. The chosen intermediate frequencies have no harmonic dependence and may not cause unwanted interference. The first solution, which used signal mixing at an operating frequency had a considerable drawback as the energy consumption was around 25W, which is a high consumption. If the same frequency plan is used, even greater redesigning of the units could not lower the energy consumption for more than 25 %. So, the solution with a different frequency plan was chosen. The lowering of energy consumption was achieved by using subharmonic mixers for conversion of channels in receiving and transmitting branches. In this way, one doubling of the local oscillator signal was avoided, which lowered the energy to 15W. As it can be seen in the diagram, amplifiers in the local oscillator branches were no longer needed. This additionally lowered the consumption. The local oscillator may generate 4 frequencies in the upper subrange and the other local oscillator generates 4 corresponding freqiencies in the lower subrange.

According to demonstrated diagram, in order to use upper or lower subrange it is neccessary that converter units are made so as their L.O.> RF or L.O.< RF, depending on which subrange is to be used.

Input waveguide filters have such bandwidth that they have all four subband channels at 13GHz (upper, i.e. lower). For this solution, waveguide diplexers were used as in standard transceivers of radio relay devices. Ampifiers at microwave frequencies are wideband and select input and output bands by waveguide filters i.e. deplexers. In the first solution of the repeater, diplexer is made by using two waveguide filters and a circulator. In the solution with subharmonic mixers, diplexers with two integrated waveguide filters and a waveguide combiner were used (no circulator is needed).

For both solutions, distributions of aplification are designed in the same way as described. Distribution of amplification in the repeater is made so as in each frequency it gains amplification of no less than 20 dB and no more than 30 dB. Reason for such design requirement is very simple. Amplification of up to 30 dB is very hard to control in the whole of temperature range and unwanted oscillations and instabilities are not likely to occur. Starting criterion upon setting requirements for total amplification of the repeater is that when at the input of receiving branch signal of - 45 dBm is gained, full transceiving power at the transceiving branch should be + 21 dBm. In this way total effective amplification of 66 dB i.e. 70 dB is gained. To the effective amplification, the lost amplification due to losses of frequency conversion by input attenuation in diplexers and intermediate filetrs should be added and thus total amplification is gained. Total amplification is effective amplification plus all specified losses. When all this is taken in consideration, distribution of effective amlification is gained as in Table III.

TABLE III

DISTRIBUTION OF AMPLIFICATION IN ONE BRANCH OF AN ACTIVE REPEATER

Aplification values in all ATS sections [dB]		
Rx	IF	Tx
25	25 + AGC	20

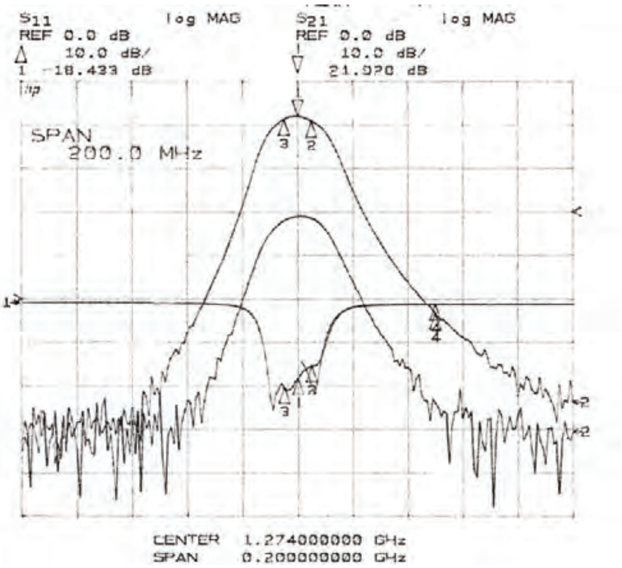

Fig.1. Frequency characteristic of the IF section operating at f_{IF2}=1274MHz

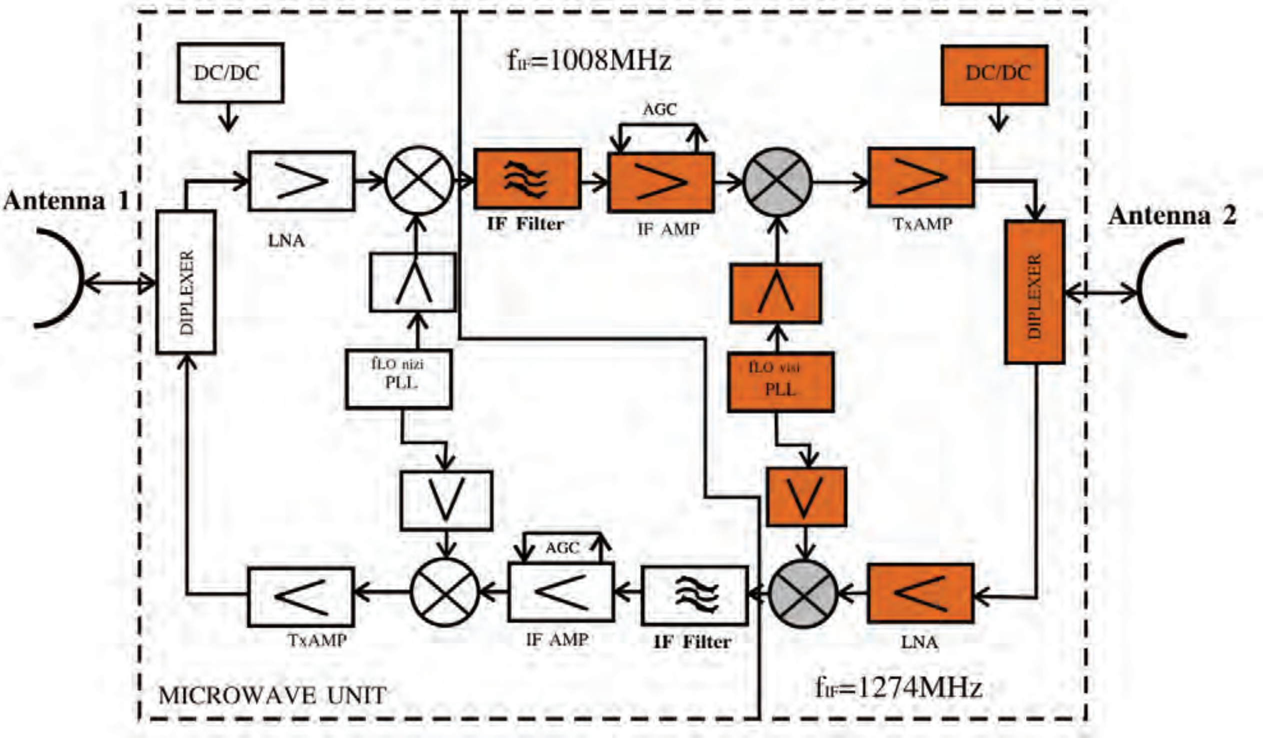

Fig.2. Block diagram of the transmitter (version A)

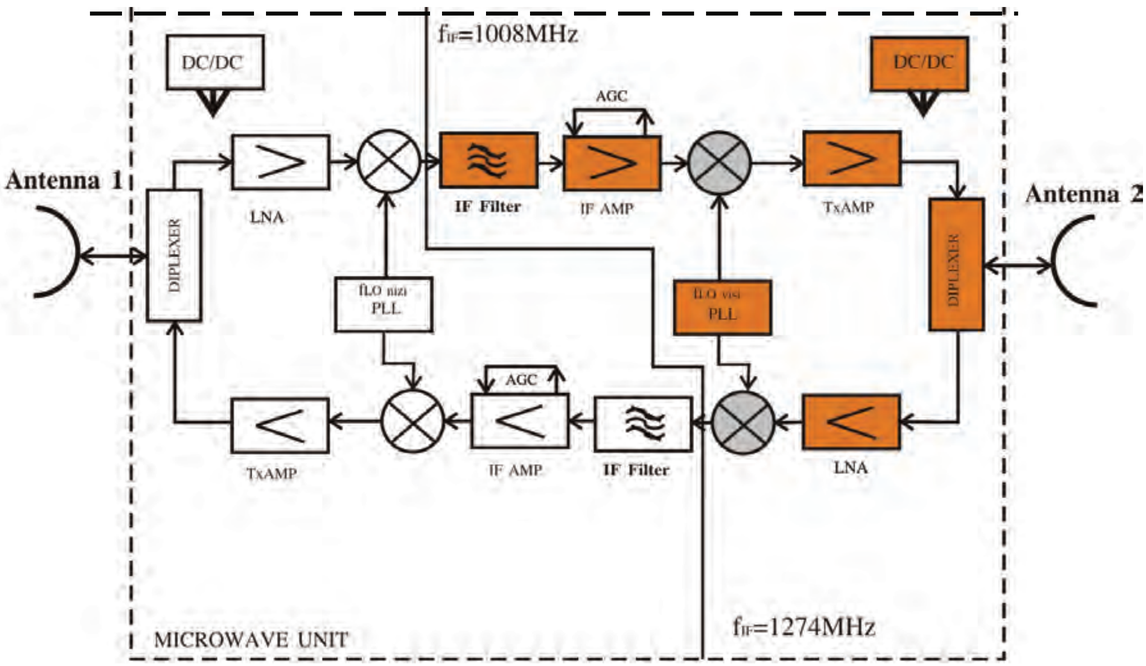

Fig.3. Block diagram of the transmitter (version B)

If signal at receiver's input exceed -45dBm, automatic gain control in IF amplifier will lower its gain preventing saturation of the output amplifiers cascade. Output power saturation would distort the transmit signal spectrum and increase BER of the transmitting signal.

Big overall gain is required to overcome all losses occurred over the signal propagation path. If total gain is provided with amplifiers that operate at the same frequency such system could easily start to oscillate. This is the main reason why the overall required amplification is distributed over three different frequency ranges. Also with conversion to the IF it is possible to achieve enhanced selectivity for suppression of unwanted near-channel interferention. Presence of unwanted signal within the input filter passband with a level suppressed for less than 30 dB related to regular signal can often cause amplifier oscillations. Fig.1. shows frequency characteristics of the IF amplifier with a bandpass IF filter for two various amplifier's gain.

III. REALIZATION AND OBTAINED RESULTS

On Fig.2. and Fig.3. are shown block diagrams of the version A and version B of the transmitter. Whole transmitter is divided into two separated parts, one consisting of an antenna and shaded parts from Fig.2. (or 3), and second part consisting of an antenna and white parts from Fig.2.(or 3). These two parts are connected with two coaxial cables, one of them transmitting signal at frequency f_{IF1}=1008 MHz, and the other with signal at frequency f_{IF2}=1274 MHz. Since the distance between these two parts of the transmitter are relatively short (up to 10m, typically), they introduce small losses that are compensated by AGC within the IF amplifier so that they don't affect operation of the transmitter. Beside these two coaxial cables the two parts of the transmitter are mutually connected with power and signalization lines. All connecting lines are placed into the rigged metal pipe for their protection against environmental influence.

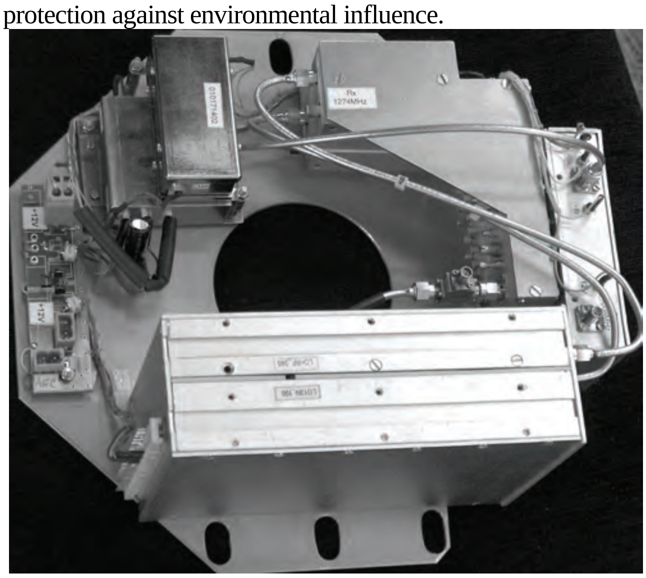

Fig.4. Photo of the repeater version A – view from above

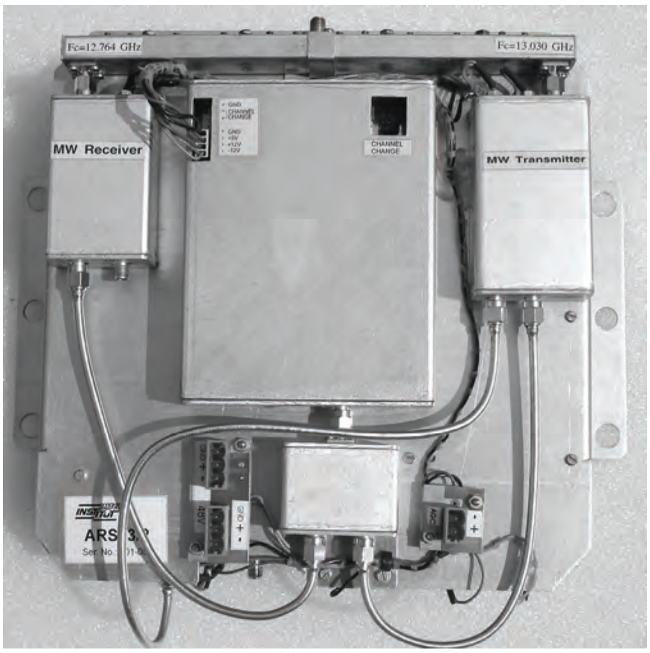

Fig.5. Photo of the repeater version B – view from above

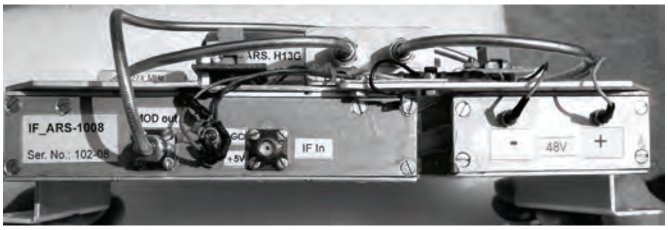

Fig.6. Photo of the repeater version B – lateral view

In the version A, all units are mounted on the upper part of the plate while in the version B units are mounted in two levels, on both upper and lower part of the plate as presented on Fig.6.

VI. CONCLUSION

Specified characteristics of the version A are improved in version B with respect to lowered power consumption and simlification of demonstrated units as well as smaller physical dimensions.

Regulation of output power, by dip switcher – from around 0 to around +20 dBm, is very easy to achieve optionally. This solution offers protection from interfering signals. This is especially important if the first step is very short, e.g. a few hundred meters, which frequently occurs in settlements in valleys and below hills. In this way, designers are given flexibility in covering various distances. In financial respect, this solution is considerably cheaper than building of passive repetares or using of back-to-back configurations.

Great flexibility is also possible in chosing of the operating channel (from 1st to 4th). Low power consumption enables applications at locations with no immediate network power supply (solar panels or wind power genartors). Small physical dimensions enable easy integration with the antenna mechanisms. Installation, servicing and maintenance is also easy to perform.

The repeater fulfills requirements regarding quality of gained signal, insulation of output ports, power consumption, physical dimensions, temperature stability and price

ACKNOWLEDGEMENT

This work has been supported by the Ministry of Science of the Republic of Serbia

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