Pilot Signals Processing Module

Oleg Borisov Panagiev[1]

***Abstract* – The pilot signals processing (PSP) module integrated in the amplifier provides optimal adjustment under all circumstances. The main function of the PSP module is to maintain a constant amplifier output level independent of variations in input level. Variations in input level are caused by change of both attenuation and tilt in the amplifier's input cable. This change of the cable's characteristic is due to temperature change in the cable over time. This can only be compensated correctly by a true two-pilot AGC controlled circuit. Using pilot tones or analogue TV carriers as a reference the PSP module control the variable interstage attenuator and equalizer, thus compensating for the change in the cable's characteristics. The pilot frequencies are free selectable and may be altered on site according to the actual channel load – no factory fixed pilot frequencies!**

***Keywords* – supertrunk amplifier, pilot signals, AGC, ASC**

I. Introduction

In long trunk lines, where are used a big number consecutively connected cable amplifiers, at the different seasons the coaxial cable signal's attenuation is changing. As with any metallic conductors, variations in temperature affect the transmission loss of coaxial cables. When the cable is warmer it has more loss, when colder less loss. In CATV systems we are involved with kilometers and kilometers of cable, and changes due to temperature variation become a problem if remedial or corrective action is not taken. Although we associate automatic gain control (AGC) and other automatic correction techniques with thermal changes, some corrective methods are equally protective against signal level changes from other causes. Possible other causes might be equipment aging, improper adjustment of equipment by service personnel, fluctuations in power source voltage, etc.

A much more positive control of system transmission levels can be achieved by tapping off and measuring the amplitude of RF pilot carriers or regular television signals designated for control purposes. RF attenuation can then be introduced or removed from the amplifier RF transmission path in direct proportion to the amplitude measured on the control signals. Variations on this technique are also possible; for example, using the "closed-loop" technology but sensing two separate control signals at different points within the spectrum. These are frequently employed to provide some "slope" correction automatically, out the basic principle is the same. If the control equipment provides only "flat" transmission level control, it is called automatic gain control level control, two signals would be sensed and the RF transmission loss removed would not be the same across the entire (AGC). In this case, if the control signal is sensed to be 1 dB low in amplitude, 1dB of attenuation would be automatically removed and all signals present would be ally raised by 1 dB. If the control equipment provides some "sloped" transmission band of interest. This is called automatic slope control (ASC) and may or may not be incorporated into every AGC equipment depending on individual manufacturer designs [1, 2].

Generally, AGC and ASC or more mutually ALC (automatic level control) are provided interstage in amplifiers where it has no significant effect on the amplifier C/N ratio. The RF sampling is through a directional coupler at the high-level amplifier output. The effect of removing attenuation is increased amplifier gain, and units 1 are sometimes referred to as having reserve gain to overcome lower input signal levels. The amplifier gain module is adjusted for some extra gain, but the actual compensating adjustment is the automatic insertion or removal of attenuation [3].

Automatic control equipments are generally specified to have, say, 4 dB reserve gain and 4 dB of increased attenuation capability. This may be stated for ± 4 dB input level changes, the output level change will not exceed ± 0.3 dB.

Automatic control, or self-regulation, is essential in systems of any practical length. It is quite important that we completely understand how it is implemented if we are to effectively incorporate it into systems.

II. Circuits Decisions

Supporting the level of nonlinear distortions within the standard borders (CENELEC EN 50083) in this case is possible by using an automatic regulating module for the output level of the amplifier. More often this module is plug-in assembled into the amplifier and the information for the output level is performed conformable to the levels of pilot signals, transmitted by the Head end.

On fig.1 is shown a block diagram of cable amplifier, using one pilot signal. The amplifying section is split into two parts (blocks 1 and 3), and between them is connected adjustable electronic regulator (2).

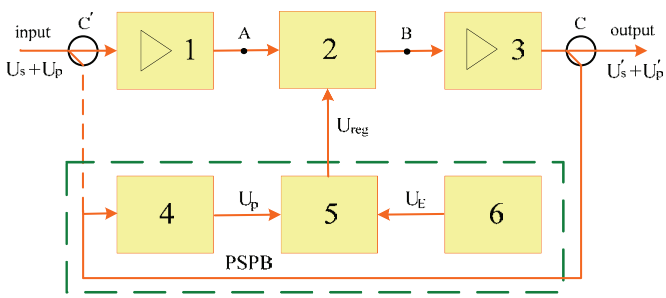

Fig.1. One pilot signal amplifier block diagram

The ALC loop consist narrowband pilot receiver (4) for separate the pilot signal from the group signal $U_s + U_p$; source

[1]Oleg B. Panagiev is with the Technical University of Sofia, Bulgaria, E-mail: olcomol@yahoo.com

of reference (etalon) voltage U_E (6) and device for comparison and amplification (5), which format regulating voltage U_{reg}. The resistance of the attenuator is changing depending on the value of U_{reg}. Mostly as regulative elements are used adjustable T – sections, compound of PIN diodes. They have indisputable advantages: uniform frequency performance at good matching on the input and output within the borders of the dynamic range of ALC in the whole working frequency range.

Tapping off of the pilot signal is taking place in the pilot receiver by filter with high selectivity. Within the borders of the narrow pass band filter (0,5÷1,5 MHz) the attenuation must not be changing with more then 0,1 dB.

At the modern cable TV systems are used more then one pilot signals, distributed within the whole frequency range of the system. Every one of them is been work up in the pilot signals processing block (PSPB) from the respective pilot receiver, after they were separated from the group signals by filters (fig.1 – C or C´).

Developed pilot signals processing module (PSPM), contains one PSPB and one electronic regulator (ER), composed of a frequency independent electronic attenuator EA and a frequency dependent electronic attenuator ET (fig.2). As a regulative elements in EA are used PIN diodes, included in Pi-section. As a regulative elements in ET (electronic tilt) are used PIN diodes, included in T-section. The regulative voltage U_{reg} is made in the pilot signals processing block (fig.3), compound of pilot receiver with distributed selectivity, detector, and scheme for comparison and amplification, as well as voltage stabilizer.

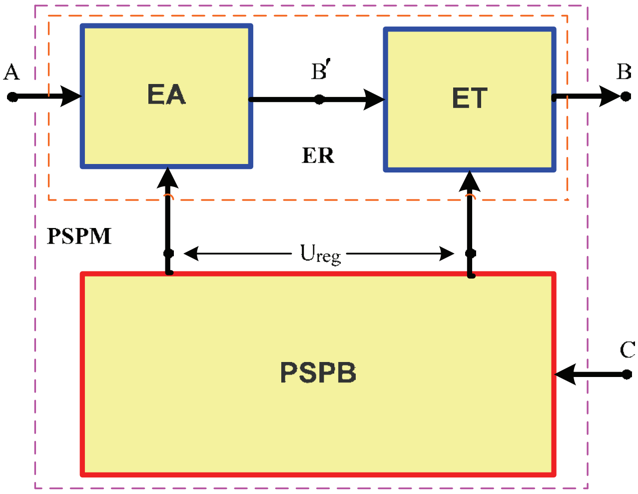

Fig.2. PSPM block diagram

The pilot receiver is compound of three band filters (BPF1, BPF2, BPF3), which ensure the pilot signal's tapping off with narrow band (Δf = 1 MHz) and two amplifiers. First of them represents low noise amplifier and is filled with integrated circuit IC1 RF2312 [4], and the second – whit N-channel MOSFET transistor T1 BF963.

D1 is the detector of pilot signal and comparison and the amplification of the formed dc voltage is made in IC2 TL082, working coincident as comparator and dc amplifier. The reference voltage, feeding onto the no inverting input 3 of IC2 and the supply of IC1 is produced from voltage stabilization, compound from the second part of IC2 and T2. By potentiometers P1 and P2 the currents flowing through diodes D1 and D2 are been made symmetric, as well as the selection for the place of the work point of the detector diode over its V-A characteristic.

The attenuator AT is used for regulating the level of pilot signals upon to a nominal value, so that to be made minimum distortions.

The band filters are multi-sections LC filters, but it is successfully possible to use SAW filters, as the amplifiers, carried out from T1 and BPF2, can fall away.

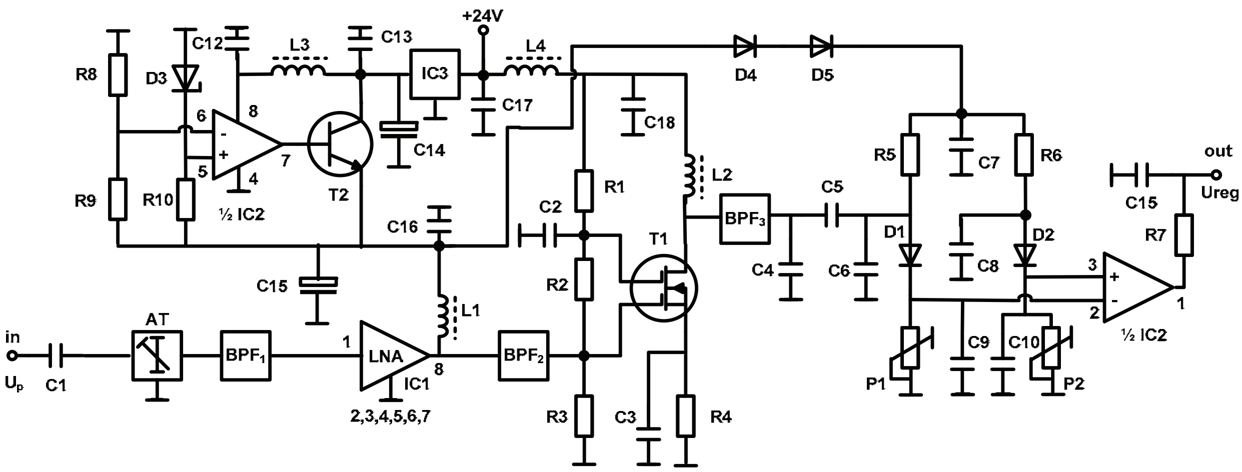

Fig.3. The functional diagram of PSPB

III. EXPERIMENTAL RESULTS AND HARACTERISTICS

How much self-regulation should be provided in a system is a difficult thing to determine. Although the general practice has been to use as few automatic control units as possible on the basis of reduced initial cost, as systems become more sophisticated, carrying many more channels and other services, this rationale becomes less convincing. Perhaps the best place to start is to plot the impact of thermal change for several conditions of construction and analyze them.

For the experimental study of the developed module is used trunk amplifier with distributed amplification within two hybrid integral circuits BGY883 and BGD802 at the range of 47 MHz to 862 MHz. In this case the coaxial cable between the amplifiers is QR-540 [5]. The characteristics of the amplifier are studied at a lack and presence of pilot signals processing module (PSPM). In Table 1 are presented the results of the research on a trunk amplifier without pilot signals for tree frequencies, placed in the beginning, in the middle and in the end of the television range at a standard D/K (49,75 MHz; 447,25 MHz; 855,25 MHz). The graphic presenting of the transmitting characteristic in this case is given in fig.4.

In Table 2 are presented the results from the research of the same amplifier, but with built in module for pilot signals (PSPM) at the up pointed frequencies and voltage change of ± 5 dB. It is used one pilot signal with frequency 295.25 MHz, which represents the picture carrier frequency of the channel SR19. It is given the values of the regulative voltage U_{reg}, conforming to the change of signal output level. For facilitation during analyzing the work of the trunk amplifier with and without pilot, the results of that table are shown in fig.4.

On fig.5 is given a graphical dependence of the alter-nation of the level of group signal in the supertrunk amplifier

Table 1

f = 49,75 MHz		f = 447,25 MHz		f = 855,25 MHz	
U_{in} dBµV	U_{out} dBµV	U_{in} dBµV	U_{out} dBµV	U_{in} dBµV	U_{out} dBµV
83,5	93,7	78,8	92,6	77,5	98,5
84,5	94,7	79,8	93,8	78,5	99,5
85,5	95,6	80,8	94,9	79,5	100,7
86,5	96,7	81,8	95,8	80,5	101,5
87,5	97,7	82,8	97	81,5	102,1
88,5	98,8	83,8	97,8	82,5	103
89,5	99,4	84,8	98,5	83,5	104,2
90,5	100,2	85,8	99,7	84,5	105,6
91,5	100,8	86,8	100,5	85,5	106,7
92,5	101,9	87,8	102,8	86,5	107,7
93,5	102,6	88,8	104	87,5	108,9

Table 2

f = 49,75 MHz	f = 447,25 MHz	f = 855,25 MHz	f_p = 295,25 MHz	
U_{out} dBµV	U_{out} dBµV	U_{out} dBµV	U_{out} dBµV	U_{reg} V
97,6	97,5	98,2	102,8	3,4
98,1	98,1	98,5	103,1	3,3
97,6	97,6	98,4	103	2,96
98,8	98,3	98,5	103,1	2,9
99,2	98,6	98,9	103,5	2,8
99,4	99	99	103,6	2,6
99	98,3	98,9	103,5	2,4
99,3	99,2	99,8	104,4	2,3
98,7	98,8	99,6	104,2	2,14
99	99,4	99,8	104,4	2,12
99	99,7	100,3	104,9	2,1

Table 3

f MHz	U_{out} dBµV	ΔU_{out} dB	ΔU_{out} dB	ΔU_{out} dB
	t^o = 20°C	no ALC	with AGC	with ALC
49,75	98,8	± 0,86	-1,1	-0,20
119,25	99	± 1,38	-0,6	-0,10
207,25	99,1	± 1,8	-0,2	-0,02
295,25	99,2	± 2,24	0	0
391,25	98,5	± 2,6	0,6	0,01
447,25	97,8	± 2,8	0,8	0,06
543,25	98	± 3,1	1,1	0,11
663,25	98,2	± 3,45	1,5	0,18
759,25	98,8	± 3,7	1,7	0,24
855,25	99	± 3,9	2,0	0,35

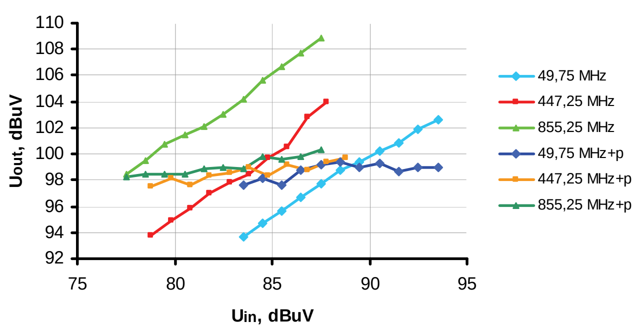

Fig.4. Supertrunk amplifier transmitting characteristics with and without pilot signals

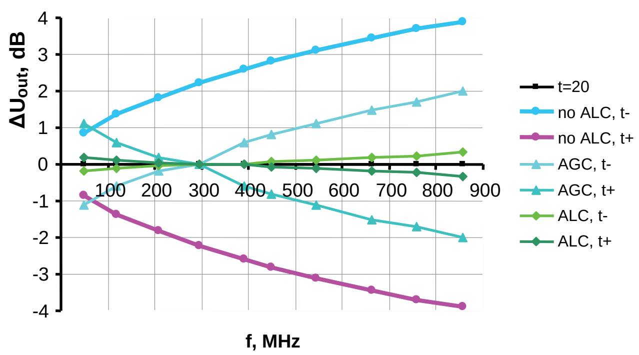

Fig.5. Alternation of the output level graphical dependence in the supertrunk amplifier

output at alteration of the attenuation in the supertrunk coaxial cable. Values of the frequencies, for which the study is made, are in conformity with Appendix C of an European standard CENELEC EN 50083 (Table 3). Presented are three cases:

- without ALC;
- with AGC;
- with ALC (AGC+ASC).

At $t^o = 20^o$ C the alteration of the output level of the supertrunk amplifier is frequency-independent and is equally to a zero. At $t^o \neq 20^o$ the alterations of the output voltage have positive or negative values in dependence of the attenuation in the coaxial cable, respective from the environmental temperature.

IV. Conclusion

Without the PSPM module, the amplifier acts as a normal amplifier with manual input attenuator and equalizer. Once the PSPM module is plugged in it takes over the control of the input attenuator and equalizer. When the desired output level has been entered into the PSPM module's "memory", the PSPM module adjusts the attenuator and the equalizer. The set up of the amplifier is now automated.

There are unique problems associated with AGC and ASC even at low levels of utilization. When we state that the system is regulated, we must recognize that this regulation is contingent upon properly adjusted and fully operative PSPM units. But, if the amplifier were previously operating near normal temperature (with, say, 4 dB of attenuation inserted), it now will increase the output level by 4 dB. We know that increasing output level by this amount (4 dB) will immediately increase nonlinear distortions (CTB or CXM) by twice this amount or 8 dB.

Since all PSPM units in the system (whatever the density) receive no regulating carrier, they all introduce 8 dB additional nonlinear distortions. Even at a density of PSPM at every third amplifier, a gross increase of this magnitude, affecting one-third of the system amplifiers [3, 6], would undoubtedly put the system out of specification as to CXM.

If the PSPM density was 50 % and each amplifier went 8 dB higher in CXM, the end-of-system CXM would go up 4 dB or so. If the PSPM density was 100 %, the system CXM would be 8 dB poorer. Either of these conditions would surely be out of specification.

However remote the possibility of control carrier loss may appear to be, we might still consider alternatives to reduce the impact of such an untimely event on end-of-system performance. We believe there are strong arguments in favor of 100 % ALC, and we also believe the CATV operators are beginning to adopt this philosophy. If PSPM is installed at every amplifier, the requirement for a wide range of control (we have been using ± 4 dB "window" in our discussions) is somewhat reduced. If, by redesign, the ALC range were restricted somewhat to ± 3 dB, or even ± 2 dB perhaps the resultant change in output level would be less and consequently the increase in CXM produced in each unit would also be lower.

A more practical alternative to this might be to simply position the ALC "window" differently. If we only expect a 2 or 3 dB lower input level (due to only having to correct for one cable span), then we could position the "window" to give us only 2 or 3 dB of attenuation removal range. Now if we lost the control carrier, the unit could only open up that 2 or 3 dB from normal attenuation, limiting the additional CXM to 4 or 6 dB rather than the previous 8 dB.

With an understanding of self-regulation and its effect on systems, both economically and technically, we are better qualified to recognize those situations or applications that might be cost-effectively addressed by using more PSPM. We can also evaluate the effects of using less PSPM more intelligently. As stated at the beginning of this paper, the decision as to how much self-regulation to provide is a difficult one to resolve, but perhaps we are now somewhat better equipped to address it.

V. References

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