Minimizing HUM Modulation Products in Coaxial Part of HFC Networks

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***Abstract* - Variants of combined AC/DC remote supply of cable amplifiers used in coaxial parts of HFC networks are offered in the report. The goal is to minimize the number and levels of products from HUM modulation that occurred in passive as well as in active devices of cable distribution network with AC supply of trunk and subtrunk amplifiers. Different methods and circuit solutions of cable amplifiers models, produced by European and world manufacturers are described. Corresponding conclusions are made on the base of practical realization of offered circuit decisions.**

***Keywords* – HFC/CATV, cable amplifier, fiber node, HUM, switching-mode power supply.**

I. Introduction

In the coaxial part of each hybrid fiber coaxial network, as also in the cable distribution network (CDN) of the existing CATV systems, the transfer of the signals to the subscribers is made by trunk and subtrunk. Because of the damping of the signals in the passive devices (coaxial cables, taps, splitters, attenuators and others), the maintenance (the support) of their normal levels in CDN is accomplished by cable amplifiers (Fig.1). The supply of the contemporary cable amplifiers is an alternating current (AC from 30 V to 65 V) and the supply unit (SU) is a switching-mode power supply (SMPS). The supply is submitted distantly from a supplying source, placed in the Head end and sometimes in some apartment building that is close to de trunk or the subtrunk. The division and the summation of supply current and group signal is made by diplexers, which are made of chokes (L_1, L_2, L_3, L_4), capacitors (C_3, C_4) and resistors (R_1,

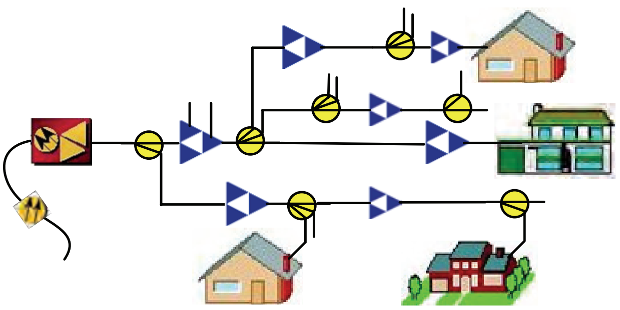

Fig.1. Cable distribution network on HFC/CATV system

R_2, R_3…R_8), (Fig.2). Also, trough the diplexers the supply current is being transferred from the input to the output (the outputs of the amplifier) and backwards. That is accompanied by an occurrence of HUM modulation in the active and in the passive devices [1], [2], [3], [4], [5]. By the cable amplifiers with DC supply (+30 V to +65 V) and ordinary power supply unit, the levels of the HUM modulation products are insignificant (suppressed to more than 90 dB).

In the present paper are offered circuit solutions for minimizing of the HUM modulation products, using:

a) Replacing of L_1, L_2, L_3 and L_4 with power passing chokes F26 of the MMG-North America [6]. By doing that it is accomplished not only the minimize of the effects of HUM modulation from 1MHz to 1GHz but also an increased bandwidth, improved reliability, expanded services, and technology upgrades. The result is chokes with proprietary windings that negate the need for dampening resistors and can withstand 15 A continuous current and a peak of 25 A for two hours without loss of performance.

b) Supplying of the cable amplifiers [7], [8] and the fiber nodes [9], [10] with AC, as well as with a DC. This way the HUM modulation products are minimized and is facilitated the upgrade of the old cable distribution networks, in which is used DC supply. A short interruption of the signal to the subscribers and a minimal temporary deterioration of the image quality are fulfillable without parallel trunks or subtrunks. However, it is necessary the respective changes in the SMPS units to be made, so that they can be supplied also with DC. On a later point of the process, when all of the amplifiers are replaced and the output level of every amplifier is optimized in the whole cable distribution network, it is possible for the supplying source for the cable amplifiers in the Head end to be replaced from DC to AC, without needing of any readjustment of the amplifiers. To be minimized the HUM modulation is recommended continuing of the usage of DC supply for the amplifiers.

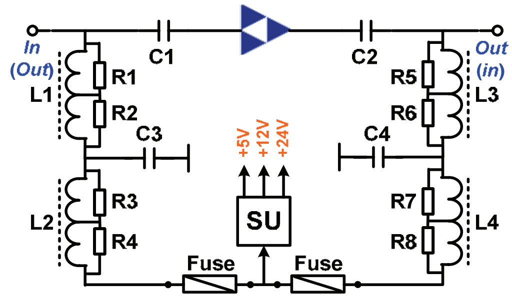

Fig.2. Electrical circuit on power supply in cable amplifier

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II. INFLUENCE OF THE HUM MODULATION ON THE TRANSMITED SIGNALS

Essentially HUM modulation represents undesired modulation of the television visual carrier by the fundamental or low-order harmonics of the power supply frequency, or other low-frequency disturbances. HUM can comes from a defective AC/DC power supply of an amplifier and/or fiber node, to amperage draw thru a passive equipment or water in connectors. Also HUM modulation occurs due to imperfect power supply filtering and as a result of parametrical modulation of magnetic components in both amplifiers and passive devices. Modulation due to power supply ripple should logically be more or less independent of RF frequency. To the extent that the parametric modulation of magnetic components is a factor, however, its effects may vary with frequency. The primary mechanism is that magnetic cores may partially saturate at peaks of the AC current. This will affect there impedance at RF, and so create a change in return and transmission loss that will vary at a 50 Hz rate. Since the impedance change may vary with frequency, as may the effect of the impedance change, there is no way of predicting how the modulation percentage will vary across the spectrum. At a given frequency, however, the percentage modulation of a video signal should be the same as that of a digitally modulated signal though the latter may be able to tolerate a higher modulation percentage.

HUM is calculated in % or in dB:

a) converting the measured logarithmic value (dB) in %

$$HUM[\%] = 100/(10^{HUM[\mathrm{dB}]/20}) ; \quad (1)$$

b) converting the percentage in logarithmic value (dB)

$$HUM[\mathrm{dB}] = 20\lg(100/HUM[\%]) . \quad (2)$$

The influence of the HUM modulation on the parameters of the carried signals in cable distribution network is unfavorable for the analog signals as well as for the digital. In the 50 Hz video oscillogram (Fig.3) this can be seen as a wave-form line on the video signal black shoulder or on the 50 Hz synchronization pulse (picture repetition impulse). A

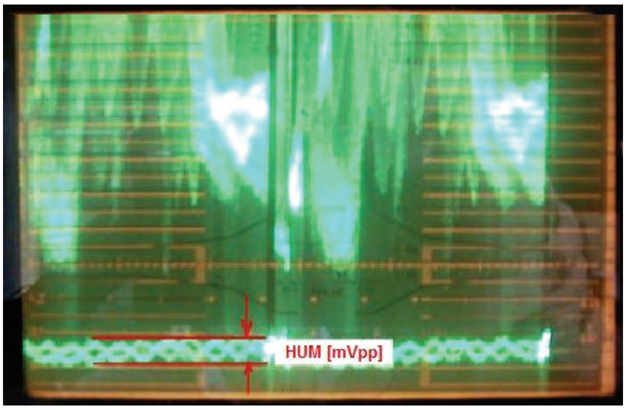

Fig.3. Hum on an analogue signal

HUM modulation on a QAM signal caused by a faulty power supply in the distribution line or in the signal processing will be seen as a low MER value. Typical disturbance in the constellation diagram with HUM transmission is presented on Fig.4. Remember that: At least 32 dB is needed for 64-QAM and 36 dB for 256-QAM at the subscriber.

III. CIRCUIT SOLUTIONS

The accomplishment of combined remote supply is made in two ways:

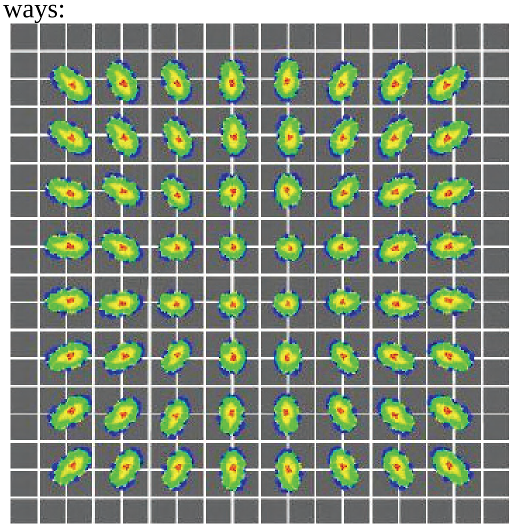

Fig.4. Typical disturbance in the constellation diagram with HUM transmission

- by building-in of new (additional) module, which carries out the initial starting of the SMPS unit;
- by making a change in the SMPS unit circuit to ensure possibility for working with DC (removal and joining of elements and electrical connections).

On Fig. 5a is shown diagrams of increase of start supply voltage $U_{cc,start}$ (with dash line) and enable voltage U_e (continuous line) for integrated circuit (IC) of SMPS unit when original (alternating) supply voltage is used.

Fig. 5b shows increase of mentioned above voltages bun when use DC supply voltage. Both voltages increase linearly and almost simultaneously because time constant is very small. That is why it is not possible to start in operation the SMPS unit. Moreover $U_{cc,start}$ must grow more slowly than U_e and time Δt_2 depends on values of R_1 and C_2, (Fig.6).

The idea, which is suggested and realized below, is to increase the time for building-up the initial voltage in exponential law and to equalize time constant with time constant obtained when alternative current supply is used.

Experiments were made by using of cable amplifiers of two different companies – C-COR/ADC PHASOR and WISI.

A. *Building-in of new module*

Elements of schematic diagram (Fig.7), that forms start impulse, is mounted on separate printed circuit board (PCB). Connection with SMPS unit is made using short wires without interruption of existed links, i.e. mounting is parallel in shown points on the figure. The required time constant is achieved selecting the values of elements C_1, R_1 and R_2.

Formed impulse is inverted and supplied by transistor T_1 of respective pin of integrated circuit, on which is received start initial supply voltage. The minimal input voltage is +30 V.

B. Change of circuit of SMPS unit

When the start impulse is formed according to diagram shown on Fig. 8 it is necessary to break some connection on PCB of SMPS unit and to create a new ones. Moreover, to obtain the time constant, C2 is replaced with a new capacitor C2* with the same operating voltage as the original one but with more capacity (C2* > C2).

In series of resistors $R_1||R_2$ is connected diode D (1N4002) to provide reliable positive start impulse on pin 6 of integrated circuit (TDA4605-3), altering on exponential law determined by R_1, R_2 and C_2^*. At the same time diode D cause discharge of capacitor C_2^* trough pin 6 of integrated circuit and isolation between main and secondary supply obtained from pulse transformer (PT). The minimal input voltage is +35 V.

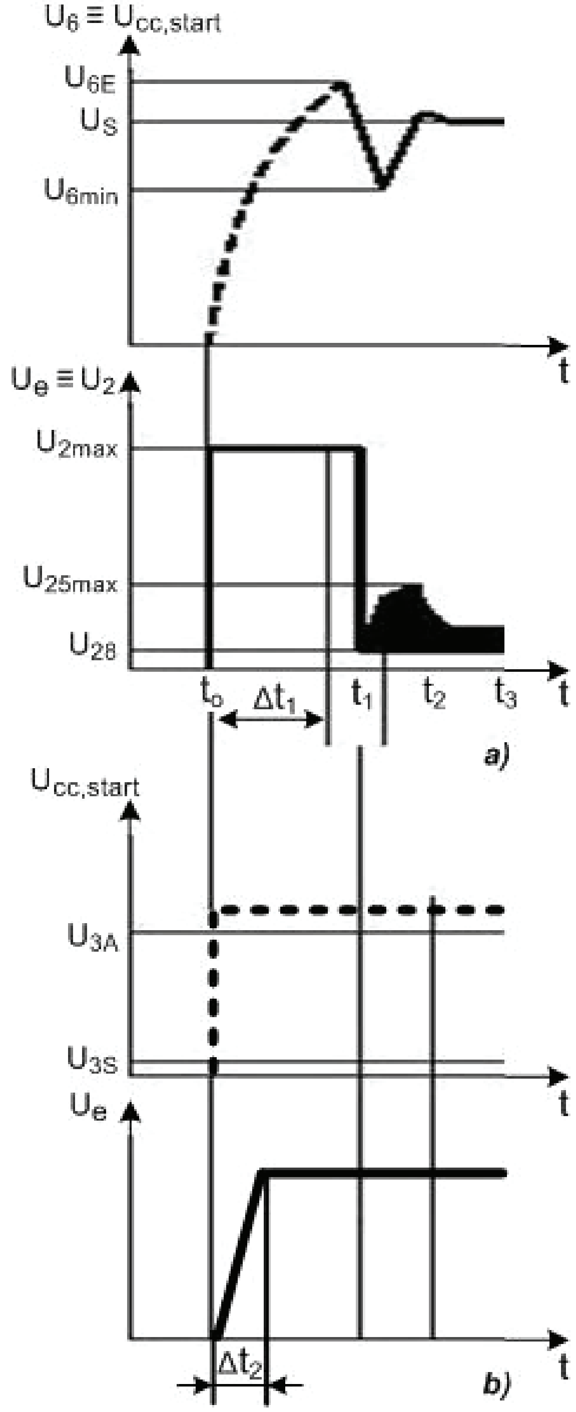

Fig.5. Diagrams of starting and enable voltages

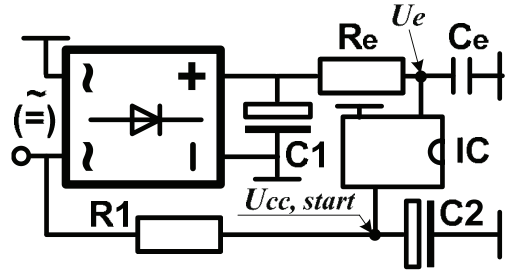

Fig.6. SMPS unit with original (alternating) supply voltage

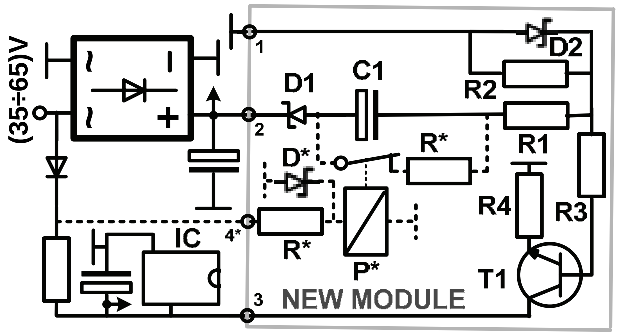

Fig.7. SMPS unit with new module

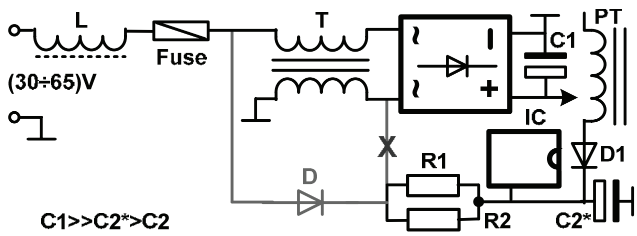

Fig.8. Change of circuit of SMPS unit

IV. Conclusion

The circuit solutions, discussed in the report, allow cable amplifiers and fiber nodes to work with AC supply (50/60 Hz) as well as with direct current one. Choice of supply depends on cable operator.

Experiments for circuit shown on Fig.7 did not show problems in switching on, switching off and normal operation of SMPS unit. For circuit shown on Fig.8 it is established that if supply because of any reason stops for a short time it is necessary to wait 2 or 3 minutes to discharge the capacitor C_1

and to start SMPS unit again. This disadvantage could be removed by adding elements (on figure they are shown by dash line) that when input voltage is switched off makes short connection of capacitor pins C_1 and discharge it.

On Fig.9 is shown graphs of HUM modulation by three cases:

1) MMG F26 core without resistors:
2) Competitor's core with resistors;
3) SMPS unit with DC supply.

HUM modulation levels are measured according to European standard CENELEC EN 50083-7. For cases 1) and 2) graphs indicate a comparison of materials of similar geometries, using the same test equipment and set up.

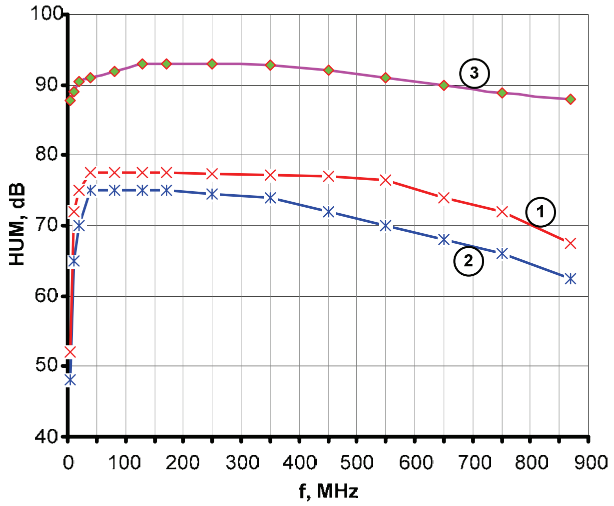

Fig.9. Graphs of HUM modulation

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