# MEASUREMENTS CONTROLLING INTERFERING SIGNALS IN THE ELECTRIC POWER SUPPLY NETWORK

**Dimitar I. Dimitrov**
Faculty of Communications and Communication Technologies, Sofia Technical University
1000 Sofia, 8 Kliment Ohridski Str., e-mail: ddim@tu-sofia.bg
**Nikola Nikolov**
Faculty of Electronic Technique and Technologies, Sofia Technical University
1000 Sofia, 8 Kliment Ohridski Str.
**Tsvetozar Hristov**
Faculty of Electronic Technique and Technologies, Sofia Technical University
1000 Sofia, 8 Kliment Ohridski Str.

*In the paper are examined interfering signals transferred in the electric power supply network from the electronic apparatuses and in particular from the TV receivers of "Sofia" Family. Their levels are considerable especially in electronic apparatuses supplied though key net power supplies (JMPS). The levels in the frequency обхват over 150 kHz (long waves) are controlled regarding the obligatory norms for the whole world dealing with communication and electronic apparatuses, in order to guarantee their outer electro-magnetic compatibility. The research and the scientific conclusions in the report include linear power supplies in continuous regime, but we will focus on the switch mode power supplies and mainly on the forward converter that is not galvanic divided from the power line. We will focus on the flayback converter that is galvanic ally divided from the power line.*

**Keywords:** SMPS – Switch Mode Power Supply, forward, flayback converter, television receiver, network.

The examination in this report is based on the science and the main point is to show the experimental methods and resources that are needed for reaching the compulsory compatibility with the standard Multimedia Home Platform (MHP) talking about the electronic apparatuses from the mass manufacturing for example TV sets, monitors that use power supply directly from the energetic line. The results from the test series and series regular production are given to give the technological stability of the apparatuses towards the noises in the power supply line.

The disturbing high frequencies currents are measured over resistance of 150 Ohms that is equal to the impedances $Z_A$, $Z_B$ and $Z_E$ between all the supply lines and ground (figure 1).

The bandwidth of the tests is 9 kHz. The detector has time constant of charge equal to 1mS and discharge constant 160mS. On disturbance level $V_{ST}$=0 dB the equal disturbing voltage is $U_{ST}=1\mu V$.

The disturbing source between the two power supply lines of TV receiver is low impedance, and the source that that closes the current circuit through the impedance $Z_E$ that is high impedance.

This gives the reason to make difference between the two disturbing voltage noises using next few equations:

a) symmetrically between the lines

$$(1) \qquad U_{is} = U_a - U_b$$

b) asymmetrically between the two supply lines and ground

$$(2) \qquad U_{iu} = \frac{U_a + U_b}{2}$$

The equivalent scheme of the symmetric disturbances focus on the variable $i_{C1}$ of the internal current of the switch mode converter we can make the conclusion that the voltage over the resistance $R_{C1}$ is:

$$(3) \qquad U_{RC1} = i_{C1}.R_{C1}$$

Practically this voltage predominates in the equivalent scheme of the electrolytic capacitor. An assessment of suppressing of the symmetrical disturbance will be made using this capacitor.

When the diodes of the rectifier are conducting the source of the disturbing voltage with low internal impedance $R_{C1}$ is over the line terminals A and B (figure 2). The voltage of the source $U_{rc1}$ is given by the harmonics $U_{RC1}$.

The triangle form currents in the flayback converter create source with disturbing voltage:

$$(4) \qquad U_{rc1} \approx \frac{R_{C1}.C_1}{k.U_{i\min}}.\frac{1}{\delta^2}.\left(\frac{f_i}{\pi f_{st}}\right)^2$$

and the trapezium currents using the forward converter create source with disturbing voltage:

$$(5) \qquad U_{rc1} \approx \frac{R_{C1}.C_1}{k.U_{i\min}}.\frac{1}{\delta^2}.\left(\frac{f_i}{\pi f_{st}}\right)^2 + 2\frac{R_{C1}.C_1}{k.U_{i\min}}.\frac{f_i}{\pi f_{st}}.\frac{1}{\delta}$$

In the worst case (rectangular current) equation (5) becomes:

$$(5.1) \qquad U_{rc1} \approx \frac{R_{C1}.C_1}{k.U_{i\min}}.\frac{1}{\delta^2}.\left(\frac{f_i}{\pi f_{st}}\right)$$

If the duty cycle is $\delta$=0,5 the equations (4) and (5.1) become:

$$(6) \qquad U_{rc1} \approx 4\frac{R_{C1}.C_1}{k.U_{i\min}}.\left(\frac{f_i}{\pi f_{st}}\right)^2$$

and

$$(7) \qquad U_{rc1} \approx \frac{R_{C1}.C_1}{k.U_{i\min}}.\left(\frac{f_i}{\pi f_{st}}\right)$$

This equation gives an adequate accuracy. In the upper equations $\delta = \frac{t_p}{T_i}, k = \frac{C_1}{P_i}, U_{i\min}, f_i, and, f_{st}$ are the duty cycle, the cycle of the charge of the capacitor over an unit of the internal power of the switch mode converter, the minimal rectified voltage, the converters frequency and the disturbing frequency.

Using equations (6) and (7) follows the symmetrical disturbances are biggest in cases when $f_{st}$=150 kHz. According to this reason the inductance $L_{MF}$ of the line filter is defined using this frequency and the condition that it is necessary to raise the low internal impedance ($R_{C1}$) of the source of the internal disturbances. The high frequency current of this disturbing signal is closed through the X capacitor of the line terminals TV receiver.

Therefore the voltage that is needed to be oppressed has to be counted by the equation.

$$\frac{U_{is}}{U_{rc1}} \approx \frac{1}{(2\pi f_{st})^2 . C_X . L_{MF}} \quad (8)$$

The value of $L_{MF}$ can raise a lot because the charge capacitor $C_1$ becomes in series with it, which is unfavorable mainly when the converter is not in standby regime.

The nonsymmetrical voltages can not be filtered preliminary with the wanted practical accuracy. The practice shows that to restrict of this disturbances a practice and practical decisions are needed.

The currents that pass these disturbances are closed using an Y type capacitors. Their values are limited up to 5 nF. This defines the essential role of the construction over these disturbances.

The elements we will focus on are the output switching transistor, the output inductance and the pulse transformer, the fast diodes and the assembling of the power circuit board.

The capacitance of the insolated from the radiator output switching transistor can become up to 100 pF. This kind of capacitance provokes asymmetrical disturbances about ten times over than the fixed levels. One of the decisions is connecting the emitter to the radiator or to the positive pole of the DC supply voltage. The optimal decisions depend on the electrical and mechanical details that are given in SWITCH POWER SUPPLY.

The dissipation inductance $L_S$ of the output inductance and the pulse transformer essentially effect on the recovering time of the fast switching diodes. To avoid the appearances of parasitic currents their recovery must become lightly.

The currents through the capacitance between the primary and the secondary windings of the transformer are limited by using of electrostatic shields constructed using copper folio connected to the cold ends of the transformer or using only the transformer.

In the black and white TV sets "Sofia 21" and "Sofia 31" using uninterruptible stabilizer the disturbances provoke by the horizontal develop are limited by the line transformer and in addition with X and Y capacitors connected to its primary winding. The best decision is the middle pin of the Y capacitor to be connected to the mass of the symmetrical antenna input.

For example the color TV sets "Sofia 81" and "Sofia 82" whose power supply is based on the forward converter with trapezoidal collector current of the output transistor the Y capacitor is recommended to be connected to the ground of the middle frequency amplifier. The oppress of the disturbances is achieved by using a small inductance of the line filter $L_{i1}=L_{i2}$=6,6mH. The steps of the horizontal development and for the SWITCH POWER SUPPLY that are fixed on the basic platform are protected from the nonsymmetrical disturbances.

When using platforms insolated from the line such as "Sofia 83", "Sofia 84", "Sofia 85", "Sofia 86", "Sofia 87" and "Sofia 88" using switch power supply based on the flayback converter and with a triangular collector current the protection depends on the construction of the receiver.

For the color TV sets "Sofia 83" the switch power supply is separated from the main platform. It is composed in a separated node and it has high noise immunity compared to the transmitions. The transformer uses copper folio shields connected to the cold ends for both primary and secondary windings.

For the other color TV sets switch power supply is placed on the power circuit board of the main platform. The line filter is placed on an separate power circuit board. The pulse transformer is developed and simplified according to its construction, there are no shields and it has low power dissipation inductance.

The Y capacitor of the line filter is connected to the ground of the switch power supply.

The practice shows that lowering the nonsymmetrical disturbances effects on lowering of the symmetrical ones.

In the table the measured nonsymmetrical disturbances measured in a specialized laboratory on separate terms:

experimental devices

experimental series and regular production of TV sets "Sofia"

The measurements in the frequency range are graphically given. On the second graph the measurements of an experimental color TV set are given. These measurements are made in radio disturbances laboratory "Siemens" for both disturbances.

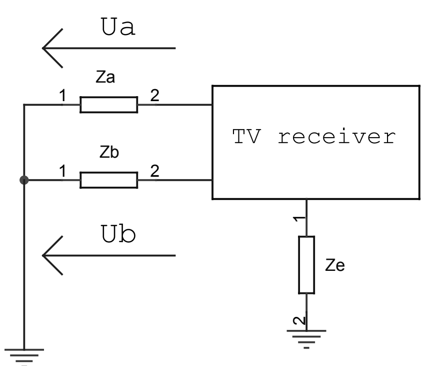


Figure 1

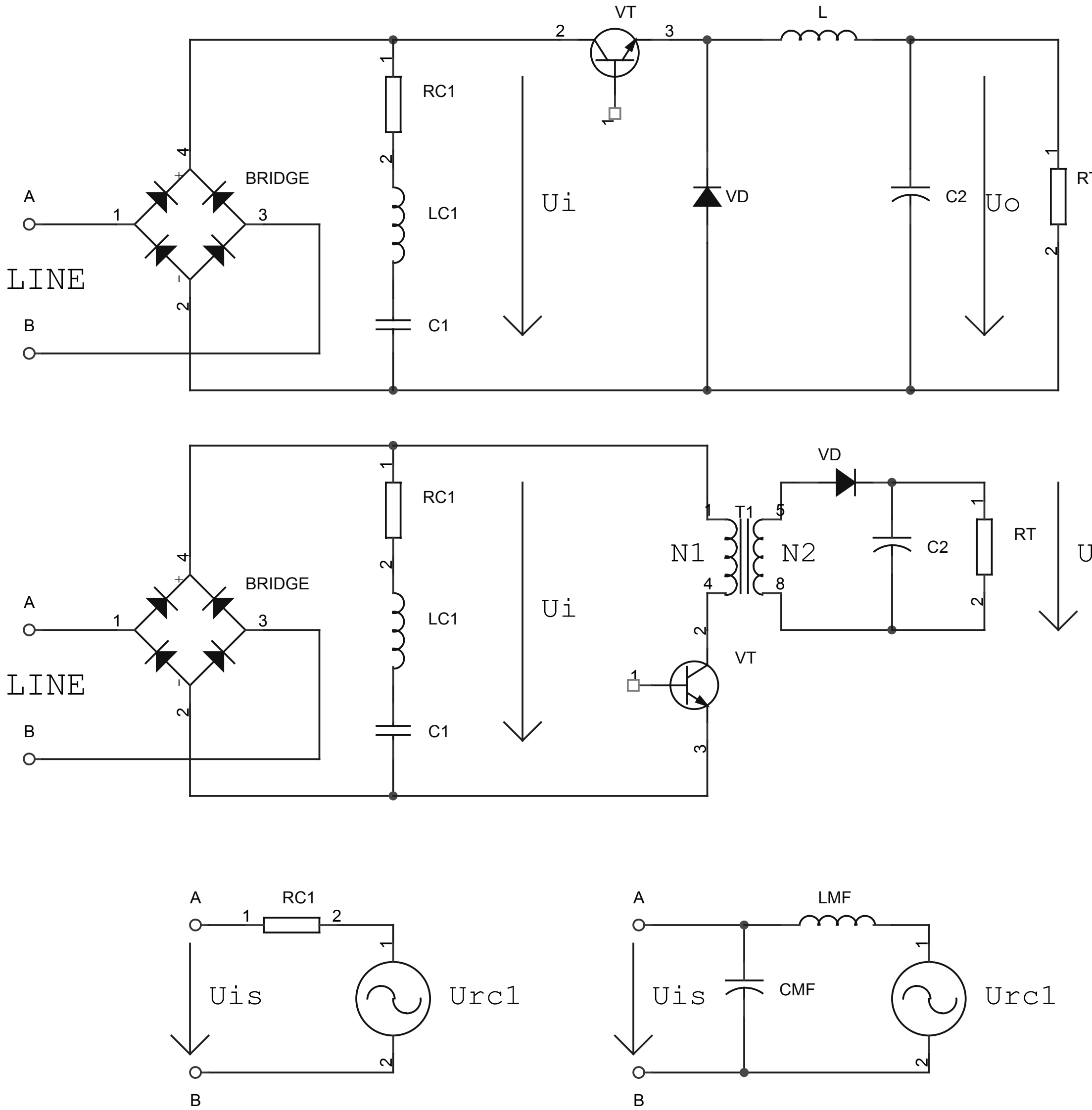


Figure 2

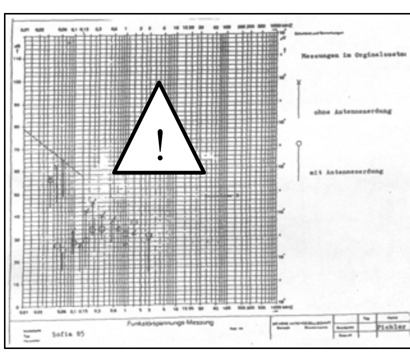

Figure 3

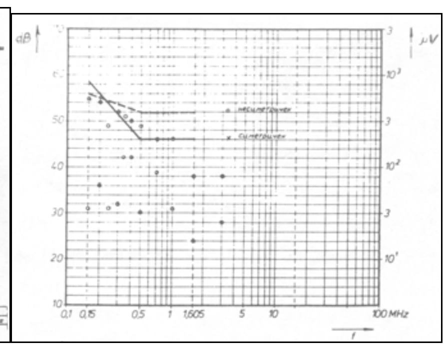


Figure 4

## Table

General data from the measurements of the line terminals of the TV sets "Sofia" in terms experimental devices and experimental series and regular production of TV sets

| Frequency MHz | Name of the TV set "Sofia" family<br>Disturbing voltages of the line terminals | | | | | |
|---|---|---|---|---|---|---|
| | "Sofia 21"<br>"Sofia 31" | "Sofia 81"<br>"Sofia 82" | "Sofia 83" | "Sofia 84" | "Sofia 85"<br>"Sofia 86" | "Sofia 87"<br>"Sofia 88" |
| 0,15 | 52÷54 | 55 | 43÷52 | 40÷55 | 31÷54 | 31÷43 |
| 0,2 | 42÷46 | 52÷54 | 36÷49 | 38÷54 | 50 | |
| 0,25 | | | 38÷47 | 30÷49 | 36÷46 | 31÷44 |
| 0,3 | 32÷37 | | | 52÷54 | 52 | 44 |
| 0,35 | | 48÷51 | 44 | 42 | | |
| 0,4 | | | | 50 | 50 | 42 |
| 0,5 | 31÷40 | 46÷49 | 36÷42 | 36÷44 | 30÷44 | 31÷42 |
| 0,7 | | 44÷46 | 39÷40 | 41 | | |
| 1 | 31÷48 | 40÷46 | 31÷39 | 39÷40 | 38÷42 | 39÷40 |
| 1,5 | | 40÷46 | 26÷36 | 36÷38 | 36 | 39÷40 |
| 1,6 | 24÷26 | | | | 38 | |
| 1,8 | | | 30 | | | |
| 3 | | | 30÷38 | | | |

## Conclusion

1. We composed and experimentally checked the equations (1), (2), (3), (4), (5), (6), (7) and (8) that let us focus with satisfied accuracy to eliminate the most dangerous nonsymmetrical disturbances.
2. The nonsymmetrical disturbances are decreased by correct engineering solutions.
3. The serious methods of limiting of the nonsymmetrical disturbances guarantee that the level of the symmetrical ones is lower.
4. An equivalent scheme is given. We can make the conclusions for the symmetrical noise sources generated from the SMPS in the power supply line.
5. The levels of the disturbances are controlled on the different terms of the life of the TV sets "Sofia": experimental devices and experimental series and regular production of TV sets. This guarantees the reliability of the given results and the effective integration according to the standard MHP (Multimedia Home Platform).
6. Figure 3 shows the possibilities for controlling the internal electromagnetic compatibility.

## References


1. Dimitar Dimitrov, Research and development of methods and means of optimizing when constructing line power supplies for TV receivers, Technical University – Sofia 1995.
2. Dimitar Dimitrov, TV and Video techniques, Ruse University 2000.
3. Rumen Arnaudov, Rumen Dinov, Measurements in communications, Technical University – Sofia 2004.
4. Tsenka Vasileva, Stefan Popov, methods for valuation of the technical condition of radio and TV equipment and systems and the carried and radiated from them signals, BTC – Sofia 1994.
5. Wüstehube J., n.a. Soltnetzteibe, VDE – Verlag, Berlin, 1982.