Main Schematic Blocks of Image Intensifier Power Supply Used for Generation 2 Plus Image Intensifier Tubes

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Main schematic blocks of image intensifier power supply used for gen. 2 plus image intensifier tubes: *The paper is dedicated to image intensifiers used with generation 2 plus image intensifier tubes. Proposed solution offer automatic screen brightness regulation, protection of screen burning, regulation of the micro channel plate, screen and photo-cathode voltages. The circuit uses two 1.5V batteries but it can be adapted to work with single one of that type. The final product is small and can be integrated in different devices.*

Key words: *image intensifier, power supply, image intensifier tube, night vision devices, night vision.*

INTRODUCTION

The image intensifiers have a large range of applications now a day. They are commonly used in the night vision devices. There are two main technologies used for night vision, the one is the infrared technology, and the other image intensifier. In fact from several years there are devices which use both technologies, creating an image based on a signal received from the infrared device and the one from the image intensifier. With a device of that type it's possible to observe a scene in really hard conditions.

In the article we will focus on the image intensifier in the night vision technology, although they are commonly used in many other applications in aeronautics, automotive industry, physics devices, aircrafts etc.

How does the image intensifier work? As we can see in fig. 1 the main components of the image intensifier tube are the photocathode, the microchannel plate and the screen. The light, the photons are converted in electrons form the photocathode and from there they passe through the microchannel plate were they are multiplied up to 10 000 times and then they reach the screen to form the image. At the first glance this is a simple process but in fact it is much more complex. To complete the process without damaging any of the components, it must be strictly monitored. To observe a scene with lower intensity, the tube needs bigger multiplication of the electrons by the microchannel plate and opposite in scenes with high intensity, low amplification is required. Malfunction on the power supply may cause critical damage to the tube.

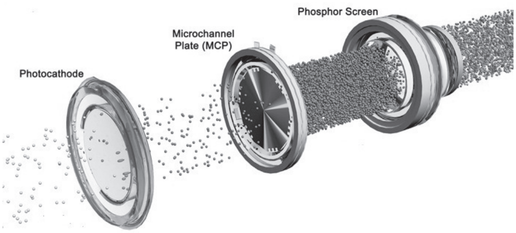

Fig. 1 Image intensifier main components

POWER SUPPLY REQUIREMENTS, PHOSPHOR SCREEN COATINGS AND SOLUTIONS

1. Power supply requirements

To complete the cycle of its operation, there are required a voltages of different polarity. For the extraction of already converted electrons form the surface of the photocathode, it is necessary to apply a voltage of about up to 220 volts, negative to the ground signal. After the separation of the electrons form the photocathode they are accelerated by the electric field at the microchannel plate, where for the acceleration up to 850 volts are needed, negative to the ground signal. To complete the process there are needed also up to 5500 volts on screen, this is the higher voltage needed for proper operation, thus the electrons are directed to create a projection of the observed scene. Because of a complicated process occurring in the tube, it is not possible to define precise values of applied voltages to micro channel plate, photo cathode and the screen. This requires presetting the power supply for each individual tube before final integration into device. To obtain better parameters of the tube, the power supply must offer regulation of a voltage in range of 600-900 volts for micro channel plate, 4500-5500 volts for the screen. Each tube is accompanied with a passport from the manufacturer showing the values that should be achieved in the initial setup. Once the values are achieved, they are monitored and controlled by the power supply, to prevent a screen from burning or a malfunction of the unit. If the scene with high intensity is observed the screen can get burned. In observing that kinds of scene photons with higher energy are deposed in the photo cathode, these photons separate a big number of electrons form the photo cathode which are multiplied by micro channel plate. As a result an enormous number of electrons are directed to the screen and the phosphor get burned. This scenario can be avoided if the voltage of the microchannel plate is damp in time. In fact, that kind of protection is mandatory, so the power unit must provide a setting threshold at which to trigger this screen protection.

One more function of the power supply is very important, automatic screen brightness control. The device must keep the luminosity of the screen constant in wide range of light fluctuation. This is needed to prevent operator of the device form dazzle, in case of immediate change of the intensity of the observed scene. Fields of application of this type of equipment require a small and versatile power supply.

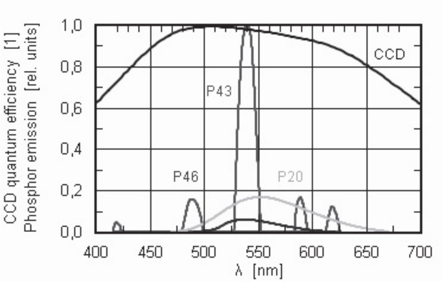

Fig. 2 Efficiency of different phosphor screens

2. **Phosphor screen coatings**

The screen represents a phosphor coating, most commonly used screens are cathode ray tube displays which are used in the early TV's. Phosphors for these cathode ray tubes were standardized and designated by the letter "P" followed by a number. The phosphor screen of image intensifiers converts the electron avalanche from the microchannel plate back into photons. Typical conversion factors of the used phosphor screens are between 20 and 200 photons per electron [1], depending on the phosphor type and the kinetic energy of the electrons, i.e. the acceleration voltage. The different

Fig. 3 Phosphor P22, green image.

Fig. 4 Phosphor P43, yellow image

Fig. 5 Phosphor P45, black and light image

phosphor coatings result in different spectrum emitted (fig.2). Using different phosphor coatings reflects to the image displayed, for example fig.3 to fig. 5 [2].

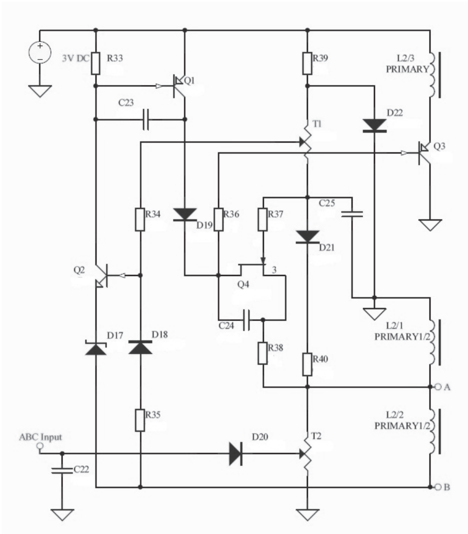

Fig. 6 Signal generator circuit

Comparing the three figures above, we can easily see the difference in the image produced at the same conditions with different devices. But it's important to note that the difference is not only in the colour of the image. The different coatings require various voltages and mode of operations of the power supply.

3. **Proposed power supply as a solution.**

There is a solution that I have proposed in my previous article [3], where we presented the main module of the power supply, the generator in fig. 6. We will discuss briefly the circuit because the purpose of this article is the comparison between two different solutions for a voltage multiplier.

On the left on fig. 6 is situated the ABC input. ABC is an acronym of the Automatic Brightness Control, which was mentioned earlier. It seeks to regulate the voltage at the midpoint of the primary winding of the pulse transformer. It will decrease or increase the amplitude of the voltage in that point when the photocathode current changes. At the same time the trimmer T2 provides an initial setup of the threshold for that function. The form of the wave is sinusoidal and the frequency is 12 kHz with ambition to obtain a higher value. Higher frequency will offer a faster automatic brightness control and screen protection and something more, it will offer better dynamics of the image.

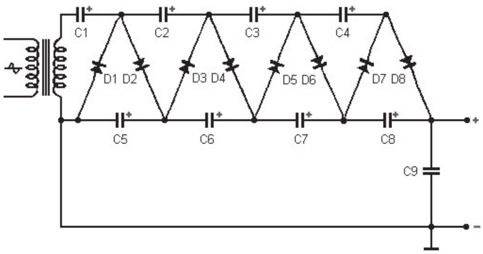

Fig. 7 Capacitors in series connection.

There are two different ways to work out the higher voltage needed for the screen, the first of them is to use a voltage multiplier with capacitance in series connection as shown on fig. 7. The first diodes D1 and D2 form the multiplier of Schenkel and with the load capacitance C5 double the input voltage, diodes D3 and D4 with C2 make the second doubling and so on.

To achieve such a high voltage, we use fourteen steps voltage multiplier. At the secondary winding we have about 400 voltages and we need to reach up to 5500 volts. In fact we don't have a big stock of voltage, but when the circuit is flooded with a high dielectric it looks different. It's important to note that the value of the capacitors must be carefully selected. Smaller capacitance leads to higher losses in the multiplier. But the limited mounting space for the circuit in the device does not allow choosing a bigger capacitance to insure that the losses will be small. In practice the image intensifier power supply is mounted directly on the tube to save space what makes the device conventional but this mounting limits the space available for the circuit.

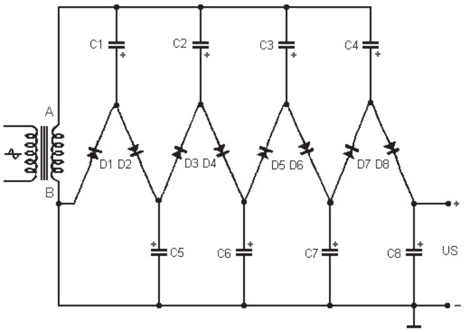

Fig. 8 Capacitors in parallel connection diagram

If we look carefully the schematics we can see that the voltage applied over each capacitance is 2.82 x Uef, where Uef is the effective value of the secondary winding voltage. That's true except for C1 where the applied voltage is 1.41 Uef and C9 which must support the highest value of the multiplier. The case with the diodes is similar; to each one of them is applied voltage about 2.82 x Uef. If we observe D8 which seems to support higher voltage than D1, we can see that because of the existence of C4 the anode of D8 stays positive at the negative part of the alternative voltage, so the difference in the potentials of the cathode and anode stays 2.82 x Uef.The second way to achieve the necessary high voltage is to use capacitors connected in parallel as shown on fig. 8

The proposed solution offers suitable results, and the voltage can be reached with smaller value of the capacitors. With this schematics with capacitors' values of order of 100 pF, the voltage of 5500 volts can be reached. With that type of circuit we needed a sixteen step voltage multiplier, but what is important here is to note that the voltage applied on capacitors is different for each one. For the first capacitor C1 it's 1.41 x Uef, for the second 2.82 x Uef, for third 4.23 x Uef and so on, each following capacitor must be able to work on a selected voltage. The case with the diodes here is the same as for the precedent circuit, they support voltage equal to 1.41 x Uef. Something more, for the diodes in the two circuits we have to use diodes with small recovery time or ultra-fast diodes, to insure that the losses are reduced to their minimum. Appropriate value for the recovery time is 75 ns. In the two cases the circuit can provide very low current. The purpose of the two circuits is to attain high voltage values but with a small current. If the current sourced by the circuit passes a couple of tens of nano Amperes, the voltage will fall down.

4. CONCLUSION

The presented circuit is a fully functional solution for an image intensifier power supply. There are two different ways to reach the high voltage needed for the screen, for the first of them the capacitors have higher value as a capacitance but they support lower voltage what is just the opposite in the second circuit, smaller capacitance - higher voltage to support. To decide which circuit is more convenient for our application, a cost effectiveness should be considered. The price of the capacitors varies according to their parameters, e.g. for the same values the capacitors used for the two schematics those for the second circuit are much more expensive. To find capacitors that support 6 kV in size of 1206 SMD size, it's mandatory to use X7R dielectric. Big difference in the first case capacitors needed must support not more than 1 kV and even if they have higher capacitance, they are much cheaper. In terms of the cost effectiveness of the product the price of the capacitors may be decisive.

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Докладът е рецензиран.