

CONVERTER CIRCUIT FOR AN ELECTRONIC FLASH DEVICE

FIELD OF THE INVENTION

5 The present invention relates generally to the field of electronic flash devices typically used in cameras, and in particular, to a converter circuit particularly adapted to be used in an electronic flash device.

BACKGROUND OF THE INVENTION

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Flash devices are used in cameras to create a bright "flash" of lights when taking a picture under conditions of insufficient lighting. To generate an intense pulse of light sufficient to create an ideal environment for picture taking, special flash tubes which are capable of generating such intense light are used.

15 Such flash tubes contain gas inside an enclosed glass envelope which must first be ionized before the flash tube can flash. To ionize the gas, a voltage of sufficient level must first be delivered to the surface of the glass envelope. Once the gas is adequately ionized, a capacitor discharge is induced through the flash tube to cause a release of a brilliant "flash".

20 The trigger voltage required to cause ionization of the gas inside the flash tube is typically around 4 KV. The voltage required to drive the discharge through the flash tube is typically around 300 to 400 Volts. Both of these voltage levels are much higher than what a typical portable DC voltage source, e.g., battery, can deliver. Therefore, proper circuits are needed to convert the
25 battery voltage to those levels which are needed to operate the flash device.

A flash device typically requires four main components which are a flash unit, converter circuit, quench circuit, and a trigger circuit. In general, flash unit

comprises a flash tube and a flash capacitor. The converter circuit converts a relatively small DC voltage, e.g., 1.5 to 6 Volts, to a higher oscillating voltage of about 300 to 400 Volts (called converter voltage) for charging the flash capacitor in the flash unit. The trigger circuit transforms the converter voltage
5 from the converter circuit to a much higher trigger voltage, e.g., 4 KV. The quench circuit discharges the flash capacitor when a appropriate amount of light has been released by the flash tube.

The configuration of a converter circuit used in flash devices can come in many forms depending on a number of factors such as cost, performance
10 requirements, etc. However, the general function of the circuit remains essentially the same which is to convert a small DC voltage to a large oscillating voltage which, after a number of cycles, fully charges up the flash capacitor. Because cost is always an issue, it is always desirable to be able to have a circuit perform this function using the fewest and least expensive components
15 as possible without compromising performance.

One component which contributes significantly to cost is the transistor. In general, a PNP transistor costs more than a comparable NPN transistor. Therefore, while from cost perspective it is less costly to use an NPN transistor over a PNP transistor, this is not always easy to achieve. One reason for the
20 difficulty is that the structure of the NPN transistor does not allow it in forward converter to be employed while still allowing the flash capacitor's minus side to be connected to a battery negative ground. Therefore, in some prior art converter circuits employing the NPN transistor, the flash capacitor's plus side has to be connected to the battery negative ground. However, because
25 connecting the flash capacitor to the battery negative ground allows greater control of the flash tube during flashing, such a configuration is highly desirable. To achieve this configuration, some prior art coverter circuits use a transformer

with a special winding. This special winding, however, contributes to additional cost. Hence, it can be seen that there is a need for a converter circuit which can utilize an NPN transistor while still allowing the flash energy to be controlled during flashing with thyristor or Insulated Gate Bipolar Transistor (IGBT).

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SUMMARY OF THE INVENTION

It is therefore an object of the present invention to provide a converter circuit which utilizes an NPN transistor without compromising the overall
10 performance of the circuit.

In one embodiment, the converter circuit for a flash device for converting a voltage from a voltage source into a converter voltage comprises a transformer having a primary coil and a secondary coil, a first end of the secondary coil connected to a first end of the primary coil, a second end of the
15 secondary coil providing the converter voltage to a flash capacitor; and an NPN transistor having a collector, emitter, and a base, the collector connected to the second end of the primary coil, the emitter connected to a negative voltage of the voltage source, the base connected to the flash capacitor and a second capacitor, the second capacitor connected to a positive voltage of the voltage
20 source. In another embodiment, the converter circuit further comprises a rectifier diode connected the second end of the secondary coil of the transformer. In yet another embodiment, the converter circuit further comprises a third capacitor connected between the base of the transistor and the positive voltage of the voltage source.

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BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 illustrates a schematic diagram of the present converter circuit which is incorporated into an electronic flash device.

Figure 2 illustrates a schematic diagram of the present converter circuit which is incorporated into an electronic flash device utilizing an IGBT.

DETAILED DESCRIPTION OF THE INVENTION

The present invention is a converter circuit which is particularly adapted for use in an electronic flash device. To fully illustrate the present invention, Figure 1 illustrates a schematic diagram of a flash device incorporating the present converter circuit. In general, the flash device 201 can be broken down to the following elements: the flash unit 209, converter circuit 205, quench circuit 211, and trigger circuit 207.

In general, flash unit 209 comprises a flash tube 214 and a flash capacitor 216. The converter circuit 205 converts a relatively small DC voltage, e.g., 1.5 to 3 Volts, to a higher oscillating voltage of about 300 to 400 Volts (called converter voltage) for charging the flash capacitor in the flash unit. The trigger circuit 207 transforms the converter voltage from the converter circuit 205 to a much higher trigger voltage, e.g., 4 KV. The quench circuit 211 releases the charge in the flash capacitor when sufficient light has been produced by the flash tube. The general function of these elements as described herein is generally well known to those skilled in the art.

Now to describe the components in greater detail, the flash unit 209 comprises a flash tube 214 which is connected in parallel with the a capacitor 216 and an inductor 218. The flash capacitor 216 which stores the energy is

charged to the converter voltage which is then used to drive a discharge through the flash tube 214 which causes the bright "flash" to occur.

The converter circuit 205 comprises a transformer 220 having a primary coil 222 and a secondary coil 228. The first end 224 of the primary coil 222 is connected to the positive terminal of a DC voltage source 250, and the second end 224 of the primary coil 222 is connected to the collector 236 of the transistor 234. The first end 230 of the secondary coil 228 is connected to the first end 224 of the primary coil 222. The second end 232 of the secondary coil 228 is connected to a diode 246 which is connected to a diode 248 which is connected to the flash tube 214. The emitter 238 of the transistor 234 is connected to the negative terminal of the DC voltage source 250. The base 237 of the transistor 234 is connected to a switch 240 which is connected to a capacitor 242. The capacitor 242 is connected in parallel to a resistor 244 which is connected to the positive terminal of the DC voltage source 250.

The quench circuit 211 comprises an NPN transistor 300. The base 302 of the transistor 300 is connected to resistors 310 and 314. The resistor 310 is connected to a capacitor 312. The emitter 304 of the transistor 300 is connected to the capacitors 312 and 362. The collector 306 of the transistor 300 is connected to the resistor 308 which is connected to the base 342 of the PNP transistor 340. The base 302 of the transistor 300 is connected to the emitter 318 of the photo transistor 316. The collector 320 of the photo transistor 316 is connected to the collector 326 of the PNP transistor 328. The emitter 328 of the PNP transistor 322 is connected to the capacitor 336, resistor 338 and the emitter 346 of the PNP transistor 340. The base 324 of the transistor 322 is connected to a zener diode 330 and a capacitor 332. The capacitor 332 is connected to a resistor 334. The base 342 of the transistor 340 is connected to the resistors 338 and 308, and the collector 344 is

connected to resistor 348. The resistor 348 is connected to the gate 356 of the thyristor 350 and to the capacitor 362. The anode 352 of the thyristor 350 is connected to the diode 248 and the cathode 352 of the thyristor 350 is connected to the capacitor 358. The capacitor 358 is connected to the resistor 360 which, in turn, is connected to the positive terminal of the DC voltage source 250.

The trigger circuit 207 comprises a transformer 260 having a primary coil 262 and a secondary coil 268. The first end 270 of the secondary coil 268 provides a trigger wire 288 for the flash tube 214. The second end 272 of the secondary coil 268 is connected to a diode 278 which in turn is connected to a trigger switch 280. The second end 272 of the secondary coil is also connected to the second end 266 of the primary coil 262. The first end 264 of the transformer 260 is connected to the capacitors 284, 286 and resistor 282. The capacitor 284 and resistor 282 are connected to the diode 248. The second end 266 of the transformer 260 is connected to the resistor 274 which is connected in series to the neon tube 286.

When the switch 240 is closed, the base 237 of the transistor 234 goes positive which places the PNP transistor 234 to an ON state. This allows current from the voltage source 250 to reach the primary coil 222. The voltage at the primary coil 222 is transformed at the secondary coil 228. The higher positive voltage at the second end 232 of the secondary coil 228 provides a feedback to the base 237 of the transistor 234 which further opens up the transistor 234. Note that the feedback is via the inductor 218 and the charge capacitor 216. The further opening of the transistor 234 allows more current to be delivered to the primary coil 222 which in turn increases the negative current on the secondary coil 228. This feedback action continually increases the positive current through the primary coil 222 until the transformer 220 reaches saturation

and the current remains momentarily constant at the primary coil 222 when the induction goes to zero. At this point, the voltage and the current at the secondary coil 228 decreases until they reach zero. The transistor 234 is now no more fully opened because the base current is lower and so the current at
5 the primary coil 222 decreases. The decreasing current at the primary coil 222 induces a negative voltage at the second end 232 which is blocked by the rectifier diode 246. As the energy in the secondary coil 228 wears out, the voltage at the second end 232 goes to zero, and the base 237 of the transistor 234 becomes now again positive over resistor 244 and the process repeats
10 itself.

When the flash capacitor 216 of the flash unit 209 and capacitor 286 of the trigger circuit 207 become fully charged, the flash tube 90 is ready to be flashed. To indicate the "flash-ready" condition, the voltage stored in capacitor 286 allows the neon lamp 276 to light up. It should be understood that two
15 capacitors 284 and 286 are provided instead of just one in order to stabilize the neon lamp 276 such that no flickering of the neon light occurs. The second capacitor may, however, be left out without unduly affecting the function of the circuit. An additional diode 248 is provided to ensure that when the converter circuit is switched off, the charge from the flash capacitor 216 does not flow to
20 the neon lamp 276 to keep it lit. By providing the diode 248, the neon lamp 286 goes off when the converter circuit is turned off. The second diode, however, may be left out in certain circumstances such as if there is another mechanism for turning off the neon lamp 286.

A flash is initiated by closing the switch 280. This allows the capacitor
25 286 to send the energy through the transformer 260 in the form of the trigger voltage (typically around 4 KV) through the trigger wire 288 to the flash tube to cause the brilliant "flash" to occur. When the flash tube 214 flashes, the charge

in the capacitor 216 decreases and the anode voltage at flash tube 214 is reduced. This reduction in the anode voltage causes a voltage difference between the flash capacitor 216 and the capacitor 332 of the quench circuit 211. This voltage difference is found at the base 324 of the transistor 322 and
5 places the transistor 322 to an ON state. At the same time, some of the flash light is captured by the photo transistor 318 which is strategically located to be exposed to the light. The photo transistor 318 produces a current which is proportional to the light it captures. After the integration capacitor 312 has reached the base-emitter breakdown voltage of the transistor 300, the current
10 produced by the photo transistor 318 turns ON the transistor 300 which in turn turns on the transistor 340. This allows current to reach the gate 356 and open the thyristor 350 which causes the flash capacitor 216 to discharge.

The present converter circuit may be utilized in a flash device having a different configuration as that shown in Figure 1. For instance, Figure 2 illustrates
15 the present converter circuit 205 incorporated into a flash device 401 using an Insulated Gate Bipolar Transistor (IGBT) and an associated driver for the IGBT both of which are well known to those skilled in the art.

The present invention may be embodied in other specific forms without departing from the spirit or essential characteristics thereof. The presently
20 disclosed embodiments are, therefore, to be considered in all respects as illustrative and not restrictive, the scope of the invention being indicated by the appended claims and all changes which come within the meaning and range of equivalency of the claims are, therefore, to be embraced therein.

CLAIMS

I Claim:

- 1 1. A converter circuit for a flash device for converting a voltage from a
 2 voltage source into a converter voltage comprising:
 3 a transformer having a primary coil and a secondary coil, a first end of the
 4 secondary coil connected to a first end of the primary coil, a second end of the
 5 secondary coil providing the converter voltage to a flash capacitor; and
 6 an NPN transistor having a collector, emitter, and a base, the collector
 7 connected to the second end of the primary coil, the emitter connected to a
 8 negative voltage of the voltage source, the base connected to the flash
 9 capacitor and a second capacitor, the second capacitor connected to a positive
 10 voltage of the voltage source.

- 1 2. The converter circuit as recited in claim 1 further comprising a rectifier
 2 diode connected the second end of the secondary coil of the transformer.

- 1 3. The converter circuit as recited in claim 1 further comprising a third
 2 capacitor connected between the base of the transistor and the positive
 3 voltage of the voltage source.

- 1 4. The converter circuit as recited in claim 3 further comprising a resistor
 2 connected in series with the third capacitor.



1 5. The converter circuit as recited in claim 1 further comprising a resistor
2 connected between the second capacitor and the positive voltage of the
3 voltage source.

1 6. The converter circuit as recited in claim 2 further comprising a third
2 capacitor connected between the base of the transistor and the positive
3 voltage of the voltage source.

1 7. The converter circuit as recited in claim 6 further comprising a resistor
2 connected in series with the third capacitor.