ABSTRACT

The 8-pin 555 timers were exposed to 1, 2, 3, 4, up to 5 Mrads gamma doses, using Co$_{60}$ as a gamma radiation source, with a total absorbed doses 5Mrads, the output of the chip, as a square wave indicate that, the electromagnetic wave (gamma radiation) affect in the operation of the timer, as: the parameter changed during radiation noise in the generated square wave, frequency ($f$) and duty-cycle ($D$), in which the high bias (6V) with higher doses, exist a noise on the output waveform, it has been found that the effect of radiation could be handled by lowering supply voltage to 3V. this could resultant to removing noise generated due to radiation, or from the analysis in some circuits by changing the values of external resistors and capacitance, the output waveform return to initial square wave without noise, that is to say the radiation induce an energy in the chip structure.

Key Words: 555-timer, gamma doses, generated square wave, noise factor, and induced energy.

INTRODUCTION

The 8-pin 555 timer must be one of the most useful chips ever mode and it is used in many projects. With just a few external components it can be used to build many circuits, not all of them involve timing. Four samples of 555 timer tested and give an initial information, and waveform, after these samples exposed to gamma radiation, the waveform output tested and gives a change in the detection and how to hardness. The 555 Timer is an IC (chip) implementing a variety of timer and multi-vibrator applications. Depending on the manufacturer, it includes over 20 transistors, 2 diodes and 15 resistors on a silicon chip installed in an 8-pin mini dual-in-line package (DIP-8)\(^{(1)}\).

The internal construction of the timer chip affected by gamma radiation, by induced energy generated by the internal transistors and diode which, generate electron hole pairs, the generated irradiation energy affect in or by the applied bias on the timer chip. When gamma ray absorbed in silicon are required to liberate one electron –hole pair, the holes (+charges) drift toward the anode, and the electrons (-charges) drift toward the cathode under the influence of an internal electric field which is directed across the diode junction from cathode to anode\(^{(2)}\).

Five timer 555 used as a square wave (rectangular on off pulses), generator in digital circuit, the wave measured initially and after timer chip exposed to different doses of gamma radiation, from Co$^{60}$ irradiator, after 5Mrad total absorbed dose, the noisy affect on the generated wave. Exposing to ionizing radiation resulted in an observed increase in the i/f noise in several of the SiGe HBTs and Si BJTs investigation in addition to this increase, an observed for the first time radiation-induced G/R noise in several devices\(^{(3)}\).
SYSTEM ANALYSIS

The 555 timer has two basic operational modes: one shot and a stable. In the one-shot mode, the 555 acts like a monostable multi-vibrator. A monostable is said to have a single stable state—that is the off state. Whenever it is triggered by an input pulse, the monostable switches to its temporary state. It remains in that state for a period of time determined by an RC network. It then returns to its stable state. In other words, the monostable circuit generates a single pulse of fixed time duration each time it receives and input trigger pulse. Thus the name one-shot. One-shot multivibrators are used for turning some circuit or external component on or off for a specific length of time. It is also used to generate delays. When multiple one-shots are cascaded, a variety of sequential timing pulses can be generated (4).

Time period analysis:

The time period (T) of the square wave is the time for one complete cycle, but it is usually better to consider frequency (f) which is the number of cycles per second.

\[ T = 0.7 \times (R_1 + 2R_2) \times C_1 \]  

And

\[ f = \frac{1.4}{(R_1 + 2R_2) \times C_1} \]  

Where:

- \( T \) = time period in seconds (s)
- \( f \) = frequency in hertz (Hz)
- \( R_1 \) = resistance in ohms (Ω)
- \( R_2 \) = resistance in ohms (Ω)
- \( C_1 \) = capacitance in farads (F)

The time period can be split into two parts:

\[ T = T_m + T_s \]  

Mark time (output high):

\[ T_m = 0.7 \times (R_1 + R_2) \times C_1 \]  

Space time (output low):
Time period analysis with radiation effects:

After 555-timer exposed to 5Mrad gamma radiation, the generated square wave have a noisy signal from equation (2) to a voided the noisy effect in the timer, the term \((R_1+2R_2)C_1\), can be adjusted to controlled in the frequency of the generated signal of the timer. This condition can be existing by controlling in the values of resistors and capacitor.

In the mono-stable mode, the 555 timer acts as a “one-shot” pulse generator. The pulse begins when the 555 timer receives a trigger signal. The width of the pulse is determined by the time constant of an RC network, which consists of a capacitor (C) and a resistor (R). The pulse ends when the charge on the C equals 2/3 of the supply voltage. The pulse width can be lengthened or shortened to the need of the specific application by adjusting the values of R and C. The pulse width which is the time it takes to charge C to 2/3 of the supply voltage. RC circuit for an explanation of this effect[5].

The values of \(C_1\), \(R_1\), and \(R_2\) can be controlled in the frequency timer generation. The defect which exists by exposing to the ionizing radiation can be reduced by controlled capacitor and two resistor values.

Analysis of 555 timers in some circuit connections and under irradiation:

1-connection in safety lights\(^{(6)}\):

![Fig. (2) 555 timer by building the DOCTRONICS Safety Lights Project \(^{(6)}\)](image)

- Normal connection without 555 timer exposed to gamma irradiations:

The component values selected for the circuit are large; so as to generate a long output pulse. That allows you to measure the pulse duration with a stop watch. Once the one-shot is triggered, the output LED stays on until the capacitor charges to 2/3 of the supply voltage. That triggers the upper comparator and causes the internal control flip-flop to reset, turning off the pulse and discharging the capacitor. The one-shot will remain in that state until it is triggered again\(^{(6)}\).
Timing the pulse should have produced output duration of approximately 7.5 seconds. Calculating the output time interval using the formula given previously, the pulse duration to be:

\[ t = 1.1 \times 0.68 \times 10^{-6} \times 10^7 = 7.48 \text{ seconds} \]

The difference between the calculated and actual measured values. The differences probably result from inaccuracies in your timing. Further more, component tolerances may be such that the actual values are different from the marked values.

The actable circuit is an oscillator whose frequency is dependent upon the R1, R2, and C values., found that the LED flashed off and on slowly (5).

The oscillation frequency is 0.176 Hz. That gives a period of:

\[ t = 1/f = 1/0.176 = 5.66 \text{ seconds} \]

Since R1 is larger than R2, the LED will be on for a little over 5 seconds and it will stay off for only 0.5 seconds. That translates to a duty-cycle of:

\[ D = t_1/t = 5.18/5.66 = 0.915 \text{ or } 91.5\% \]

That translates to a period of 1.41 seconds. Calculating the t1 and t2 times, you see that the LED is on for 0.942 second and off for 0.467 second. That represents a duty-cycle of:

\[ D = 0.942/1.41 = 0.67 \text{ or } 67\% \]

Using an oscilloscope, the output to be a distorted rectangular wave of about 2 volts peak-to-peak. That distortion is caused by the speaker load. Removing it makes the waveform nice and square and the voltage rises to about 5 volts peak-to-peak. The capacitor waveform is a combination of the classical charge and discharge curves. The time is useful in computer, function generators, clocks, music synthesizers, games, flashing lights, printers, scanners (8).

- After 555 timer exposed to 5 Mrad gamma irradiation:

I have placed a couple 555 circuit examples below for your convenience. Play with different component values and use the formulas mentioned earlier to calculate results. Things to remember: For proper monostable operation with the 555 timer, the negative-going trigger pulse width should be kept short compared to the desired output pulse width.

Values for the external timing resistor and capacitor can either be determined from the previous formulas. However, you should stay within the ranges of resistances shown earlier to avoid the use of large value electrolytic capacitors, since they tend to be leaky. Otherwise, tantalum or miler types should be used. (For noise immunity on most timer circuits I recommend a 0.01uF (10nF) ceramic capacitor between pin 5 and ground.) In all circuit diagrams below I used the LM555CN timer IC from National, but the NE555 and others should not give you any problems (9).

Play with different indicating devices such as bells, horns, lights, relays, or whatever. Try different types of LDR’s. If for any reason you get false triggering, connect a ceramic 0.01uF (=10nF) capacitor between pin 5 (555) and ground. In all circuit diagrams used the LM555CN timer IC from National The 555 timer will work with any voltage between 3.5 and 15volt. A 9-volt battery is usually
a general choice. Keeping notes is an important aspect of the learning process, 3V can be induced in the timer structure if exposed to gamma radiation up to 5Mrad.

**2- Circuit Geiger counter using timer 555**

A simple Geiger counter using 555 timer ICs, some transistors, capacitors and resistors. generated via a capacitor-diode charge pump. When ionizing radiation hit the Geiger tube a short Circuit is powered from 5V source and the necessary high voltage is pulse is generated at the output. In that way the output events rate indicate radiation activity intensity.

![Fig. (3) Timer 555 embedded in Geiger meter](image)

The circuit contain two 555 timer, one as a square wave generator, and the another one as a pulse generator, if any timer exposed to gamma radiation as a total accumulated radiation doses, the generated square wave can be noised, controlling by the power supply as a variable voltage to overcome the generated charge in the timer. The circuit may be protected by external shield to protect the timers and the internal component from radiation. This is a case of the timer if generated DC or AC with zero frequency, conformed with the effects of expose the timer to gamma irradiation. If the timer bias changes from 6V to 3V after irradiation the timer generate a square wave by the same frequency and smaller amplitude as in measured figures follow in result and discussion. Precaution to timer existed in a high radiation field, the value of capacitor C1, R1 and R2 can be adjusted to compensate the effect of the radiation fields. If 555 timers as device exposed to gamma irradiation the generated square wave generate a noise factor within 5 Mrads, The generated square wave from 555 initially without espoused to gamma irradiation, by bias 6V.

**RESULTS AND DISCUSSIONS**

In the timer circuit connected with external capacitor and two resistors Fig. (1) connected as a charging and discharge cane be changed in values to compensate the radiation effects, and after tested to generate the square wave after irradiation and bised by 3V the shape of the wave s bias used as a parameter to compensate the effects of radiation on the 555 timer which used in a Geiger counter. The generated electron holes in the depletions of chip structure, generated a noise signal to destructive the operation of 555-chip as a square wave generator with the normal bias (6V), and by experiment we bias the chip by low voltage (3V) sow a compensation in the effect, also the square wave generated again by low bias.
The timer connected as actable to generate a square wave as in Fig. (4) A and b with applied voltage 6V, and the same waveform generated from another initial timer as in Fig. (5), Fig. (6) Indicate the generated waveform with bias 6V, after 1Mrad irradiation the amplitude of the waveform increased by carrier shifted as residual due chip fabrication.

After timer exposed to 2, 3, 4, and 5 Mrad in Fig. (7), (8) and (10) respectively, a noise in the square-wave exist, also the timer generate DC line.

With 5Mrad gamma radiation as a total absorbed dose in the chip of the timer, and after chip connected with bias 6V, the squarewave loss and the noise exist by 100%.

Lowering the chip timer bias from 6V to 3V of the sample irradiated by 5Mrad of two chips in Fig. (11), a and b the timer return to generate the squarewave signal as the initial one, but the amplitude decreased by slower value. That is to say the radiation induced internal energy inside the timer structure.

![Oscilloscope](image1)

![Waveform](image2)

**Fig. (4) Generated square wave by 3V bias illustrated by (a) Oscilloscope screen and (b) initial generated waveform from timer 555.**

![Initial generated signal by 6V timer 555](image3)

![Generated wave, 6V bias after exposed to irradiation 1Mrdas](image4)

**Fig. (5) Initial generated signal by 6V timer 555**

**Fig. (6) Generated wave, 6V bias after exposed to irradiation 1Mrdas**

280
Fig. (7) noise by 6V bias and 2 Mrad irradiation

Fig. (8) noise by 6V, 3 Mrad

Fig. (9) Noise by 6V, 4 Mrads

Fig. (10) noise by 6V, 5 Mrads

(a)                                                                                   (b)

Fig. (11) irradiated two sample (a) and (b) with 5 Mrads and lowered the bias from 6V to 3V.)
In the timer circuit connected with external capacitor and two resistors Fig. (1) connected as a charging and discharge can be changed in values to compensate the radiation effects, and after tested to generate the square wave after irradiation and bised by 3V the shape of the wave s bias used as a parameter to compensate the effects of radiation on the 555 timer which used in a Geiger counter. The generated electron holes in the depletions of chip structure, generated a noise signal to destructive the operation of 555-chip as a square wave generator with the normal bias (6V), and by experiment we bias the chip by low voltage (3V) sow a compensation in the effect, also the square wave generated again by low bias.

Using as an application circuits to use the 555 timer as a generated digital waveform Fig.(2) 555 timer by building the Safety Lights Project, and Fig.(3) Timer 555 embedded in Geiger meter. The effect of irradiation can protected in that circuit by compensates the effects by external resistor and capacitor, also by variable applied bias in the timer ship.

CONCLUSION

The radiation effect on the physical structure of the IC. 555, which constructed from many transistors and diodes, in which the gamma radiation induced trapped oxide charge to produce semi-permanent shifts in the device characteristics, and the radiation creates an extra depletion region, increase the the carries in the chip, due to that effects the timer 555 by exposed to gamma radiation up to 5Mrad, a noise generated in the frequency of the generated square wave, with normal chip bias 6V, and by changing the bias to 3V, the noise in the signal are removed, and returned to the normal operation. And by equation analysis an external resistor ratio can be used to compensate the radiation effects. Finally the gamma radiation induce an internal energy in the internal structure of timer 555, used to practical circuit as an example to shown the performance of the time if exposed to radiation field.

REFERENCES