A NOVELL METHOD OF ELECTRONIC TECHNIQUES FOR SOLVING HIGH SPEED ILLUMINATION IN HIGH SPEED MEASURING SETUPS

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Abstract − With the demand in shorter process cycles in the production, the requirements for light pulses increase. This applies in particular to build stable and high intensity pulses with good reproducibility. With the help of the freezing the picture, the moving object can be almost independent of disturbances recorded. The aim of the project was a digitally controlled lighting control with regard to design specific criteria.

On the market available flash and lighting controls were investigate the suitability of a particular application. Given the low fitness, theoretical and practical methods were used for providing a regulated current source. On this basis, a circuit design and board layout prepared. The prototype was made in preview to the use of programming. The programming took initialization routines between several microcontrollers and electronic components. After programming, practical tests were carried out and the desired properties investigated. The tests were positive and a manifold useful.

The main focus of this paper will be in finding, simulate, practical tests and the results of control circuits for current control of LEDs.

Keywords: lighting control, flash control, strobe controller

1. BASIC INFORMATION

Machine Vision is a wide area of parameters which can be affected. But also there are problem specifications, which are given and only can be optimized with other components. One parameter can be controlled is illumination.

Illumination is an inherent part in machine vision, because there is no image you can grab or analyze without it. Finding right adjustments of illumination for a device under test is not easy. Solving the measuring problem gets more difficult if the sample is in motion.

The resulting motion can be an effect from free fall, transportation mechanics (conveyer) or actuators, which generate vibrations to the system.

High precession measuring of geometrical variables is affect of these motions. To generate a snapshot, the camera-integration-time must be very low in dimensions of microseconds. The snapshot from a short moment is necessary, because the distance by time will be affect motion blur effects. A new addicting result problem of short integration-times is lower sensitivity of the camera-sensor. To get although object-information it is necessary that the light intensity must be high in a short time. Light intensity even has to be absolute constant. If the Light intensity wouldn´t be constant in all facts, the image processing algorithms will not work, because the picture of same situation isn´t equal to each other.

A sample of necessity is real time measurement in the production cycle of screws. The measurement at own is under high vibrations and parasitic vibrations. In the moment of measure the screw is on the fly. Summarized in this special measurement situation the camera is under vibration and the screw is in the air. Those are two parameters that provide a fail of a standard measurement.

2. REQUIREMENTS AT THE DEVICE

2.1. Theoretical founded control circuit

The light will be generated by LED. One method is to control voltage and another is to control current. It came to the decision of current-control, because light intensity can be different at the same voltage and different temperatures.

After the background to generate an electronic system to control, adjust and regulate the illumination in machine vision. The Requirement specifications are the following.

Table 1. List of specifications

Parameter	Specification
Channels	2
Voltage IN & Out	24V
Current pulsed	Adjustable from 0 to 10 A
Current continuous	Adjustable from 0 to 2A
Step size	1mA
Timer	0 to 1s
Step size	1µs
Delay	<20µs

To reach the specifications an elaborate electronic design must be created. The basic structure contains different integrated circuits − each for a separate job. For example there are microcontrollers, high current control circuits, USB-Controller, decoupled inputs, lots of filter circuits, but no current-measure-parts. To reach this short operation times a measuring system will be inert. There are different

ways to measure the current with voltage above a shunt resistor or a contactless hall sensor. But this method is time inefficient. It would be an addition about test times of measuring voltage, converting into voltage, calculate new and settling the parameters of DAC.

2.2. Creating a structure of components

At the beginning there were ideas of a control-structure. The ideas have a range from one microcontroller for all to one for each channel or substitute microcontrollers for CPLD or FPGA. The founded concept is based on short reaction-times, after a trigger-signal. The concept is a combination of one master microcontroller and one microcontroller for each part. The matters for microcontrollers are low prices and a lot of functions. Fig.1 shows the simplified concept.

The concept shows the problems of time dependent and time independent parts. The parts which have to be analyzed are the time dependent parts. The parts like optocoupler or switch have a minimal influence to the total time. These parts are digital parts, which only transmit a signal which can be 0 or 1. There are influences of capacities and so on, but this will be insignificant at short ways on circuit board. Switching times of these parts are in the area of some hundred nanoseconds. As example optocoupler has a delay of 15ns and rise-up-time of 30ns.
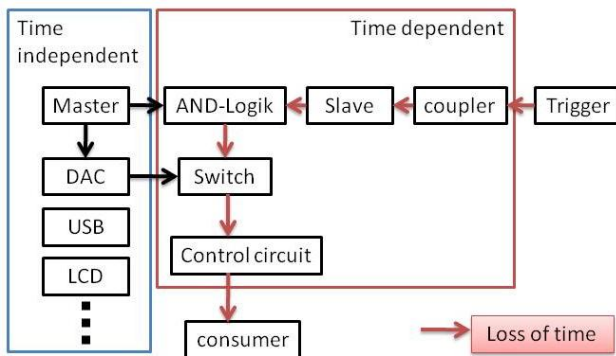

Fig.1. Simplified structure-design of global components [1]

So the main focus will be the control circuit for current control of LED. In the following chapters it is described, how the idea of control circuit is, how the results of the simulation results are and how it works in real.

3. CREATING A CURRENT-CONTROL-CIRCUIT

3.1. Theoretical founded control circuit

The control circuit with his elements is special in itself. There are hands of methods to control and adjust a current. As example there are control circuits with fixed voltage regulator, transistor in a lot of combinations like current mirror, FET, OPA and combination of FET or transistor with an OPA.

After careful consideration of requirements and circuit possibilities, at the end the decision was falling at a combination of OPA with transistor or FET. The structure is visualized in Fig. 2.
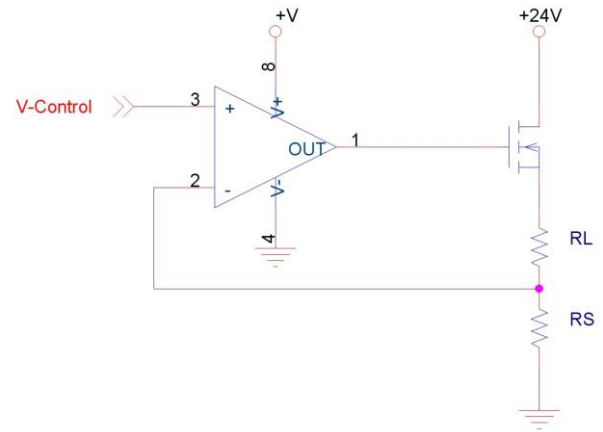

Fig. 2. Simplified current-control-design of OPA and FET [2]

In Fig. 2 the resistor named RL is the light source or consumer and RS is a resistor for sense, also named shunt. The consumer in simulation is a resistor, because the output of control-circuit has to be analyzed in its self and not the light source. The influences of light source can affect larger rise up times or larger drop-out times. Simplified the output of the circuit in Fig. 2 can be described by developing formula (1) to (2) [3].

$$R = \frac{U}{I} \qquad (1)$$

$$I = \frac{V_{Control}}{R_S} \qquad (2)$$

One of the special requests to the control circuit is that the negative consumer potential is the ground-potential. One advantage is that machine chassis can be used as common ground. In this view the circuit from Fig. 2 isn´t the solution. A founded solution is shown in Fig. 3. With a high frequency instrumental amplifier the shunt can be anywhere in control circuit and it isn´t necessary to have the same potential like the operational amplifier. The shunt can be replaced by consumer.
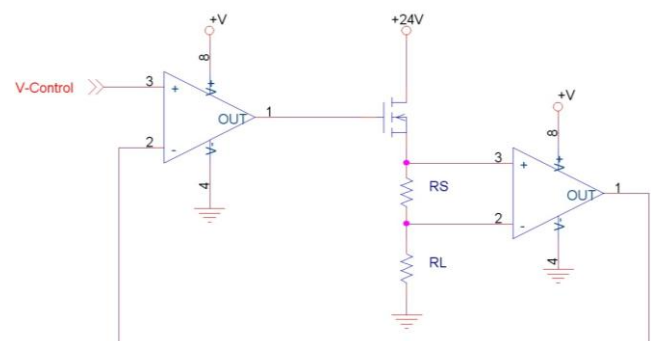

Fig.3. Control-circuit with one consumer-potential on ground

By using an instrumental amplifier like Ina114 in this case the minimal amplification is 2. So the voltage over shunt never reaches control-voltage. In formula (3) "n" is value of amplification.

$$I = \frac{1}{n} \cdot \frac{V_{Control}}{R_S} \qquad (3)$$

3.2. Simulation of standard control circuit

In Fig. 2 the Influences from environment like capacities, induction of voltage, temperature and even influence of several parts on circuit board to each other cannot be simulated. The reactions of these influences also cannot be estimated. Simulation is even important for electronic design. The influences cannot be simulated but the several electronic parts and signal processes. It is still faster and cheaper than practical tests on test boards.

In Fig. 4 the bank of simulation starts with finding the processing of the standard circuit like layout from Fig.2. The marked points to analyze in circuit are the voltages at the inputs of OPA, the Voltage over shunt and the current-output on RL.
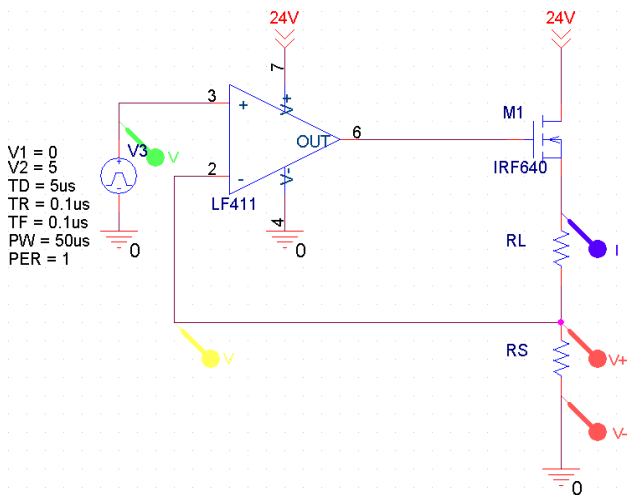
Fig.4. Control-circuit with shunt on Ground

The results of first simulation are in Fig. 5 and 6. The green curve is the input signal at OPA. The parameters are like a rectangle signal. It´s a rise up from 0V to 5V in a time of 0.1µs after a delay-time of 5us. The pulse-wide is only 50µs till drop-out to 0V. The expected curve from output-current is nearly input, because the value of shunt is 1 ohm. The yellow and violet curves are always the curve from current, shunt-voltage and negative input of OPA.

In Fig. 5 the OPA is a cheap standard OPA. The problem you can see is a slow rise-up to connect through the MOSFET an soon the current will be reached after 20µs. This is the upper limit of specification. The difference between current, shunt-voltage and negative input at OPA are nearly same.
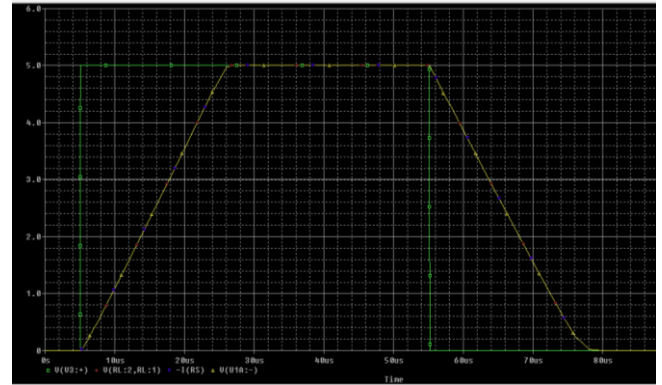
Fig.5. Graph of control-signal and current-output with OPA LM358

In Fig. 6 the OPA is a standard audio-OPA. There is no problem in rise-up to connect through the MOSFET an soon the current will be reached after 1µs. This is much faster than upper limit of specification. All curves are nearly the same.

The conclusion of this simulation is, that the standard control circuit can be very dynamic at all values of currents without any oscillation, which is very good for illumination. Even here it is obvious that no current measuring system can regulate the current and an analogue control circuit is the answer.
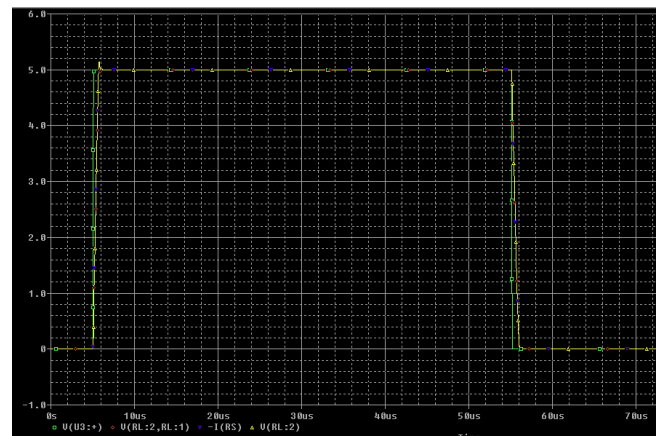
Fig.6. Graph of control-signal and current-output with OPA LF411

3.3. Simulation of control circuit with instrumental amplifier

After finding the processing of the standard circuit, in Fig. 7 the bank of simulation proceeds with finding the processing of the circuit with an instrumental amplifier. There the istrumantal amplifier INA114 was used with a frequency up to 1.5 MHz. The amplification was set to 2. The expected output-current is nearly 2.5A. The test points in circuit are even same.
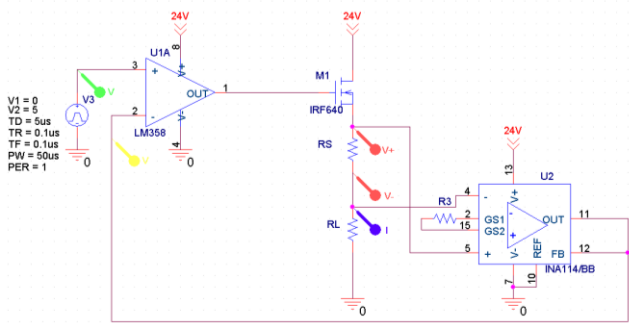
Fig.7. Control-circuit with instrumental amplifier and shunt not on ground

The results of first simulation with LM358 are in Fig. 8. The green curve is the input signal at OPA. The parameters are like a rectangle signal. The rise up of current from 0A to 2.5A is in a time of 15µs after a delay-time of 13us. The expected curve from output-current is not nearly input. Also at current there is an oscillation and fish tail of 400mA. The yellow curve is curve negative input of OPA or rather from output at instrumental amplifier.
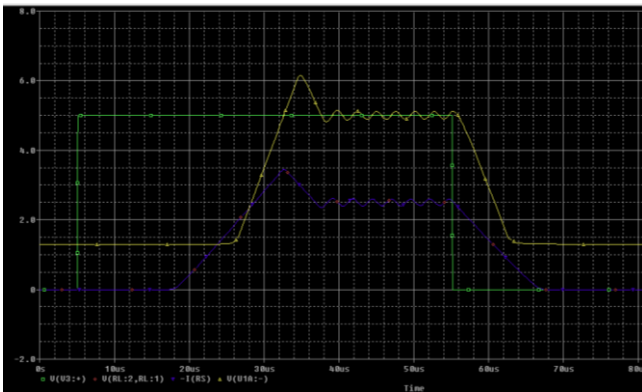
Fig.8. Graph of control-signal and current-output with OPA LM358

In Fig. 9 and 10 the OPA is the standard audio-OPA. There is no problem in rise-up to connect through the MOSFET an soon the current will be reached after 1µs. This is much faster than upper limit of specification. The audio-OPA has a frequency of 3MHz. This can be the reason for this curve. There is a fast rise-up in current, but the feedback of voltage over shunt is to slow at the negative input of OPA. The result is the long connect through of MOSFET. Especially in Fig.10. in a time of 500µs the oscillation is clear.
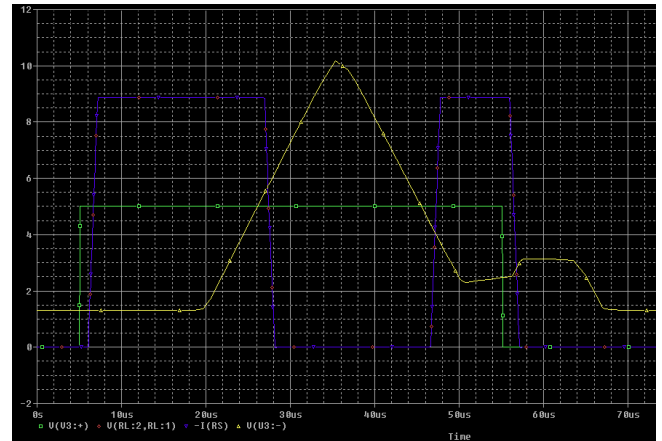

Fig.9. Graph of control-signal and current-output with OPA LF411 at one pulse of 50µs
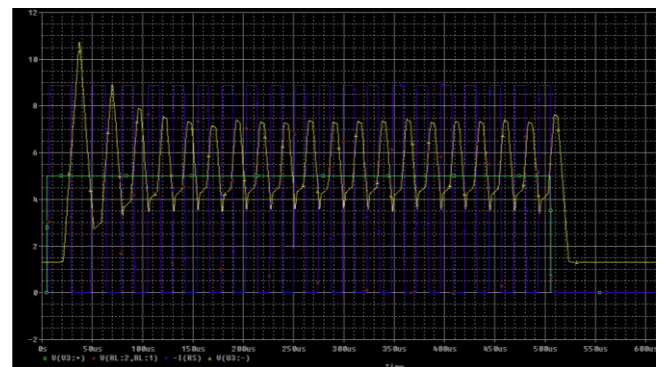

Fig.10. Graph of control-signal and current-output with OPA LF411 periodically about 500µs

The conclusion of this simulation is, that the control circuit is very dynamic at all values of currents. The crunch is in any oscillation. The oscillation with LM358 goes against 0, but there is the problem of The problem to find best configuration of operational and instrumental amplifier.

4. BUILD-UP AND PRACTICAL TESTS

Building Up was made on a double-sided circuit board, illustrated in Fig. 11. Simple failures can be detected and solved. After placing and soldering there was the part of programming. Programming was made in a development environment in programming language C.
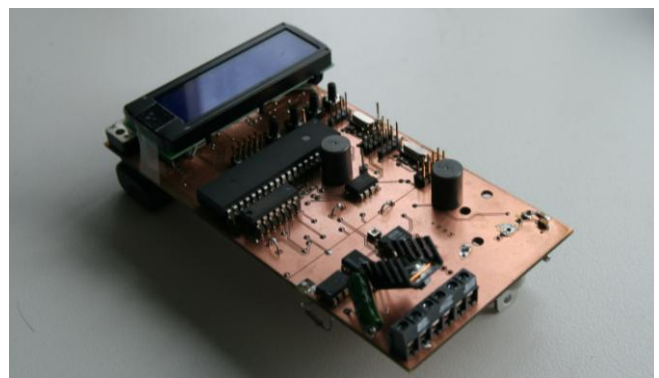

Fig.11. Simplified structure-design of global components [4]

In aspect of practical tests there were tests about aspects like reaction time, time accuracy, time resolution, current accuracy, current resolution and specially slew rate.

The setup was the control-circuit with LM358 as OPA and INA114 as instrumental amplifier. Fig.12. shows the green curve of trigger signal and the yellow curve of voltage over shunt, which value is equal to output current. There is a delay of 16µs and a rise up until 2A in 3µs. It is slower with rising current but very linear.
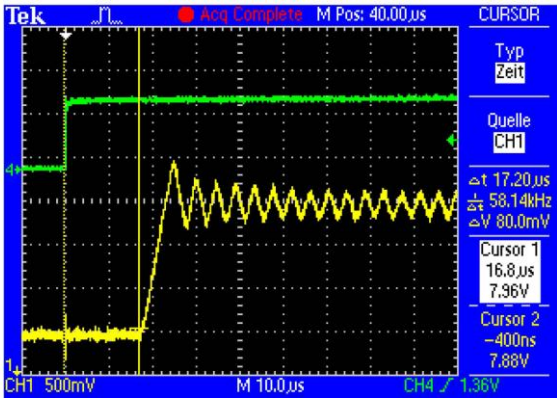

Fig.12. Delay and Rise-Up from 0A to 2A in setup

Fig.13. shows as example one of the other time dependent parts of the whole circuit. It's the processing of trigger signal (blue) and output of optocoupler (yellow). There you can see that the lost time on this part is only about 100ns. It is consequently a very small part of delay.
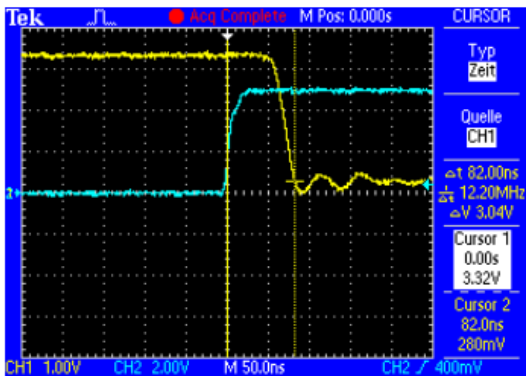

Fig.13.Delay of optocoupler after trigger signal

5. CONCLUSIONS

Actually the prototype is well operating for high speed illumination. There are high precision adjustable timer and precision adjustable currents. All this parameters are tested at laboratory and industrial test conditions.

High speed illumination can be used in machine vision systems. Because all parameters are adjustable, it can be adapted to every setup.

Simulation of control circuits was very helpful to get right configuration to the idea. There was found a current control circuit for high speed illumination in machine vision with very good specifications and properties.

6. LOOK-OUT

To get even better conditions in future there will be analyzed another idea. It is shown in Fig.14. It's the idea of a measuring bridge. The problems can be the divergences of the resistors, the sensitivity about influences from the outside. The first results of simulation with a high speed amplifier are in Fig. 15 and 16. Fig. 16. Is a detail of Fig. 15. Which shows the fish tail after rise up.
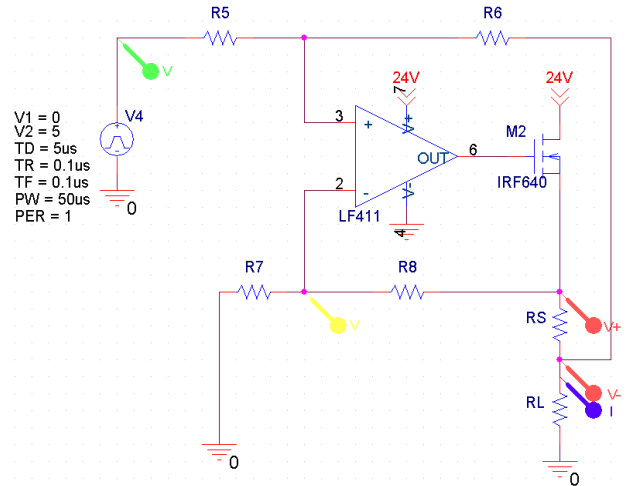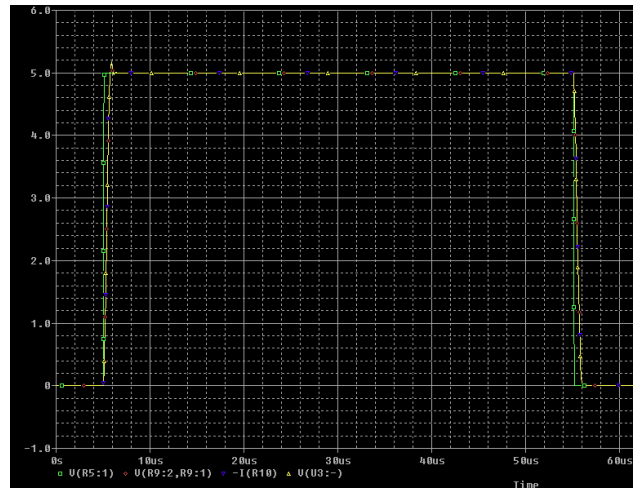

Fig.14. Another idea of circuit
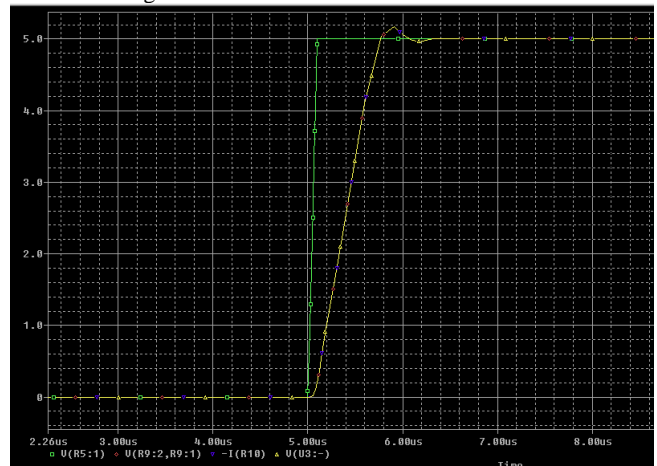

Fig.15.Simulation of another idea of circuit

Fig.16. Detail of simulation of another idea of circuit

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