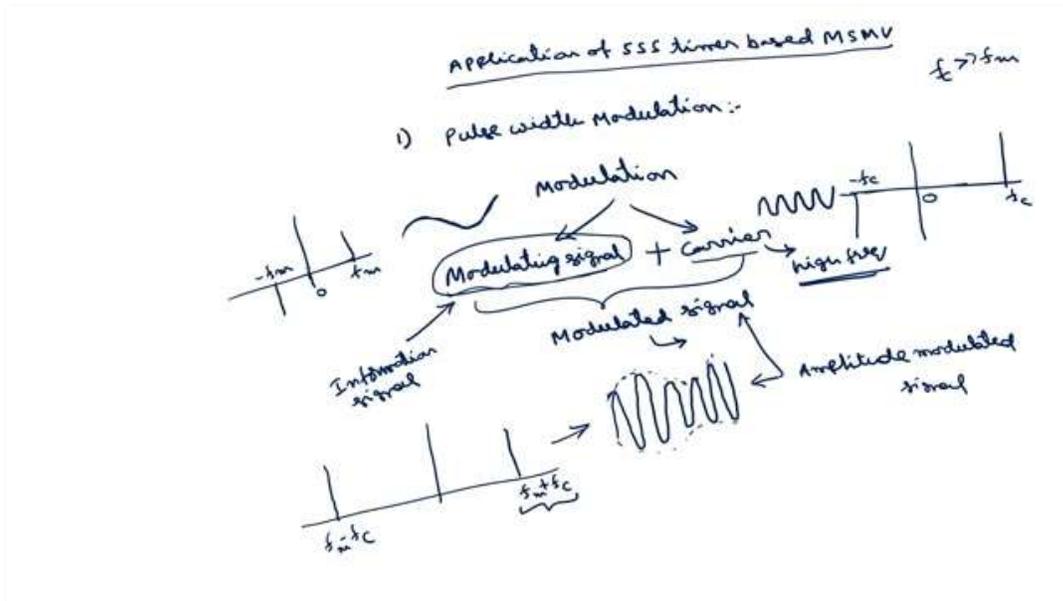


Integrated Circuits and Applications
Prof. Shaik Rafi Ahamed
Department of Electronics and Electrical Engineering
Indian Institute of Technology, Guwahati

555 Timer
Lecture - 27
Monostable applications I

Okay! In the last lecture we have discussed the monostable multivibrator implementation using 555 timer. We have derived the expression for the time interval of monostable multivibrator. There are lot of applications of this 555 timer operates in monostable multivibrator mode. Today we will discuss some of the applications of this 555 timer based monostable multivibrator. MSMV stands for monostable multivibrator is pulse width modulation. So, in communication systems this pulse width modulation plays an important role. Even in case of power electronics also, so in order to drive the power electronic circuits we will use pulse width modulation. Pulse width modulation is having a lot of applications. So, before going for the 555 timer based pulse width modulation I will explain what is pulse width modulation. So, in pulse modulation systems there will be a modulating signal and one carrier.

(Refer Slide Time: 05:52)



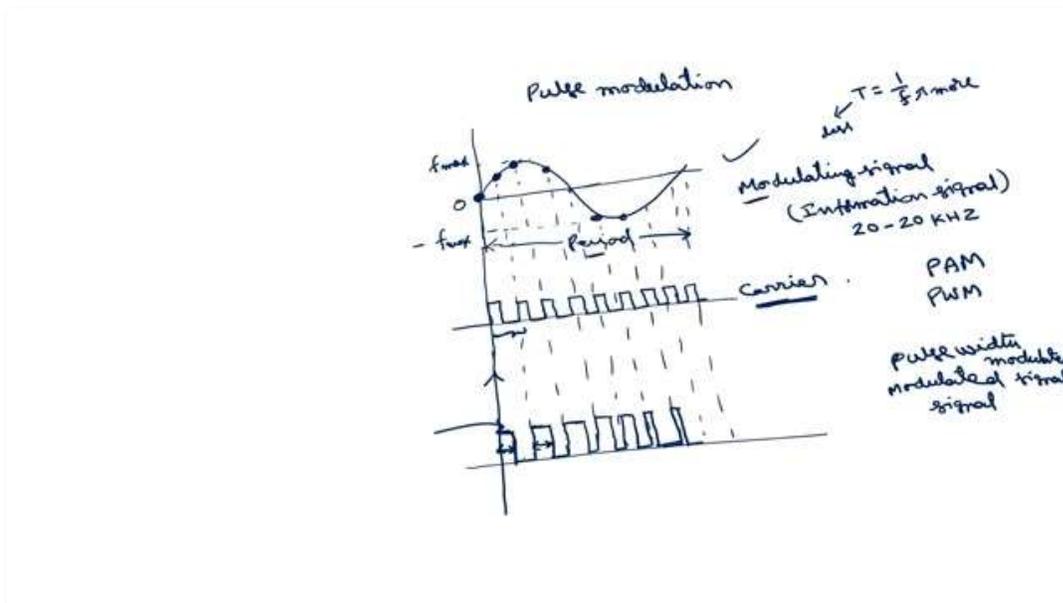
For that matter in any modulation there are two signals. One is called modulating signal, another is carrier. So, after combining this the resultant signal is called modulated signal. So, normally carrier is high frequency signal when compared with the modulating signal. So, that this can propagate over the long distances. As the name implies this carrier is going to carry the modulating signal which is nothing, but the information signal. Actual information is present in this modulating signal, but because this modulating signal is low frequency signal it cannot propagate over the long distances. So, that is why we are going to use a carrier signal

which is high frequency signal which carries the modulating or information signal. So, that after the modulation the resultant frequency becomes high and that high frequency signal can propagate over the long distances that signal is called modulated signal. This is combination of both modulating signal or information signal plus carrier.

So, in case of the continuous time modulation techniques carrier is a high frequency sine wave and this is modulating signal is low frequency signal. If you combine these two in case of amplitude modulation this type of modulated signal you will get actual information is present in this envelope. This is the actual information signal, but this is low frequency signal whereas, this carrier is high frequency. So, both combine this is called modulated signal this is amplitude modulated signal in fact. f_m is the maximum frequency. This is the frequency spectrum of modulating signal.

If carrier frequency is f_c which is much much greater than f_m , then after modulation what happens is you will get $f_m + f_c$, $f_m - f_c$ this modulated signal will be having two frequencies such as $f_m + f_c$, $f_m - f_c$. This is overall large frequency we can send this over the long distances that is the basic principle of the modulation. This is the case of continuous time modulation. In case of pulse modulation this carrier is a square wave signal.

(Refer Slide Time: 10:43)



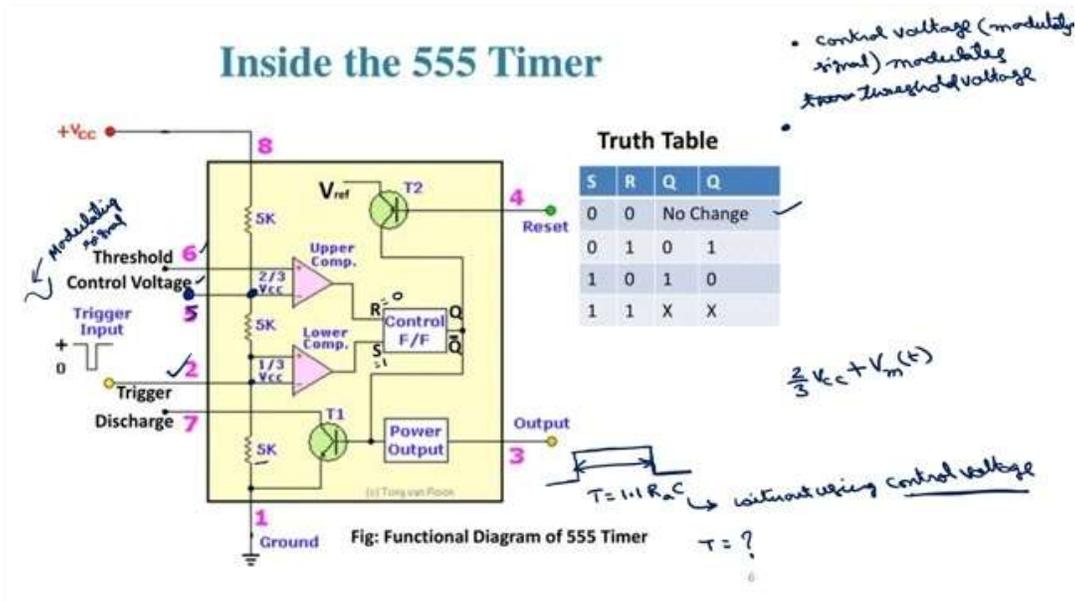
Modulating signal is this continuous time signal this is also called information signal such as audio or video signal. If it is audio signal the frequency raises 20 to 20 kiloHertz and the carrier is square wave which is of high frequency. You can see that the time period here is less than the time period of modulating signal. If this is the time period one period of this modulating signal of course, this need not be a periodic signal I am just giving the example. Then this period is much much less than the period of this one means the frequency is much much greater than because time period and frequencies are having reciprocal relation. So, time period is less means frequency is more.

Now, this is carrier signal it can be unipolar or bipolar. Now, we are going to send a modulated signal. There are many ways to obtain the modulated signal either you can change the amplitude of the carrier in accordance with the modulating signal that is called as pulse amplitude modulation PAM or you can change the width of the carrier with respect to the modulating signal which is called as PWM. Here we are interested in PWM because we can generate this PWM using a 555 timer okay. So, here if I consider pulse width modulated signal is if I consider this as 0 input this has 0 input and this is the maximum input say f_{max} and this is $-f_{max}$.

So, in the modulated signal what happens is at 0 will have some reference width say this is the width corresponding to 0 amplitude. Now, if I take different sampling periods, we are going to sample this continuous time signal according to the sampling theorem say these are the sampling instance. Now, here this magnitude is greater than 0 magnitude. So, here the width of the signal is greater than that of this signal. This signal is having smaller width now this width is more because this amplitude is greater than this.

Now, here still it is greater than this. So, here this will be again further greater than this and here this is same as the previous one this. Here this is 0 again. So, you will get this width. Here in the negative the width becomes very less. So, like that the width of this carrier signal this if I take a reference at 0 modulating signal value this is the width, then if modulating signal is having larger magnitudes then larger width, lower magnitudes lower widths like that this width of this signal will be varied. This is what is called the pulse width modulated signal.

(Refer Slide Time: 15:13)



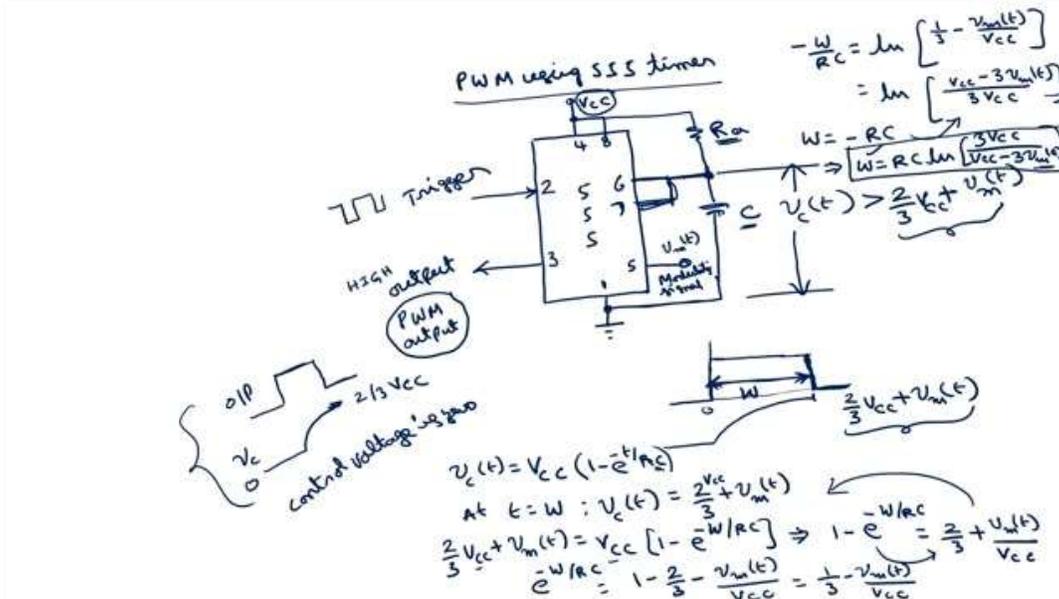
We can generate this type of pulse width modulated signal using 555 timer okay. PWM using 555 timer. So, circuit diagram this one is if I take the 555 timer as a block diagram. We know the internal circuitry of this 555 timer. These are the different pins. This is V_{CC} , this is ground, this is R_a , this is C . This is the point where trigger is applied, this is the point where output is taken. Here at this point 5 we are going to apply the modulating signal. So, that at the output

we will get PWM signal. Now, what is the operation? As I have discussed in the earlier lecture also. Here this voltage is $\frac{2}{3}V_{CC}$. If I want to change this time interval we can apply the control signal also. This pulse width this is initially in standby mode zero.

If I apply negative going trigger at the second pin it becomes positive. How long this will be positive? This will be decided by this $\frac{2}{3}V_{CC}$ and $\frac{1}{3}V_{CC}$ okay. Now, if we want to control this pulse width using the control signal what I am going to do is I am going to apply some control signal here. This is modulating signal. Here I am going to apply at this pin number 5 which is called control voltage modulating signal.

Now, what will be this resultant threshold? This becomes previously it was $\frac{2}{3}V_{CC} + V_m$ modulating signal magnitude is v_m . This is variable actually we can call this as a $v_m(t)$ also in fact. So, when does this comes to this standby mode again? So, this time period t will be decided by $1.1R_aC$ without using this control signal. Now, if I use the control voltage this relation no longer is valid. Now, what will be the expression for t ? If I apply the control voltage is if I apply the control voltage here this is going to modulate the threshold voltage which is modulating signal modulates threshold voltage. How this will modulate is the operation of this mono stable multivibrator is we have connected between this 6 and ground there is a capacitor.

(Refer Slide Time: 21:33)



If you consider this circuit also in pulse width modulated circuit between 6 and this is 6 and 7 between 6 and the ground there is a capacitor. So, initially if you apply the negative going trigger this output becomes high that is initially in standby mode 0 then this becomes high. This will be high until the capacitor charges to $\frac{2}{3}V_{CC}$ if you do not have the control signal. If the capacitor charges to $\frac{2}{3}V_{CC}$ from 0 then it will go to the low state. This is the output in case of control voltage is 0. Now, if control voltage is $v_m(t)$ because we are here we are going to apply say $v_m(t)$ which is modulating signal. Then when does it come to this 0? So, this output was

initially in standby mode low and whenever the trigger pulse voltage is slightly less than $\frac{1}{3}V_{CC}$ it will go to high state so, that the capacitor will charges. Now, whenever it charges to a value which is equal to $\frac{2}{3}V_{CC} + v_m(t)$ then only this will comes to the low state because this voltage was $\frac{2}{3}V_{CC} + v_m(t)$.

So, if the voltage at the sixth terminal where the capacitor is connected if it is slightly greater than $\frac{2}{3}V_{CC} + v_m(t)$ then non-inverting terminal will be having more voltage than the inverting terminal output becomes R is equal to 1. So, that the flip flop becomes reset. So, this Q or this output will become 0. So, in order to make this output is equal to 0 the voltage at this terminal 6 or terminal 7 both are grounded here both are shorted here this is nothing but voltage across the capacitor with respect to this ground. If this voltage is slightly greater than $\frac{2}{3}V_{CC} + v_m(t)$ then this will goes to the this one.

So, now, this pulse width will be decided by not only $\frac{2}{3}V_{CC}$, but also $v_m(t)$. If I want to derive the expression for this pulse width if I call this pulse width as W . So, we know that the voltage across the capacitor is given by $v_c(t)$ is equal to the final voltage to which it has to charge is V_{CC} . This capacitor has to finally, charges through this R_a to this V_{CC} , but whenever it charges to this the output becomes low. So, $V_{CC}[1 - e^{-\frac{t}{RC}}]$, $R_a C$ because this is $R_a, R_a C$.

But what is the condition if I start this with 0 and this is W at t is equal to W . What is the voltage across the capacitor? Because this comes to the 0 state this will be $\frac{2}{3}V_{CC} + v_m(t)$. So, if I substitute this $\frac{2}{3}V_{CC}$, $v_m(t)$ is $\frac{2}{3}V_{CC} + v_m(t)$ is equal to V_{CC} into 1 minus e to the power of this t becomes W . So, if I divide with V_{CC} implies $1 - e^{-\frac{W}{RC}}$ is equal to this V_{CC} this V_{CC} will get cancelled $\frac{2}{3} + \frac{v_m(t)}{V_{CC}}$ or what is $e^{-\frac{W}{RC}}$? If I take this to this side and this times to this side is equal to $1 - \frac{2}{3} - \frac{v_m(t)}{V_{CC}}$.

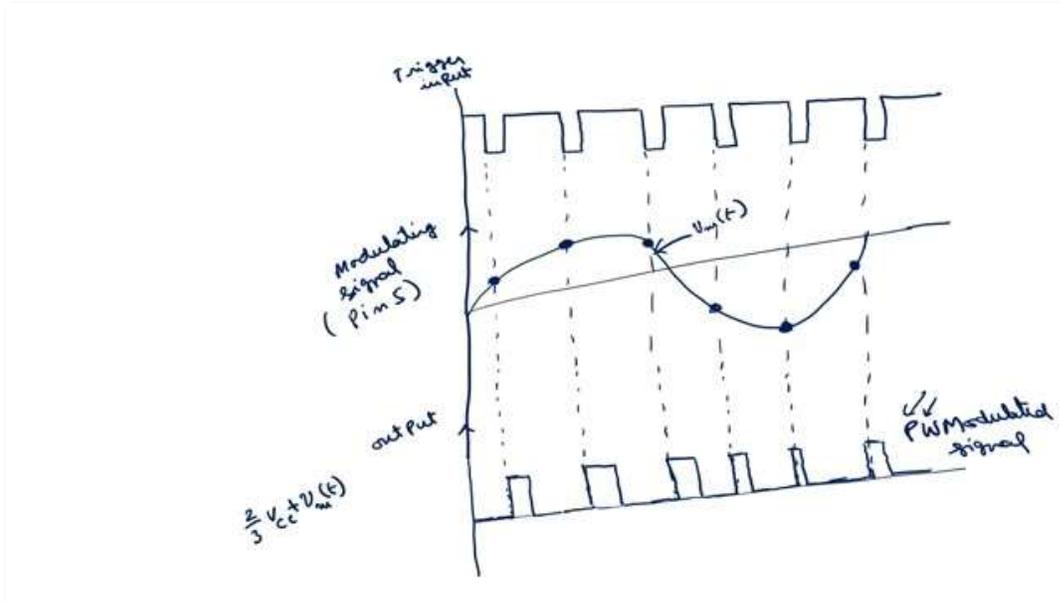
This is equal to $\frac{1}{3} - \frac{v_m(t)}{V_{CC}}$. Therefore, what is $-\frac{W}{RC}$? this is equal to $\ln \left[\frac{1}{3} - \frac{v_m(t)}{V_{CC}} \right]$. If I take LCM here, thrice $V_{CC} V_{CC} - 3v_m(t)$. W is equal to $-RC$ times this logarithm of this or if I take this minus sign inside then this will reverse. So, implies what is the expression for $W = RC \ln \left[\frac{3V_{CC}}{V_{CC} - 3v_m(t)} \right]$ that is the pulse width is going to vary with $v_m(t)$.

So, as a result of that this input output waveforms if I draw here and this is the trigger input applied at pin number 2. These are the points where the output will change negative going pulse whenever this amplitude is less than $\frac{1}{3}$ of the V_{CC} output will change. Here the modulating signal is something like this. This is modulating signal. This is applied at pin number 5 which is the control voltage pin number 5 which is nothing, but the control voltage.

Then what will be the output at pin number 3? So, initially in standby mode this was low and in the negative clock cycle is applied whose amplitude is slightly less than one-third this is V_{CC}

this will go to the high and how long this will remains high this will be decided by as I have told this is $\frac{2}{3}V_{CC} + v_m(t)$ this is your $v_m(t)$.

(Refer Slide Time: 25:28)



So, here the magnitude is somewhat lower value. So, this width is slightly lower one. Then at the second clock signal is $\frac{2}{3}V_{CC}$ plus this value. So, this is greater than this value. So, the width here will be more than this and at this point the width is slightly less than this, but greater than this. Now this value is in between this and this.

Whereas, at this point this is negative. So, width is less than this value. This is the peak negative value. So, width will be minimum and this is somewhat more than this value this will be somewhat greater than this width. This is nothing, but pulse width modulated signal this is PWM stands for pulse width. This is how we can generate this pulse width modulation using 555 timer.

This is one of the important application of this 555 timer. So, we have some more applications that we will discuss in the next lecture. Thank you.