DEVELOPMENT OF JAMMER AGAINST CENTRALIZED REMOTE CONTROL CAR DOOR LOCKING SYSTEM BASED REMOTE CONTROL IMPROVISED EXPLOSIVE DEVICES

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Project Report Submitted to Faculty Of Electrical Engineering, Military College of Signals, National University of Sciences and Technology, Rawalpindi in Partial Fulfillment For The Award Of B.E Degree In Telecommunication Engineering

JUNE 2012

ABSTRACT

DEVELOPMENT OF JAMMER AGAINST CENTRALIZED REMOTE CONTROL CAR DOOR LOCKING SYSTEM BASED ON REMOTE CONTROLLED IEDs

The security condition in Pakistan is worsening day by day. The miscreant elements come up every day with a new form of terrorism causing terror in the hearts of people and leaving them in a state of shock. One of the modern techniques is the use of radio controlled improvised explosive devices (RCIED’s).The radio controlled improvised explosive device (RCIED) is one of the deadliest threats to military personnel supporting the global war on terrorism and due to its success it is expected to play a major role as a weapon of choice in future insurgencies.

To mitigate the risk of a RCIED attack, electronic jamming devices are utilized to interrupt the communications between a remote control and the RCIED trigger. This project will help to counter the triggering of IED’s using car remote control devices.

DECLARATION

No portion of the work presented in this dissertation has been submitted in support of another award or qualification either at this institution or elsewhere.

DEDICATION

In the name of ALLAH, the Most Merciful, the Most Beneficent

TO

Our Beloved Parents and Siblings, Our Respectful Teachers and To the People of Pakistan.

ACKNOWLEDGEMENTS

We would like to take this opportunity to pay our humble gratitude to Almighty Allah, the Most Merciful who gave us the strength and determination and enlightened us with the requisite knowledge on portion of this subject to complete this project.

We are extremely thankful to our Project Supervisor Maj. Asim Rasheed who supervised the project in a very encouraging and helpful manner. Sincere and constant encouragement from him was a valuable aid in completing the project.

Lastly, we are also thankful to lab engnr. Intisar Rizwan for his helpful suggestions at different stages of the project**.**

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CHAPTER 1

CAR ALARM SYSTEMS

1.1 Introduction:

A car alarm is an electronic device installed in a vehicle in an attempt to discourage theft of the vehicle itself, its contents, or both. Car alarms work by emitting high-volume so und when the conditions necessary for triggering are met, as well as by flashing some of the vehicle's lights.

Figure 1.1 Car Alarm System

1.2 Triggering mechanism.

The simplest aftermarket alarms are one-piece units with a siren and control module. The most common type of sensor is a shock sensor and two wires 12 volt constant power and ground which are connected to the car's battery. This type of alarm is triggered by vibration transferred to the shock sensor, or by voltage changes on the input the alarm assumes that a sudden change in voltage is due to a door or trunk being opened, or the ignition being turned on; however it is very prone to false triggers on late-model vehicles with many electronic control modules, which can draw current with the ignition off.

More sophisticated aftermarket alarms are wired in to the vehicle's electronics individually. Typically, these alarms have inputs for power and ground, as well as for po sitive- and negative-switched door open circuits, negative trunk and/or hood circuits, and ignition-switched circuits to detect the ignition being turned on; aftermarket alarms also usually have a shock sensor which may be built into the control module or external to it.

In addition, some aftermarket alarms have provisions for optional sensors. The tilt sensor can sense the vehicle being tilted. Tilt sensors come in digital or mercury. The digital sensor is more accurate since it sets itself allowing for the vehicle to be to placed on a hill and not causing false triggers. The sound discriminator or glass breakage sensor senses o nly the sound of glass breaking. Typically the sound discriminator sensor can be eliminated using the shock sensor. A proximity, infrared, or motion sensors sense motion inside or outside the vehicle.

The sensors mentioned here are usually adjustable in order to avoid false alarms - for example a shock sensor will sometimes vibrate due to a loud noise in the area, or an accidental bump to the car from a passerby. Proximity sensors can cause false alarms in parking lots when a passerby is entering or exiting their vehicle parked next to the armed car. These can cause the alarm to falsely sense an attempted break-in.

Some alarms will bypass some or all of the inputs at times by design. For example, Directed Electronics alarms have a feature called "Nuisance Prevention Circuitry" which ignores any input which has triggered 3 times within 1 hour, unless the car owner turns the ignition on to reset it.

1.3 Types Of Car Alarms

1.3.1 Passive Car Alarms

A passive car alarm system is simply an alarm that doesn’t need to be manually armed when you leave your vehicle. Instead, the alarm is automatically activated when you turn off and lock your vehicle. Some of these systems have a special key equipped with a microchip, which disables the alarm when it is inserted into the car’s lock. This is usually the type of alarm system that is included in newer model vehicles. In some vehicles, a passive car alarm system will also include o ther security features (such as disabling the ignition, or locking the wheels).

1.3.2 Active Car Alarms

An “active” car alarm is a system that requires you to manually arm it when you lock or leave your vehicle. If the system is not armed, it will not activate if a car thief attempts to break in to your vehicle. These manually activated alarms do have a few advantages over passive car alarms, especially for people who want to have more control over the operation of their vehicle’s security features.

1.3.3 Factory Alarms

When someone refers to a car alarm as being a “factory” alarm, this simply means that the alarm system was installed before the car was distributed for sale. In most cases, these types of alarms are installed while the car is still being constructed. Though it's not accurate to say that all factory car alarms are inferior (especially due to advancements in car security), some people still opt to uninstall the factory car alarm, and install a custom security system. Depending on what level of security you want for your vehicle, you can always ask about customizable security options when purchasing a new vehicle

1.3.4 After-Market Alarms

After-Market alarms are security alarms that are not installed by the manufacturing company of a specific vehicle. They may either be installed by the buyer of the vehicle, or (in rare cases) by the car dealership. Some people choose to install after-market car security systems in order to have more control over the operation of their vehicle's security. Customized car alarms can range in price fro m around $75, to upwards of $2,000 for vehicles that require heavy security.

1.3.5 Silent Car Alarms

Due to some car owners complaining about the excessive noise from their car's alarm system, silent car alarms are now available. Instead of emitting an audible alarm or siren, silent ones transmit an electronic signal to a device held by the o wner of the vehicle. Though this does eliminate the sound problem, it also does no t have as many advantages as audible alarm systems. Silent alarms will not scare off potentail car thieves, and won't alert nearby bystanders that car's security is being breached. Because of this, silent car alarms are not very popular among car owners.

1.3.6 GPS Car Alarms

Advanced car alarms use GPS tracking systems to alert owners, monitoring services or the police the location of a stolen vehicle. GPS tracking helps with a speedy recovery of stolen vehicles. Car thieves often still vehicles to strip for parts and hard to find accessories. The audible alarm may alert that a vehicle is being tampered with and with the addition of a GPS car alarm system the autho rities are able to track and recover your vehicle often before there is time to strip parts or hide the vehicle.

GPS monitoring can be tracked via a computer and can alert vehicle owners via text messages or email. If a vehicle is moved a message can be sent to the owner alerting them of possible car theft. Monitoring services can track the vehicles lo cation by computer and satellite and can assist the police with tracking the vehicle and the car thieves. A professional thief may be able to bypass audible car alarms however GPS tracking can help recover a stolen car whether it was stolen as by an opportunist car thief or a professional.

1.4 Working of a Car alarm system

The fob that you carry on your keychain or use to open the garage door is actually a small radio transmitter.

When you push a button on the fob, you turn on the transmitter and it sends a code to the receiver the car. Inside the car is a radio receiver tuned to the frequency that the transmitter is using (300 or 400 MHz is typical for modern systems).

There is a small chip that creates the code that gets transmitted, and the small silver can (about the size of a split pea) is the transmitter. it works as: The transmitter's controller chip has a memory location that holds the current 40-bit code. When you push a button o n your key fob, it sends that 40-bit code along with a function code that tells the car what you want to do

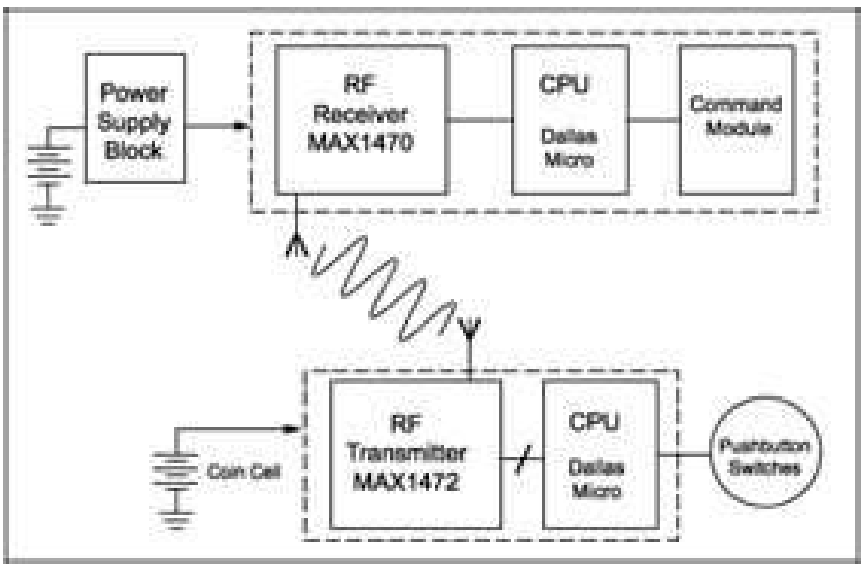


Figure 1.2 Block Diagram Of A Car Alarm System

The receiver's controller chip also has a memory location that holds the current 40-bit co de. If the receiver gets the 40-bit code it expects, then it performs the requested function. If not, it does nothing.

Both the transmitter and the receiver use the same pseudo-random number generator. When the transmitter sends a 40-bit code, it uses the pseudo-random number generator to pick a new code, which it stores in memory. On the other end, when the receiver receives a valid code, it uses the same pseudo-random number generator to pick a new one. In this way, the transmitter and the receiver are synchronized. The receiver only opens the door if it receives the code it expects.

CHAPTER 2

JAMMERS

2.1 Overview

2.1.1 Introduction

Radio jamming is the (usually deliberate) transmission of radio signals that disrupt communications by decreasing the signal to noise ratio. Unintentional jamming occurs when an operator transmits on a busy frequency without first checking whether it is in use, or without being able to hear stations using the frequency.

Figure 2.1 A Conventional Jammer

Another form of unintentional jamming occurs when equipment accidentally radiates a signal, such as a cable TV plant that accidentally emits on an aircraft emergency frequency. The concept can be used in wireless data networks to disrupt information flow. It is a common form of censorship in totalitarian co untries, in order to prevent foreign radio stations in border areas from reaching the country.

2.1.2 Jamming and interference

Originally the terms were used interchangeably but nowadays most radio users use the term "jamming" to describe the *deliberate* use of radio noise or signals in an attempt to disrupt communications whereas the term "interference" is used to describe *unintentional* forms of disruption. However the distinction is still not universally applied. For inadvertent disruptions.

2.2 Methods of Jamming

Intentional communications jamming is usually aimed at radio signals to disrupt control of a battle. A transmitter, tuned to the same frequency as the opponents' receiving equipment and with the same type of modulation, can, with enough power, override any signal at the receiver.

The most common types of this form of signal jamming are random noise, random pulse, stepped tones, warbler, random keyed modulated CW, tone, rotary, pulse, spark, recorded sounds, gulls, and sweep-through. These can be divided into two groups – obvious and subtle.

2.2.1 Obvious Jamming

Obvious jamming is easy to detect because it can be heard on the receiving equipment. It usually is some type of noise such as stepped tones, random-keyed code, pulses, music, erratically warbling tones, highly distorted speech, random noise (hiss) and recorded sounds. Various combinations of these methods may be used often accompanied by regular morse identification signal to enable individual transmitters to be identified in order to assess their effectiveness.

The purpose of this type of jamming is to block out reception of transmitted signals and to cause a nuisance to the receiving operator. One early Soviet attempt at jamming western broadcasters used the noise from the diesel generator that was powering the jamming transmitter.

2.2.2 Subtle Jamming

Subtle jamming is jamming during which no sound is heard on the receiving equipment. The radio does not receive incoming signals yet everything seems superficially normal to the operator. These are often technical attacks on modern equipment, such as "squelch capture". Thanks to the FM capture effect, frequency modulated broadcasts may be jammed, unnoticed, by a simple unmodulated carrier.

2.2.3 Electronic Jamming

Electronic jamming is a form of Electronic Warfare where jammers radiate interfering signals toward an enemy's receiver, blocking the receiver with highly concentrated energy signals. The two main technique styles are noise techniques and repeater techniques. The three types of noise jamming are spot, sweep, and barrage.

Spot jamming occurs when a jammer focuses all of its power on a single frequency. While this would severely degrade the ability to track on the jammed frequency, a frequency agile radar would hardly be affected because the jammer can only jam one frequency. While multiple jammers could possibly jam a range of frequencies, this would consume a great deal of resources to have any effect on a frequency-agile radar, and wo uld probably still be ineffective.

Sweep jamming is when a jammer's full power is shifted from one frequency to another. While this has the advantage of being able to jam multiple frequencies in quick successio n, it does not affect them all at the same time, and thus limits the effectiveness of this type of jamming. Although, depending on the error checking in the device(s) this can render a wide range of devices effectively useless.

CHAPTER 3

JAMMER DESIGN

3.1 Block Diagram

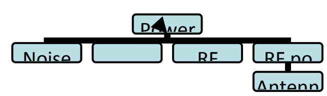


Figure 3.1 Block Diagram Of Jammer

3.2 Power Supply

Transformer: is used to transform the 220VAC to other levels of voltages.Rectification this part is to convert the AC voltage to a DC one. The Filter used to eliminate the fluctuations in the output of the full wave rectifier “eliminate the noise” so that a constant DC voltage is produced. Regulator this is used to provide a desired DC-voltage.

Figure 5 shows the general parts of the power supply.

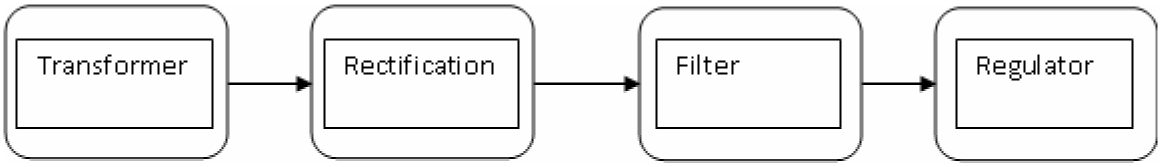


Figure 3.2 Parts Of A Power Supply

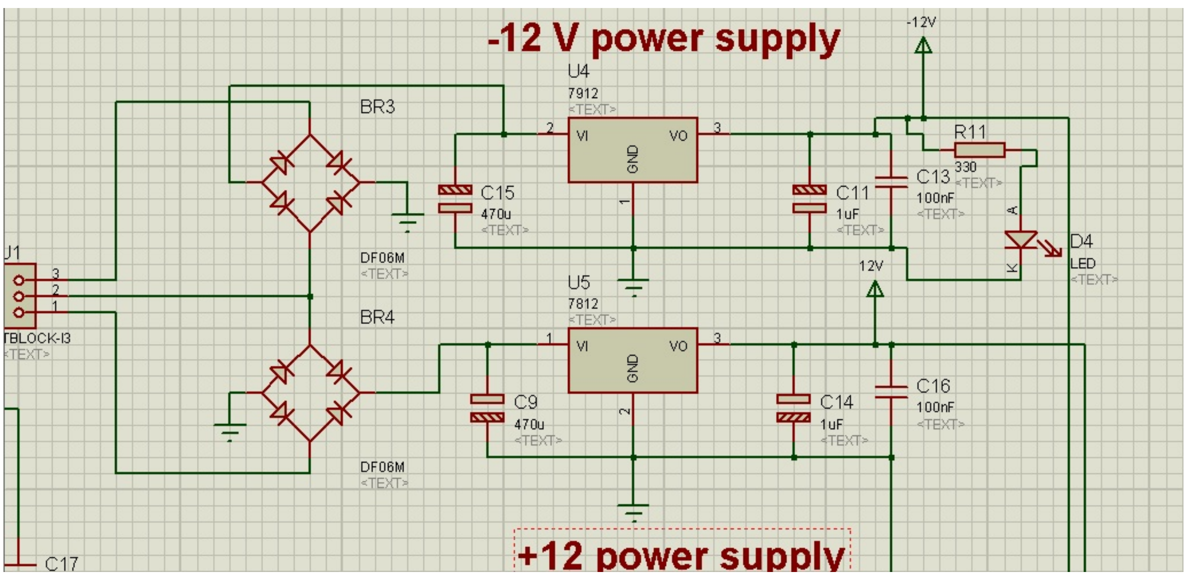


Figure 3.3 Circuit Diagram Of Power Supply

3.3 IF Section

The tuning section of the jammer sweeps the VCO through the desired range of frequencies. Basically, it is just a triangle or sawtooth-wave generator; offset at a proper amount so as to sweep the VCO from the minimum desired frequency to a maximum. The IF section consists of three main parts:

Triangle wave generator. (To tune the VCO in the RF section)

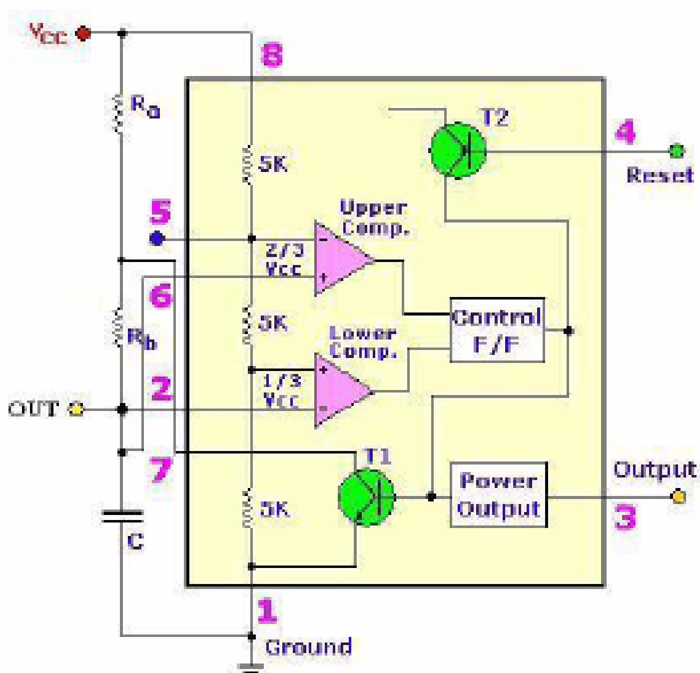
Noise generator (provides the output noise).

Mixer" summer" (to mix the triangle and the noise waves.

3.3.1. Triangle wave generator

The main use of the triangle wave is to sweep the VCO through the desired frequency range. We want to cover the UHF band through our VCO.

A 555 timer IC operating in the a-stable mode to generate the sweeping signal .



The duty cycle (D.C.) equal to 50% which means the time needed for charging equals the discharging time. This can be done by using Ra=Rb and placing a diode across Rb. The output frequency is 10 KHz.

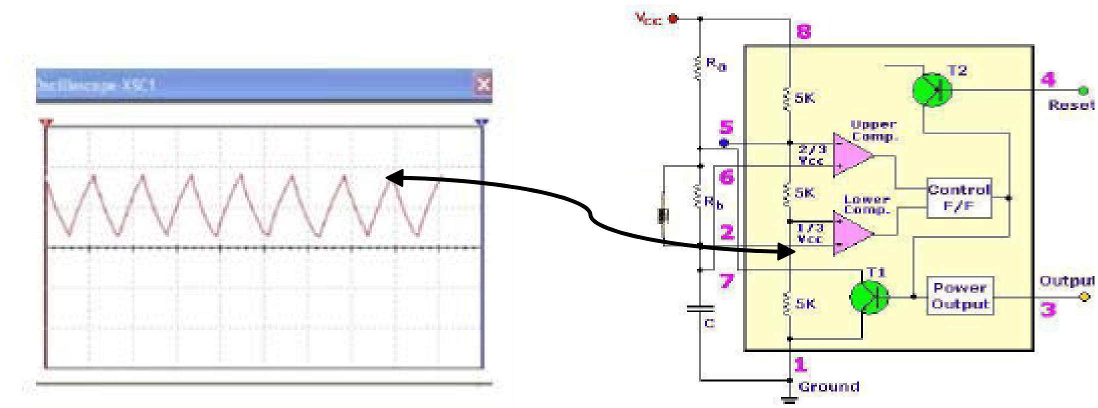


Figure 3.4 555 timer in A stable Mode

Resistor Ra=Rb=750 Ω with C=0.1 µF, then the output frequency is 10 KHz .Since we use +12 V (Vcc), the output signal will be bounded from 4 V (Vcc/3) to 8 V (2Vcc/3).

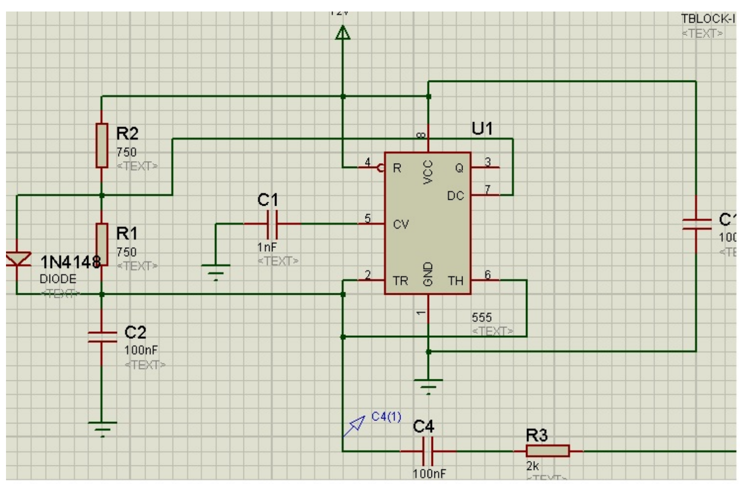


Figure 3.5 Triangular Wave Generator

The output is shown in figure 9

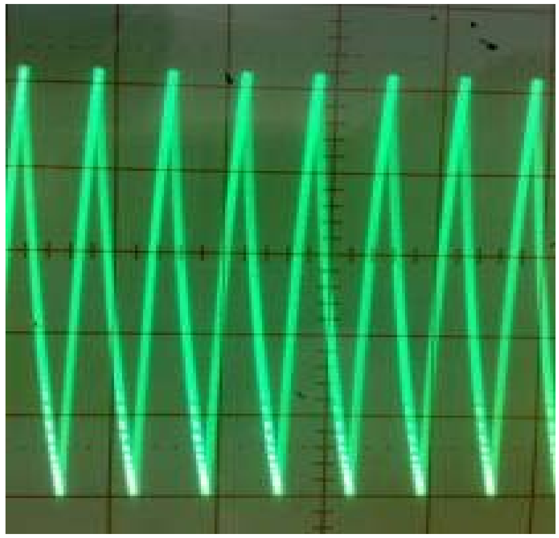


Figure 3.6 Output On Oscilloscope Of Triangular Wave Generator

3.3.2. Noise Generation

Without noise, the output of the VCO is just an un-modulated sweeping RF carrier. So, we need to mix the triangular signal with noise (FM modulating the RF carrier with noise). To generate noise signal, we used the Zener Diode o perated in reverse mode. Operating in the reverse mode causes what is called avalanche effect, which causes wide band noise. This noise is then amplified and used in our system. We use two amplification stages: in the first stage, we use NPN transistor as common emitter, and in the second stage, the LM386 IC {Audio amplifier}. This is shown in Figure 10. The output of this section is clearly seen in the figure 11.

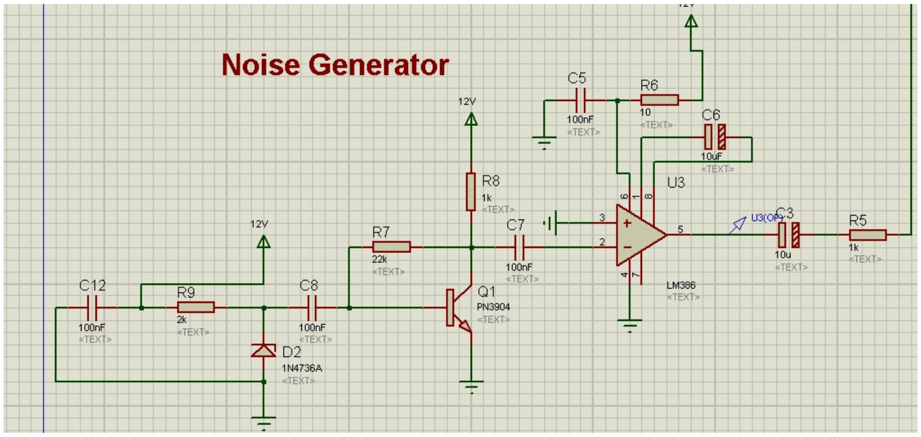


Figure 3.7 Circuit Diagram Of Noise Generator

After applying the circuit on the output on oscilloscope was shown as

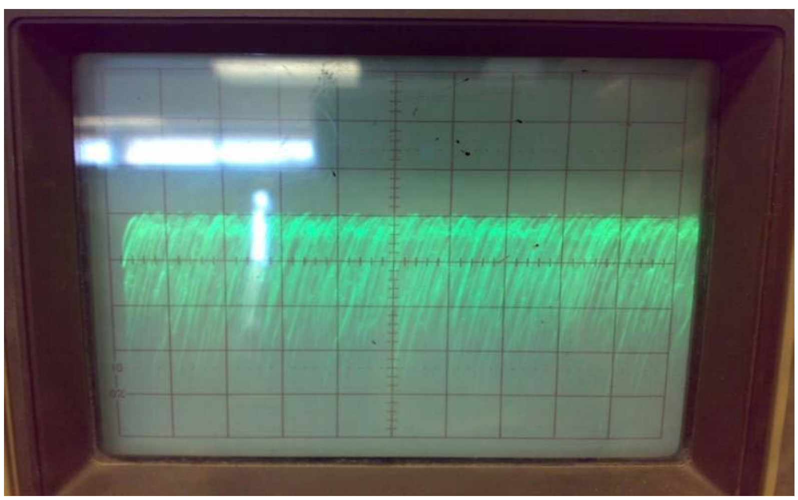


Figure 3.8 Output On Oscilloscope Of Noise Generator

3.3.3. Noise And Sweep Mixer

The mixer here is just an operational amplifier that operates as a summer. So, the noise and triangular wave will add together before entering the VCO. The LM741 IC was used to achieve this.

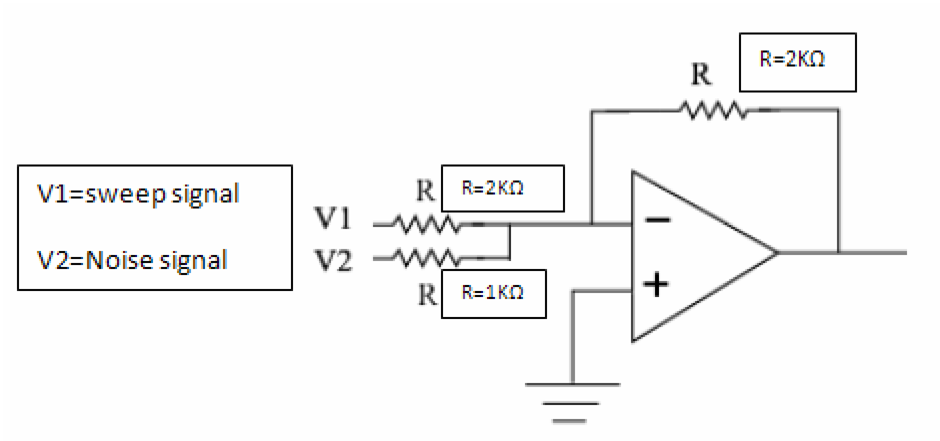


Figure 3.9 LM741 IC

Using R noise =1 KΩ, we amplify the noise signal by 2. In this case, the ratio of the noise to thesweep signal is 2:1.

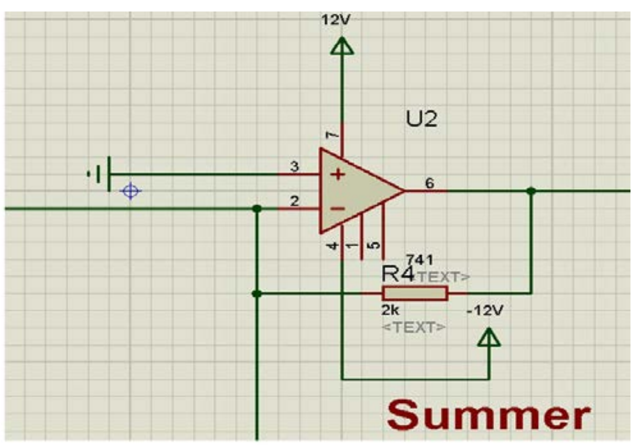


Figure 3.10 Noise And Sweep Mixer

3.3.4. Clamper

The input of the VCO must be bounded from 0 to 3.5 V to get the needed frequency range. So, a clamper is added to get the goal. The clamper consists of a capacitor connected in series with a resistor and diode, as shown in Figure 14.

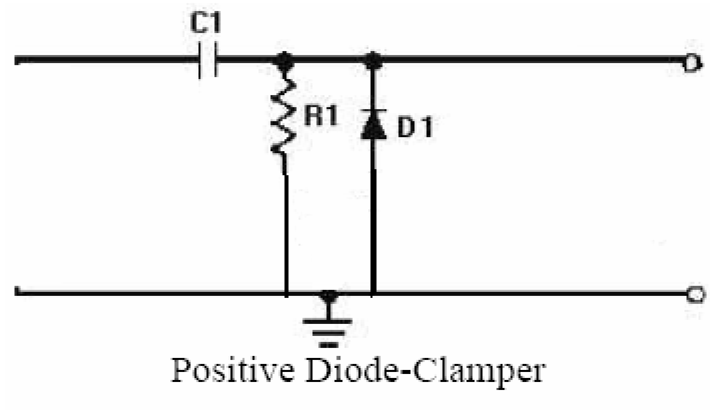


Figure 3.11 Clamper

3.4 RF SECTION

3.4.1. Introduction

This is the most important part of the jammer, since the output of this section will be interfacing with the device. The RF-section consists of three main parts: vo ltage controlled oscillator VCO, power amplifier and antenna.

3.4.2. Voltage Controlled Oscillator

The voltage controlled oscillator (VCO) is the heart of the RF-section. It is the device that generates the RF signal which will interfere with the receiver. The o utput of the VCO has a frequency which is proportional to the input voltage, thus, we can control the output frequency by changing the input voltage. When the input voltage is DC, the output is a specific frequency, while if the input is a triangular waveform, the output will span a specific frequency range. In our design, we need to find a VCO for UHF band. There are three selection criteria fo r selecting a VCO for this application. Most importantly, it should cover the bands that we need, secondly, it should be readily available at low cost, and finally, it should run at low power consumption.

3.4.3. Power Amplifier

Since the power output from the VCO is not sufficient enough for the jamming purposes therefore we need a power amplifier to amplify the output power from the VCO. We have used an IC which has a inbuilt power amplifier and thus reduces the size of our circuit. The two IC's we used in the RF section as transmitter and power amplifier are TDK 5100 and TDK 5101.

We chose these IC's as they are surface mount, which reduces the size of product. Have sufficient output power that reduces the number of amplification stages that we need. Provide same value of power supply which is typically equal to 3-5 volt. Current consumption is very low maximum upto 10 mA.

3.4.3.1. TDK 5100:

The TDK 5100 F is a single chip ASK/FSK transmitter for operation in the UHF frequency band . The IC offers a high level of integration and needs only a few external components. The device contains a fully integrated PLL synthesizer and a high efficiency power amplifier to drive a loop antenna. A special circuit design and an unique power amplifier design are used to save current consumption and therefore to save battery life. It also has additional features are a power down mode and a divided clock output.

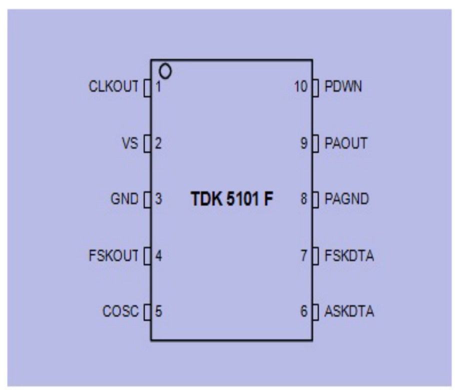


Figure 3.12 Pin Configuration of IC

3.4.4. Circuit Diagram of RF Section

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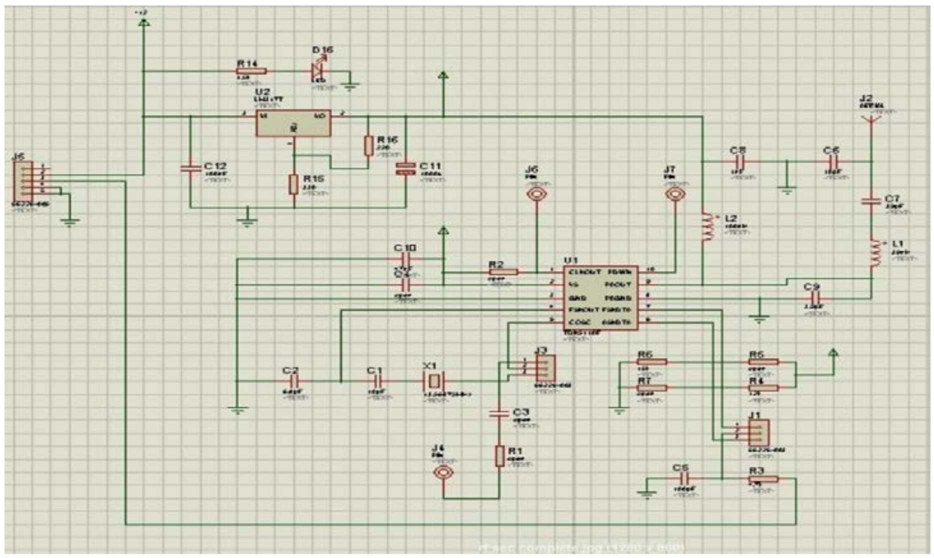

Figure 3.13Complete RF Section

3.4.5. PCB Layout of RF Section

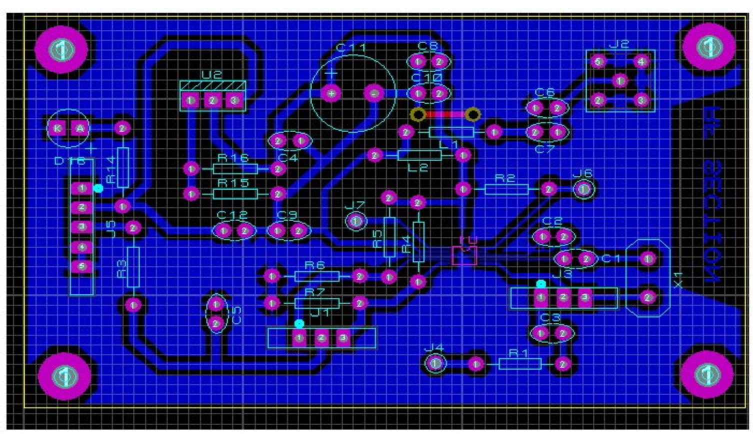

Figure 3.14 PCB lyout RF section

3.4.6 Antenna

A proper antenna is necessary to transmit the jamming signal. In order to have optimal power transfer, the antenna system must be matched to the transmission system. Two monopole antennas are used, with 50 Ω input impedance so that the antennas are matched to the system. Monopole antenna antennas are used since the radiation pattern is omni-directional.

Figure 3.15 Wideband antenna along with SMA connector

CHAPTER 4

RESULTS AND CONCLUSION

4.1 Trial Results of Jammer

After developing our jammer we started conducting extensive trials. The trials were co nducted in two different environments we brought different results. The trials were co nducted both indoors and outdoors.

4.1.1 Indoor Trials

The receiver was placed in the middle and jammer and transmitter and receiver were placed at opposite ends. Distances were varied step by step to get a good picture of jammers capabilities against the transmitter.J-R is distance between jammer and receiverT-R is distance between transmitter and receiver when it starts to operate when jammer is on.

Table 4.1 Indoor Trial Results of the Jammer

J-R(m)	T-R(m)
5	2.5
10	5
15	7.5
20	10

4.1.2 Outdoor Trials

The same placement was used for jammer, receiver and transmitter as used in indoor trials.

Table 4.2 Outdoor Trial Results of the jammer

J-R(m)	T-R(m)
5	3
10	6
15	9
20	12
25	15
30	18

4.2 Conclusion

In this project , which turned out to be a full success, we designed a device that jams a car keyless fob. This device can be used in order to effectively jam a car alarm being used to trigger an IED. The designed device works in UHF band. The project was implemented according to the following plan:

Firstly the jamming techniques were studied to find the best jamming method. The system block diagram was also specified in this stage.

Components that are needed for building this device were searched and main co mponents were specified which were:For RF section , two VCOs that operate at the needed bands, two power amplifiers and two antennas.For IF section, 555timer, zener diode, mixer ,power supply and some discrete compo nents(capacitors and resistors)

The schematic was drawn and some simulations for the IF section were perfo rmed. Then designed the layout using PCB. The PCB was built using etching pro cess on copper clad board.All the IF-section components were brought from the local companies.Then the IF section was built and tested.

After that searched for the RF – components (VCO and power amplifiers) in the local market. Since failed to collect the IC’s from the local market , ordered them from abroad.Finally assembled and tested the jammer. By the grace of Allah Almighty , got positive results . Both bands were fully jammed.

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4.3 Final Shape of the Project

Figure 4.1 Final Project Design

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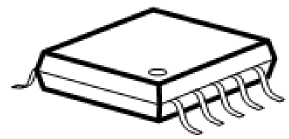
APPENDIX 1

Product Info

General Description The TDK 5101 F is a single chip ASK/ FSK transmitter for the UHF frequency band . The IC offers a high level of integration and needs only a few external components. The device contains a fully integrated PLL synthesizer and a high efficiency power amplifier to drive a loop antenna. A special circuit design and an unique power amplifier design are used to save current consumption and therefore to save battery life. Additional features are a power down mode and a divided clock output.

Package



Features

- fully integrated frequency synthesizer
- VCO without external components
- ASK and FSK modulation
- high efficiency power amplifier (typically 5 dBm)
- low supply current (typically 7mA)
- voltage supply range 2.1 - 4 V
- temperature range ↨40 ... +125°C
- power down mode
- crystal oscillator 9.84 MHz
- FSK-switch
- divided clock output for µC
- low external component count

Applications

- Tire pressure monitoring systems
- Keyless entry systems
- Remote control systems
- Alarm systems
- Communication systems

1.1 Overview

The TDK 5101 F is a single chip ASK/FSK transmitter for the UHF frequency band . The IC offers a high level of integration and needs only a few external components. The device contains a fully integrated PLL synthesizer and a high efficiency power amplifier to drive a loop antenna. A special circuit design and an unique power amplifier design are used to save current consumption and therefore to save battery life. Additional features are a power down mode and a divided clock output.

The IC can be used for both ASK and FSK modulation.

1.2 Applications

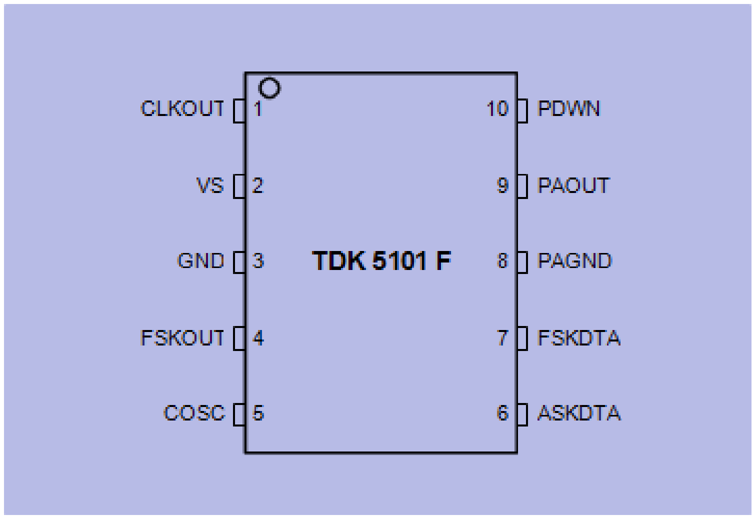
- Tire pressure monitoring systems
- Keyless entry systems
- Remote control systems
- Alarm systems
- Communication systems

1.3 Features

- fully integrated frequency synthesizer
- VCO without external components
- ASK and FSK modulation

- high efficiency power amplifier (typically 5 dBm)
- low supply current (typically 7 mA)
- voltage supply range 2.1 - 4 V
- temperature range –40°C ... 125°C

2.1 Pin Configuration



Pin_config.wmf

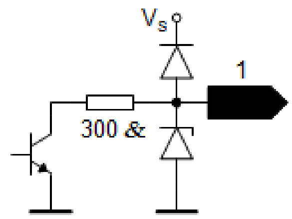
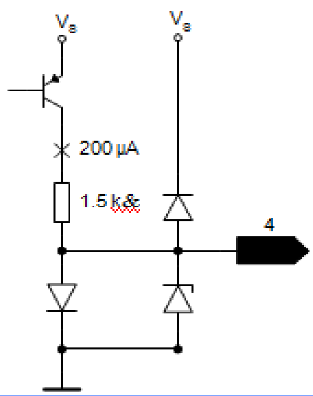
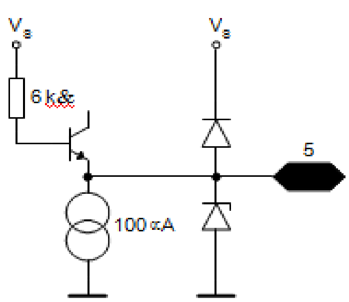
Figure 2-1 IC Pin Configuration

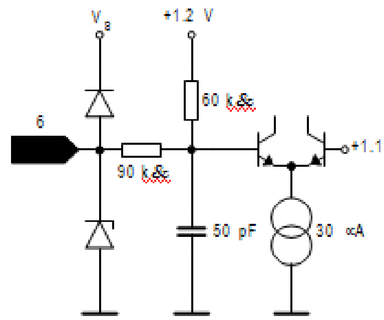
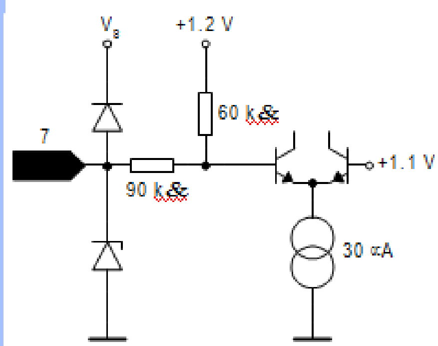
Table 2-1

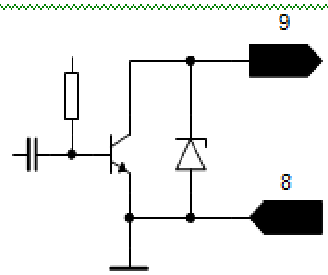
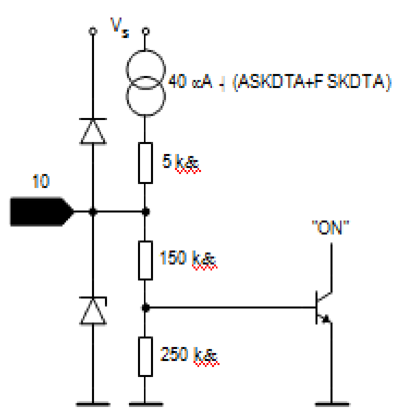
Pin No.	Symbol	Function
1	CLKOUT	Clock Driver Output (615.2 kHz)
2	VS	Voltage Supply
3	GND	Ground
4	FSKOUT	Frequency Shift Keying Switch Output
5	COSC	Crystal Oscillator Input (9.84 MHz)
6	ASKDTA	Amplitude Shift Keying Data Input
7	FSKDTA	Frequency Shift Keying Data Input
8	PAGND	Power Amplifier Ground
9	PAOUT	Power Amplifier Output
10	PDWN	Power Down Mode Control

2.2 Pin Definitions and Functions

Table 2-2

Pin No.	Symbol	Interface Schematic[1)]	Function
1	CLKOUT		Clock output to supply an external device. An external pull-up resistor has to be added in accordance to the driving requirements of the external device. The clock frequency is 615.2 kHz.
2	VS		This pin is the positive supply of the transmitter electronics. An RF bypass capacitor should be connected directly to this pin and returned to GND (pin 3) as short as possible.
3	GND		General ground connection.
4	FSKOUT		This pin is connected to a switch to GND (pin 3). The switch is closed when the signal at FSKDTA (pin 7) is in a logic low state. The switch is open when the signal at FSKDTA (pin 7) is in a logic high state. FSKOUT can switch an additional capacitor to the reference crystal network to pull the crystal frequency by an amount resulting in the desired FSK frequency shift of the transmitter output frequency.
5	COSC		This pin is connected to the reference oscillator circuit. The reference oscillator is working as a negative impedance converter. It presents a negative resistance in series to an inductance at the COSC pin.

6	ASKDTA		Digital amplitude modulation can be imparted to the Power Amplifier through this pin. A logic high (ASKDTA > 1.5 V or open) enables the Power Amplifier. A logic low (ASKDTA < 0.5 V) disables the Power Amplifier.
7	FSKDTA		Digital frequency modulation can be imparted to the Xtal Oscillator by this pin. The VCO-frequency varies in accordance to the frequency of the reference oscillator. A logic high (FSKDTA > 1.5V or open) sets the FSK switch to a high impedance state. A logic low (FSKDTA < 0.5 V) closes the FSK switch from FSKOUT (pin 4) to GND (pin 3). A capacitor can be switched to the reference crystal network this way. The Xtal Oscillator frequency will be shifted giving the designed FSK frequency deviation.

8	PAGND		Ground connection of the power amplifier. The RF ground return path of the power amplifier output PAOUT (pin 9) has to be concentrated to this pin.
9	PAOUT		RF output pin of the transmitter. A DC path to the positive supply VS has to be supplied by the antenna matching net-work.
10	PDWN		Disable pin for the complete transmitter cir-cuit. A logic low (PDWN < 0.7 V) turns off all transmitter functions. A logic high (PDWN > 1.5 V) gives access to all transmitter functions. PDWN input will be pulled up by 40 μA inter-nally by either setting FSKDTA or ASKDTA to a logic high-state.

2.4 Functional Blocks

2.4.1 PLL Synthesizer

The Phase Locked Loop synthesizer consists of a Voltage Controlled Oscillator (VCO), an asynchronous divider chain, a phase detector, a charge pump and a loop filter. It is fully implemented on chip. The tuning circuit of the VCO consisting of spiral inductors and varactor diodes is on chip, too. Therefore no additional external components are necessary. The nominal center frequency of the VCO is 630 MHz. The oscillator signal is fed both, to the synthesizer divider chain and to the power amplifier. The overall division ratio of the asynchronous divider chain is 64. The phase detector is a Type IV PD with charge pump. The passive loop filter is realized on chip.

2.4.2 Crystal Oscillator

The crystal oscillator operates at 9.84 MHz.

The crystal frequency is divided by 16. The resulting 615.2 kHz are available at the clock output CLKOUT (pin1) to drive the clock input of a micro controller.

To achieve FSK transmission, the oscillator frequency can be detuned by a fixed amount by switching an external capacitor via FSKOUT (pin 4).

The condition of the switch is controlled by the signal at FSKDTA (pin 7).

Table 2-3

FSKDTA (pin7)	FSK Switch
Low[1]	CLOSED
Open[2], High[3]	OPEN

1) Low: Voltage at pin < 0.5 V
2) Open: Pin open
3) High: Voltage at pin > 1.5 V

2.4.3 Power Amplifier

The VCO frequency is divided by 2 and fed to the Power Amplifier.

The Power Amplifier can be switched on and off
by the signal at ASKDTA (pin 6).

Table 2-4

ASKDTA (pin 6)	Power Amplifier
Low[1)]	OFF
Open[2)], High[3)]	ON

1) Low: Voltage at pin < 0.5 V
2) Open: Pin open
3) High: Voltage at pin > 1.5 V

The Power Amplifier has an Open Collector output at PAOUT (pin 9) and requires an external pull-up coil to provide bias. The coil is part of the tuning and matching LC circuitry to get best performance with the external loop antenna. To achieve the best power amplifier efficiency, the high frequency voltage swing at PAOUT (pin 9) should be twice the supply voltage.

The power amplifier has its own ground pin PAGND (pin 8) in order to reduce the amount of coupling to the other circuits.