MOBILE VEHICLE TRACKER USING RF (HARDWARE)

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DEDICATION

For my family members and friends,
especially to my mom and dad for your morale support.

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ABSTRAK

Kejadian pencurian kereta dalam negara semakin menular-nular kebelakangan ini. Penggera konvensional bukanlah pilihan terbaik lagi. Kereta yang dicuri lebih sukar dicari kerana pencuri kereta kebiasannya memotong kereta yang dicuri dan menjualnya sebagai alat ganti kereta. Alat penjejak digunakan untuk menjejak kereta yang dicuri sebelum sebarang kerosakkan terjadi kepada kereta yang dicuri. Penjejakkan boleh dibahagikan kepada penjejakkan frekuensi radio (RF) atau penjejakkan dengan menggunakan Satelit Penempaten Global (GPS). Penjejakkan dengan menggunakan Satelit Penempatan Global menjejak kereta dengan menggunakan satelit tetapi it sangat mahal untuk digunakan. Penjejakkan frekuensi radio menyediakan penjejakkan yang lebih murah dan baik.

Dalam projek ini, kesemua penjejakkan frekuensi radio yang ada haruslah diketahui. Dengan pengetahuan setiap penjejakkan frekuensi radio yang menggunakan rekabentuk yang berlainan memberi kesan kepada litar elektronik , pertimbangan wajar adalah penting untuk menentukan langkah yang dilaksanakan. Dengan menyempurnakan rekabentuk untuk langkah penjejakkan frekuensi radio, penjejak frekuensi radio boleh dibina. Litar elektronik yang dipilih dalam peringkat rekabentuk akan dilaksanakan. Apabila peringkat perlaksanaan telah dijalankan, penjejak frekuensi radio yang sempurna dan boleh berfungsi akan dibina.

ABSTRACT

Car thief incidents have increased tremendously in our country recently. Conventional alarm is not the best option anymore. Stolen cars are harder to be recovered because car thief normally cut down the car into small parts and sell then as spare parts. Tracking device is used to track down stolen car before any harmed could be done on the stolen cars. Tracking methods are divided into Radio Frequency (RF) tracking and Global Positioning Satellite (GPS) tracking. GPS track down cars using satellite but it is expensive to implement. RF tracking could provide a cheaper and better tracking method.

In this project, available RF tracking methods should be known. By knowing each RF tracking methods utilizing different design and circuitry, careful consideration need to be taken when choosing which method should be used. By completing the design of the RF tracking method, the mobile vehicle tracker could be built. The circuit selected during design stage is used. After going through the implementation stage, mobile vehicle tracker is completed and tested.

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Chapter 1

Introduction

1.0 Introduction

Car thief incidents have increase tremendously in our country in recent years. Conventional car alarm is not the only protection that can be provided because it is far too common and could be disarmed easily. Therefore, it is not the best option anymore. If the stolen cars have not being track down within few hours, the possibility of getting the stolen cars back is very low. Stolen cars will be total lost because car thief normally cut down the car into small part and sell them as spare parts. The best backup protection in the market is using tracking device to track down stolen cars before any damaged can be done on stolen cars. There are two widely known tracking systems in the market. One of them is utilizing satellite known as Global Positioning Satellite to track down stolen cars while the other system implementing Radio Frequency (RF) tracking. Current available market products for tracking mobile vehicle are implementing Global Positioning System (GPS) but it is relatively expensive. RF tracking is less popular method because it uncommon. By improvising a new more reliable RF tracking system, all people can have a better protection for their mobile vehicle at much reasonable price.

When talking about mobile vehicle tracking, GPS is definitely the first thing that came into everyone mind. This system is used by United States (US) government for defensive purposes but it is open to public used recently. There is 24 Global Positioning Satellite orbit the earth where a GPS receiver can receive radio signals. It can calculate the receiver position within few feet if the receiver can receive a signal from at least 3 satellites at a time. This information will be displayed on computerized map by transmitting the location information to the base station. There are a lot of advantages by using GPS tracking system. This included it can track down plentiful of mobile vehicle simultaneously accurately. It will show vehicle current location, which direction the vehicle is headed, how fast it is going within few minute to computer. The down sides of GPS are it is expensive, hard to install, and the antenna must install so that it under open sky. If the mobile vehicle is situated inside a closed area, for example inside cargo container, underground car parks, garage or even tunnel, the GPS system couldn't detect the vehicle location. Therefore, GPS system is not suitable for tracking down a stolen car but it is much better for fleet management. Fleet management is managing transportation of products from factory to destination.

There is another type of tracking systems. It is using RF and is known as RF tracking systems. If search online on tracking system, there are abundant companies selling GPS tracking products while there is hardly any companies producing RF tracking technologies. In RF tracking system, a radio transceiver which is known as Vehicle Locator Unit (VLU) is set up inside the mobile vehicle. The VLU stays dormant until the mobile vehicle needs to be tracked. The VLU is activated by a remote radio activation signals that is transmitted when a specific

vehicle is needs to be detected. After the VLU activation, it will send signals that can be received by receivers. These signals are then pass through the computer and show it on computerized map. The distance between receiver station and the mobile vehicle can be measured by using angle of the arrival or signals strength or using both. RF tracking technologies have many advantages in oppose to GPS tracking system. RF tracking system is more suitable for tracking stolen vehicle. The tracking capacity of RF tracking system is smaller because there is only small amount of mobile vehicle simultaneously. It can track virtually unlimited numbers of vehicle and it saves energy consumption because VLU remains inactive until it is need for tracking the stolen vehicle. If a well improvise RF tracking system is developed, it will be more easy market penetration and widespread implementation because of it easier installation processes and inexpensive prices. The vehicle locator unit that is produce could be hidden within several places in the car is another advantage. The last but not less advantage is it could find cars that GPS system can't because the powerful RF signals could pass through close areas such as cargo container, underground car parks and garage.

Actually RF tracking system can be divided into two types. They are active tracking systems while the other is passive tracking systems. The passive tracking systems normally set up the receiver to receive any incoming signals coming from all sources. Therefore, the VLU is sending information all the times even when we don't want to track that particular mobile vehicle. There are quite a few disadvantages of using passive tracking systems because the VLU is always on. The power source of the VLU is easily to get drain because it is always on. Not only that, it will slow down the tracking of another mobile vehicle at the same time because of signal congestion

of unwanted mobile vehicle signals. The better solution to this problem is to use active tracking systems. Active tracking systems need remote radio activation signals to activate the VLU. After the activation of the VLU, signals from the mobile vehicle is detected by using at least 3 base stations and the information is send to the computer to process. The advantages of active tracking systems by cutting down the power consumption of the VLU power supply. Not only that, the signal congestion of unwanted signals that from passive tracking systems is free here because there is only few mobile vehicle that is activated for tracking.

To solve the car thief problem, the most suitable tracking system is RF tracking systems. With this system, car thief problem could be reduced if not eliminated. This is because the price of RF tracking systems is much cheaper than GPS tracking systems. Not only that, it can function better in track down stolen mobile vehicle than GPS tracking systems. The RF tracking systems must be active tracking system because this will help in track down specific mobile vehicle with the vehicle locator unit (VLU). This is much more efficient ways to track down mobile vehicle compare to the passive tracking systems.

Chapter 2

Literature Review

2.0 Introduction

Before even start going into the building the whole hardware of RF tracking system, consideration should be given on knowing the basic of RF tracking. Without strong basic on these fields, the hardware of RF tracking system build will be very problematic and eventually unusable. This basic knowledge includes:

1. Definition of Radio Frequency.
2. Types of Radio Tracking Method.
3. Types of Antenna System.
4. Types of Transmitter and Receiver Used in Tracking.
5. Types of Transceiver Used in Tracking.
6. Timer for Interfacing Circuit.
7. Types of Communication Port.
8. Types of Processor for Interfacing Circuit

2.1. Definition of Radio Frequency

In the making of tracking system utilizing RF, first of all the fundamental of RF must be comprehend completely. RF is a non-ionizing wave and it is categorized as thermal wave because it causes high induced current that causes heating. RF is assigned between 300 kHz to 300 MHz. The radio frequency is divided into three bands. They are Medium Frequency (MF) which ranges from 300 kHz to 3 MHz, High Frequency (HF) which ranges from 3 MHz to 30 MHz and Very High Frequency (VHF) which ranges from 30MHz to 300 MHz.

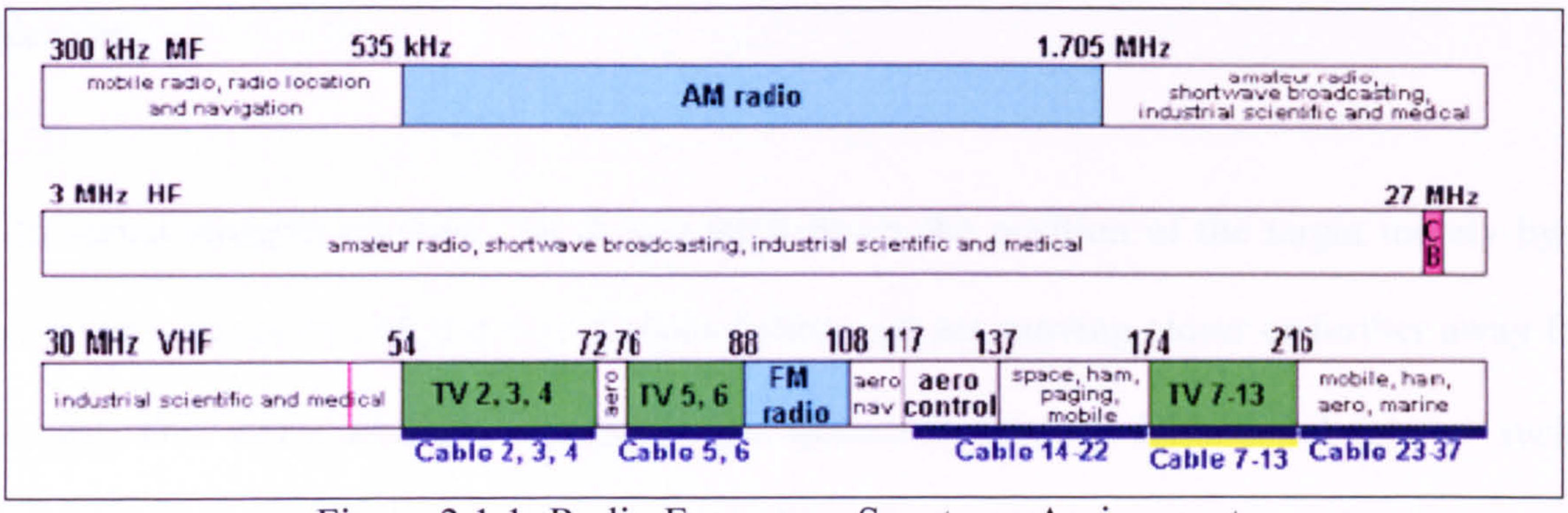

Figure 2.1.1: Radio Frequency Spectrum Assignment.

Mobile radio as well as radio locating and navigating is assigned at MF 300 kHz to MF 535 kHz. Amplitude Modulation (AM) radio is assigned between MF 535 kHz to MF 1.705 MHz. Shortwave broadcasting is assigned between MF 1.705 MHz to HF 27 MHz. Amateur radio band is located between MF 1.705 MHz to HF 27 MHz, between VHF 137 MHz to VHF 174 MHz and between VHF 216 MHz to 300 MHz. The industrial, scientific and medical band is assigned between MF 1.705 MHz to VHF 54 MHz. Frequency Modulation (FM) radio is assigned VHF

88 MHz to VHF 108 MHz. Aero navigation and control is assigned between VHF 108 MHz to 137 MHz. These bands are shown in Figure 2.1.1.

2.2. Types of Radio Tracking Method

In RF tracking itself, there are few methods and technologies used for direction finding and tracking. There are five tracking methods is identified. They are Signal Strength, Adcock, Doppler, Switched Pattern and Triangulating. Different RF tracking methods or technologies have its advantages and disadvantages. These different is used in implementing different application.

In signal strength tracking, the device track down the position of the target merely by the varying tones or series of lights that shows whether you are moving closer or further away from the target. This signal strength tracking is also known as homing. Directional antenna such as Beam or Yagi is normally used this type of tracking device. With these directional antennas, the direction or the bearing of the strongest signals could be detected. One directional antenna is not the best ways use in real world RF tracking because it's merely impossible of deriving an exact location. If however, there are more than one directional antenna are used for tracking, the location of the target might be able to locate. But there is a need of very powerful software to plot the cross point between these directional antennas bearing to determine the target position. This type of tracking using more than one antenna is known as triangulating.

Adcock is another system of RF tracking. Adcock is referred to the technique of deriving bearing information. In an Adcock system, four vertical antennas in box pattern with a fifth antenna, called the sense antenna in the middle. With a low profile antenna, the antenna can be hidden rather easy. Comparisons between transmitter's signals received by the sense antenna and the four other side antennas done by the appropriate electronics. The comparison results are then displayed and it tells you where the target transmitter position relatives to receivers. Adcock tracking systems works the best with vertically polarized antenna and very poor with signals with mixed polarization. Adcock tracking systems works well with short pulses signal which might be connected data transmission to and from satellite .This method of RF tracking is much larger than practical mobile tracking. It works much better with tracking down target transmitter in the cleared area like coast or sea than at crowded area like forest or town because of multi-path interference.

Other type of RF tracking method is using Doppler system. A Doppler system normally is assembled with four antennas giving it's the characteristics of 360° device. Doppler receivers are more like a compass that can track all around its 360°. Severe multipath will cause the signals seems to be received in every direction even though in theory, a specific direction of signals incoming will be detected. A Doppler system needs stronger signal to indicate accurately the wanted signals with the multipath interference through field test. For Doppler systems, comparison is done on transmitter's signals received by the four antennas through a smart electronics and it will determine which antenna is closest to the transmitter. Doppler systems are good in determining bearing but are quite poor in determining range. This doesn't imply that

other systems are good in determining range but they could make more accurate extrapolation of range to the signal strength than Doppler systems. It is harder to operate in crowded area like in city for Doppler systems. Accurate bearing information with a quick transmission is the main advantage of Doppler systems. For mobile vehicle tracker applications, the advantages of fast detecting on the transmission are not that important. Even though, Doppler direction finding is a viable technique but it is not suitable for mobile vehicle tracker.

Switched pattern technique is another method of RF tracking. Switched pattern involves two for 180° or four for 360° coverage antennas with switched alternately one at a time of the receiver. It can switch up to 120 each second. The antenna must affix on roof of a vehicle because with the approximate "pattern" of the antenna the signal received from the beacon transmitter will be stronger at one of the antenna in the system. Receiving electronics can reliably derive bearing information because the system knows which antenna can receive the signal better and where the vehicle is. Multi-path interference is easier to differentiate due to the fact that a single antenna is connected to the receiver at a particular time. It is the best solution for mobile vehicle RF tracking method.

Another RF tracking method is utilizing the concept of triangulating. Two or more signals bearing coming from different locations (preferably at angles of about 90° to one another) is implicated in this triangulating method. The more bearings for example more than two, is better for a better determine the tracking location because of antenna directionality is imprecise. By using more than two antennas, the precision of locating a tracking beacon on a map is improve

tremendously. If the bearing is taken in a relatively short period then significant error no need to be introduced and vice versa. In this method, if combination could be done with switched pattern antenna, the beacon could be detected more precisely.

2.3. Types of Antenna System

For the transmitter part, the antenna system should have a radiation pattern of omni directional. This is because the transmitter should send out its signals in all direction of a single plane so that the receiver antenna at different location could detect the transmitter signals. The most suitable antenna that could be use at the transmitter part is a dipole antenna. This is because it is common and easy to implement. Not only that, it has omni directional radiation pattern that achieve the requirement of the transmitter antenna systems.

For the receiver part, one of antenna system that has potential in radio frequency tracking is smart antenna system. From the name, it seems that its antenna is smart but actually it isn't, the system is. Smart antenna systems have a digital signal-processing capability in transmitting and receiving in adaptive manner. This adaptive system could change the directionality of its radiation patterns with the changes in its environment. This help in increasing the performance characteristics dramatically.

Smart antenna could be categorized into two main groups known as beam switched or adaptive array systems. The difference between beam switched and adaptive array systems is the

beam switched system has a finite numbers of pre-specific patterns while adaptive array system has infinite numbers of patterns that adjust during real time.

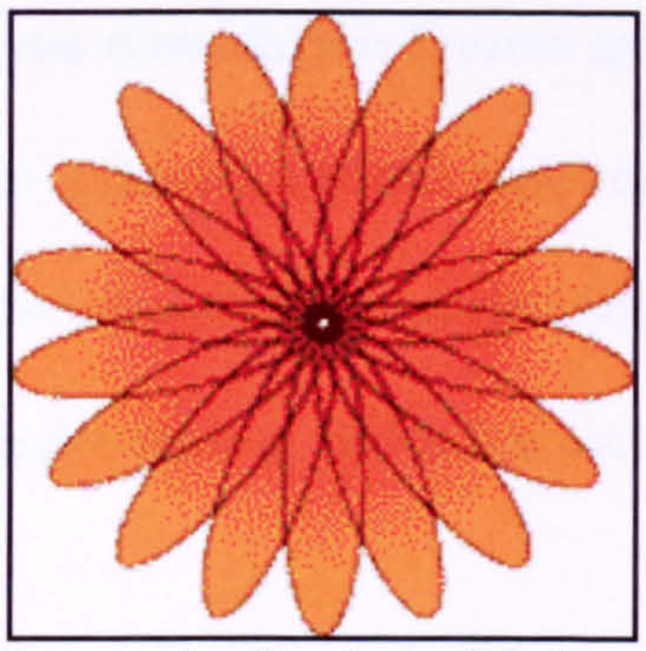

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Figure 2.3.1 Switched Beam System Coverage Pattern.

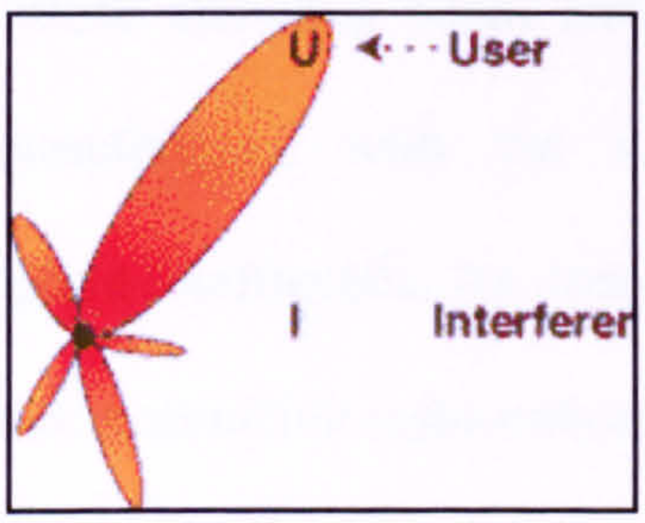

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Figure 2.3.2 Adaptive Array System Pattern

Multiple fixed beams with specific sensitivity in a particular direction are formed in beam switched antenna systems. One of several predetermined, fixed beams are chosen of this antenna system through detection of signal strength. As the mobile moves from a sector to another, it switched from one beam to another. Switched beam systems combine the outputs of multiple antennas to form finely sectorized (directional) beams with more spatial selectivity that can be achieved with conventional, single-element approaches. This is different with the conventional

methods of shaping the directional antenna pattern with metallic properties or physical design of a single element (like sectorized antenna).

The most advanced smart antenna nowadays is known as adaptive antenna technology. This adaptive has an advantages of locate and track various types of signals effectively to dynamically minimize interference and maximize intended signal reception. The adaptive provides optimal gain while simultaneously identifying, tracking, and minimizing interference signals.

Omni-directional could be easily differentiated from the intelligent antenna by the numbers of antenna element implemented. Both switched beam and adaptive array system share the similarities in the hardware characteristics with the intelligent counterpart. They are distinguished primarily by their adaptive intelligence. An array of antenna elements typically 4 to 12 elements are needed for directionally sensitive information for process. These elements could be arranged in linear, circular, or planar configurations. This smart antenna system smart because of its digital signal-processing facilities. Numerous advantages in terms of accuracy and flexibility of operation are offer by electronic systems today through manipulation of RF data in digital format.

Even though, a smart antenna systems will be a great advantages to radio tracking system, this system is hard to get in the market and it is still in its early stage of development. Both the antenna and the intelligent systems are hard to get and the algorithm itself are very rare. It's hard

to implement in this project but maybe in further future, this is not impossible and at that time, this RF tracking efficiency will increase enormously.

Another suggestive solution for an antenna system is using more mechanical part. The mechanical part is actually control by electronic. That is different from the smart antenna system that is using pin diodes to control the parasitic element and thus control direction of the receiver antenna. Implement a good operational directional antenna and mounted it on a stepper motor that is connected to a control circuit. This stepper motor is control to tune on to the strongest signal received from the transmitter. If the directional antenna located the strongest signal received at a specific bearing, it will send the bearing data to the computer to process. Even this method is not as smart as the smart antenna systems, it is the most economical and yet easy to be build compare to a complex smart antenna systems.

A directional antenna such as Yagi-Uda antenna is easy to build. The problem is of this system is to design an operational antenna with relatively small in size problem concern on multipath interference signals. A better solution to this multipath interference is using a smaller antenna with very small beam width. This is because with smaller beam width, the scanning process could be more precise. When using directional antenna such as Yagi-Uda antenna, the beam width is too broad to use in tracking. An alternative to using Yagi-Uda antenna is by much smaller beam width antenna such as patch antenna. The polarization of both antennas should be vertically polarized. This is because the transmitter antenna should transmit in omni directional

and the receiver antenna should use the same polarization of the transmitter antenna to receive correctly.

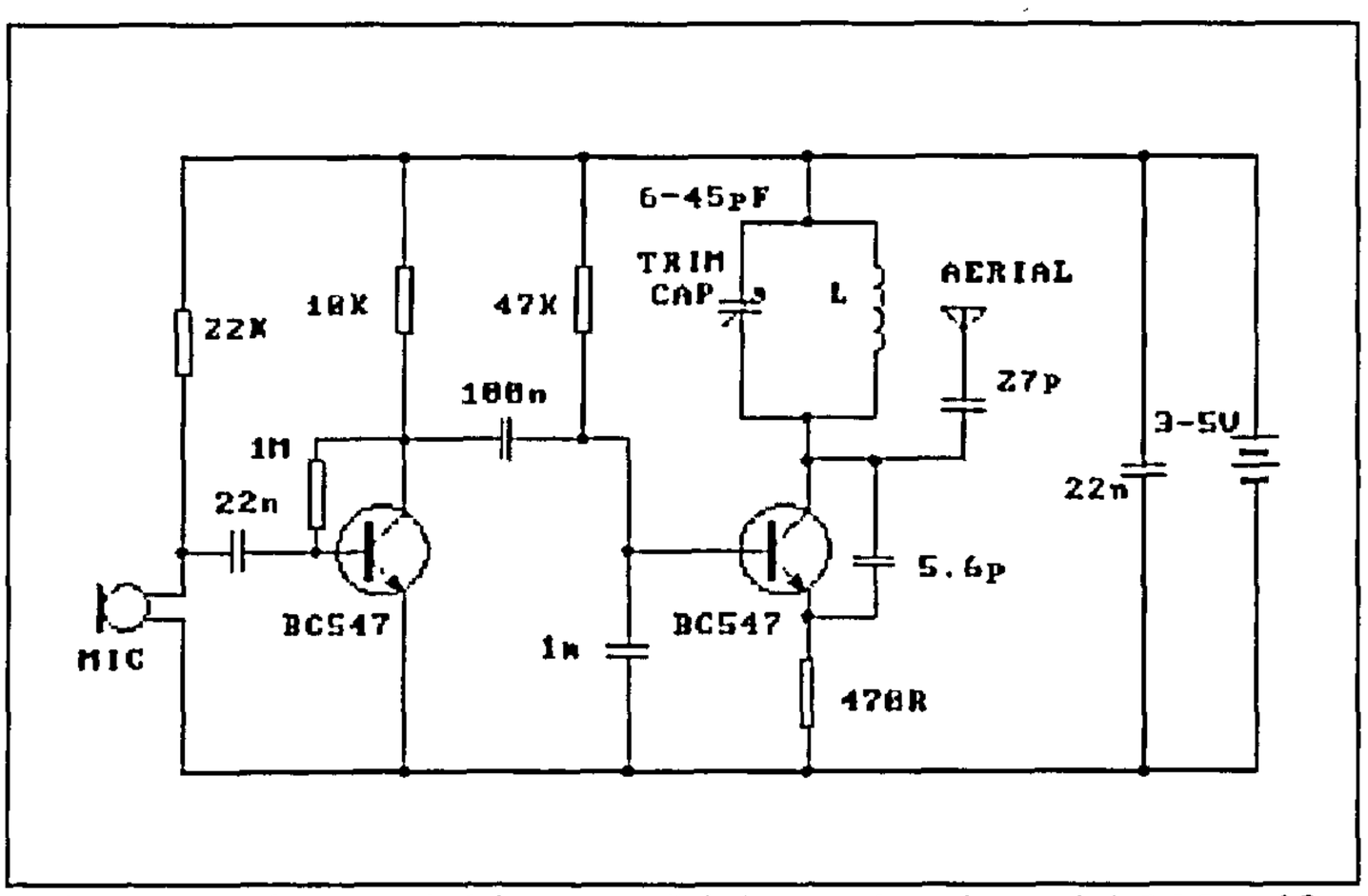
2.4 Types of Transmitter and Receiver Used in Tracking

In radio frequency tracking, a transmitter which is sending a pulsed signal out in every direction so that the receiver could pick up the pulsed signal is needed. At the receiver ends, the receiver must be able to detect pulsed signals. This detection is depending on different methods. The detection is depended on the signals strength, signal direction of arrival or other parameters. Therefore, the both design of the transmitter and receiver should be similar in frequency transmit and receive.

For the transmitter, a suitable frequency should be selected so that the transmitter could be build easily and yet the directional antenna such as Yagi-Uda antenna size will be decrease. A frequency in 100 MHz and above that is not interfered with local radio station frequency will be the best frequency. This is because transmitter circuit within radio station frequency range is easy to build because it is quite common. The frequency above 100MHz is selected because for a directional antenna, such as Yagi-Uda antenna will have smaller size if the frequency is high. This is because frequency is inverse proportional to the wavelength and the wavelength is proportional to antenna size. Therefore, both transmitter and receiver should be transmitting and receiving signals frequency ranges 100MHz and above.

There are several transmitter circuit that could used and implement on this project. These transmitter circuits could be easily obtained online. Some of the circuits are home-brewed but most of the circuits that is posted online are done by people involve in amateur radio worldwide. From all the circuits online, it noticeable that they could be divided into two large sections known as Frequency Oscillator or Modulator and Amplifier Stage.

The most important section of the transmitter is the frequency oscillator or modulator. This part of the FM transmitter normally could contain oscillator which consist of capacitor and inductor. Tuning the oscillator could be done by varying the capacitor or inductor. By fixing the inductance, the capacitance should be varied and vice versa. Colpitts Oscillator is one of oscillator that used varying inductor or capacitor.



Source: electronickits.com/kit/complete/surv/ck200.pdf
Figure 2.4.1: FM transmitter with amplifier stage before oscillator

The other section of the transmitter is amplifier stage. Some of the circuits contrast from each other in number of amplifier stages. All FM transmitters have amplifier stage. Some have