Transponder Reader Antenna Design Overview

Version 1.0b

Document: 9S13-8004-A001

Revision History

Date	Revision	Description	Signature / Date	
03/05/10	1.0a	Initial Draft	Prepared	D Stagg
			Verified	
			Approved	
			Prepared	
			Verified	
			Approved	
			Prepared	
			Verified	
			Approved	
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			Verified	
			Approved	

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CGI Transponder Antenna - Hardware Design

1 Introduction

The transponder antenna is a hermetically sealed unit that normally mounts to the underneath of locomotive. It continuously generates and broadcasts a low power electromagnetic field. When the antenna passes over a transponder system it receives transponder data transmission and passes it to the reader system. The transponder antenna uses DC power to drive its circuitry which in turns generate 200 KHz electromagnetic signal. This electromagnetic signal is strong enough to energize the transponder system by inductive coupling. The transponder antenna incorporates circuitry to receive the high frequency (27 MHz nominal) transmission from the transponder system as well as interface circuitry to the reader for DC power, frequency reference and RF data. It is a sealed unit designed for high reliability in the severe environment under a locomotive.

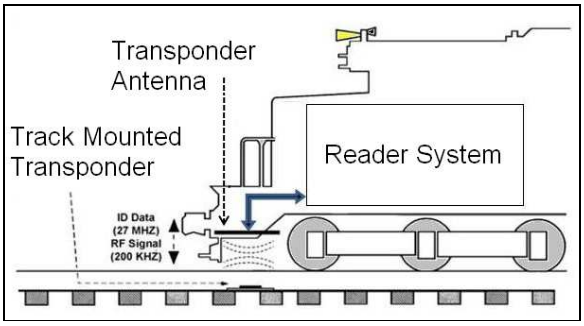

Figure 1-1 Transponder System

1.1 Purpose of this document

The purpose of this document is to list all aspects of the electronic design including circuit design calculations and details to help draft Schematics of the proposed design.

1.2 Scope

This document contains all electronic design aspects including circuit design calculations, description, operation theory, component selection criteria and information.

1.3 References

Sr.	Reference	Detail
1		
2		
3		
4		
5		

Table 1-1 References

1.4 Abbreviation, Definitions and Acronyms

Items	Detail
CPLD	Complex Programmable Logic Device
DPSK	Differential Phase Shift Keying
DXF	Design Exchange Format
JTAG	Joint Test Action Group
RF	Radio Frequency
RFID	Radio Frequency Identification

Table 1-2 Abbreviation, Definitions and Acronyms

2 Mechanical Design

2.1 Design Overview

2.1.1 Board Size

Board Size is 24" x 17".

2.1.2 Mounting Holes

Board has two Non- Plated, 0.2" diameter mounting hole and tooling holes as per following drawing.

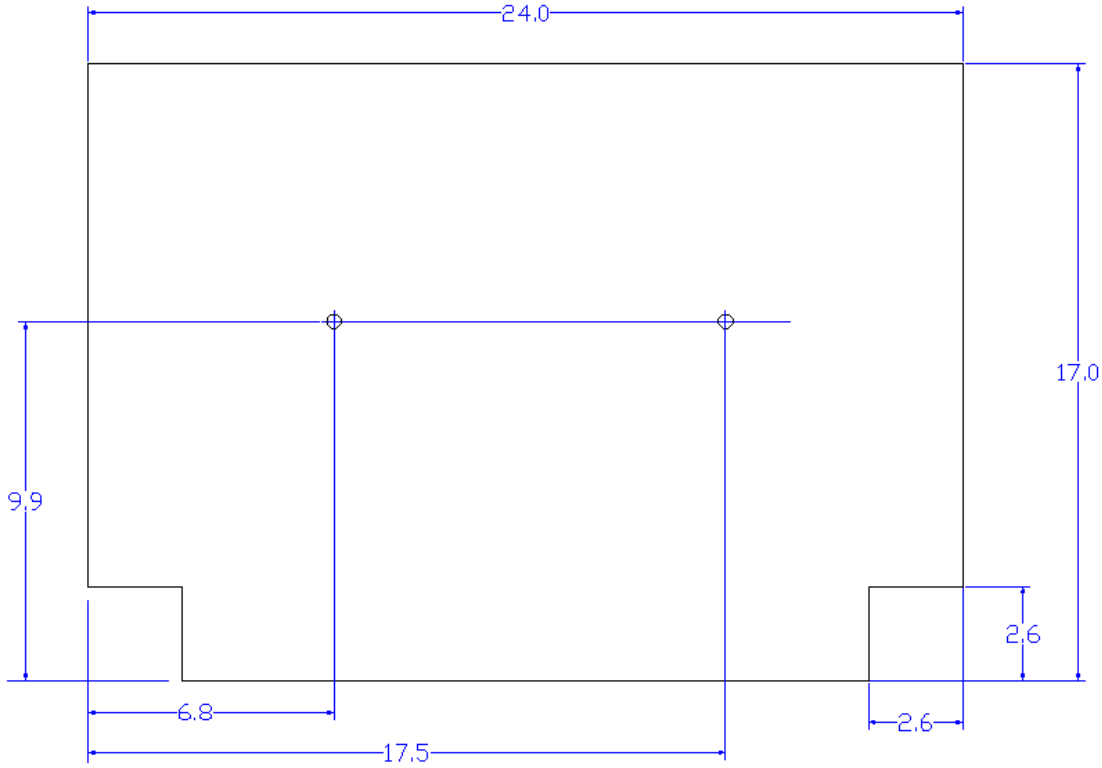

Figure 2-1 Board Outline

2.1.3 Floor Plan

The board features a critical 27 MHz antenna design as per following drawing.

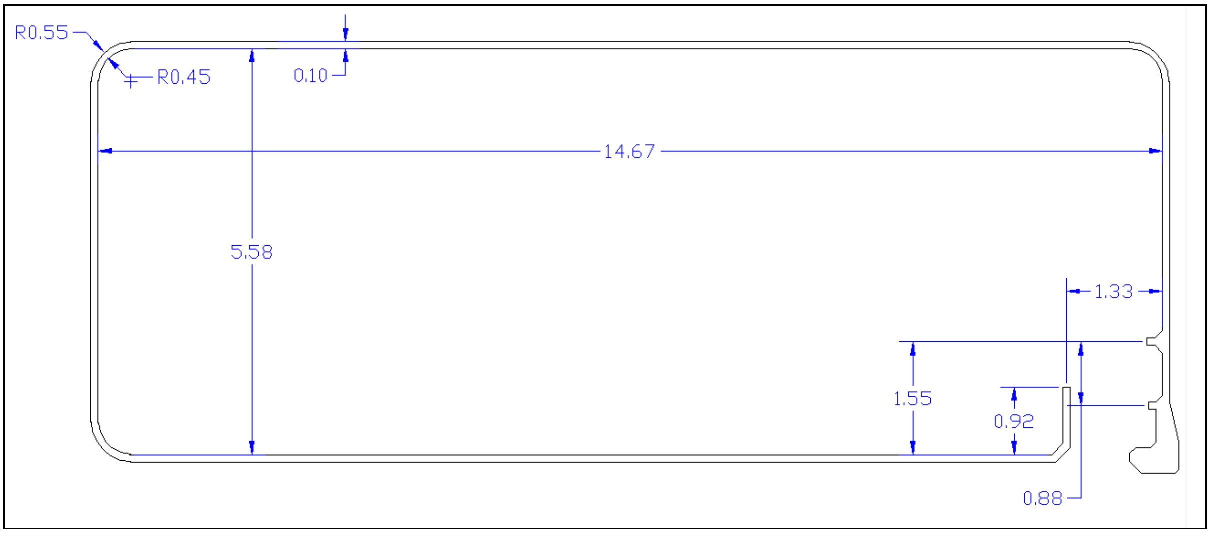

Figure 2-2 27 MHz Antenna Design

2.1.4 Component Height Restriction

There are no components which have height higher than 1050 mils.

3 Electrical Design

The Electrical Design deals with all the circuit details, calculations and theory of operations involved. Design Overview

In the train location and identification system, the hermetically sealed transponder antenna is mounted underneath the locomotive. It continuously emits a low power un-modulated 200 KHz signal that energizes the track mounted transponder as the locomotive passes over.

When the antenna passes over a transponder, it receives that transponder's data transmission by means of 27 MHz receiving antenna. This signal is then passes through a band pass filter for removing unwanted signals. After passing through filter the signal is directly passed to reader system.

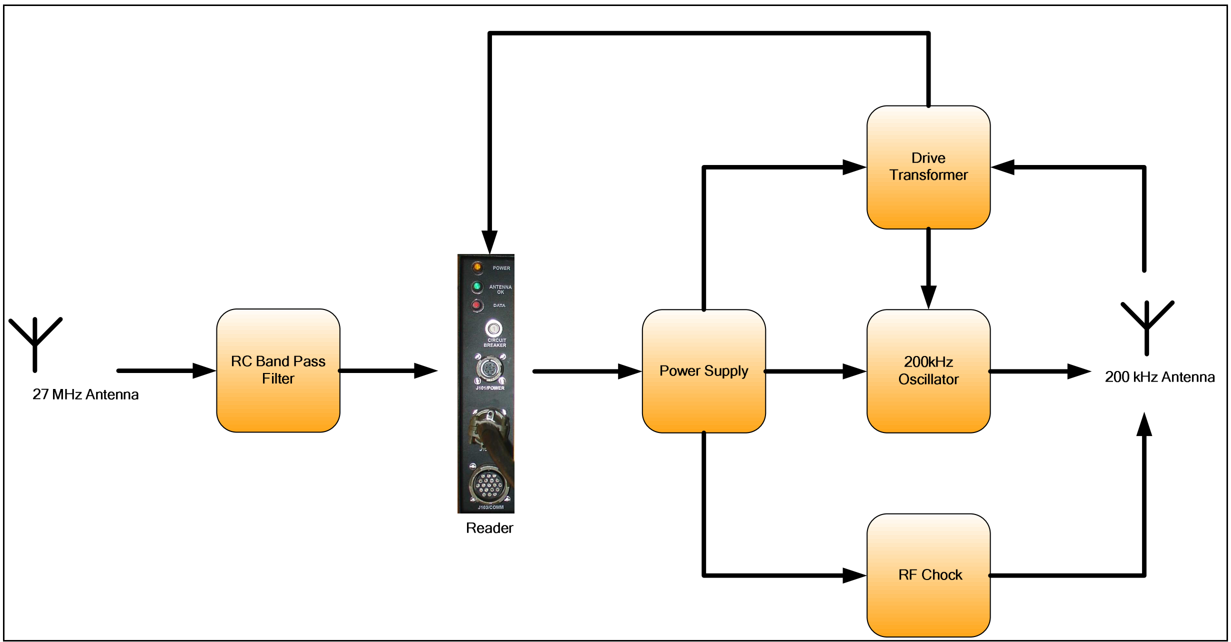

Figure 3-1 Transponder High-level Architecture

3.1 Interfaces

The transponder design has four interfaces to interact with the external environment.

3.1.1 Transmitter

The transmitter circuit consists of a PCB based loop antenna tuned to resonate at 200 KHz frequency and an oscillator, it has a gain less than unity.

3.1.2 Receiver

The receiver has a PCB based single loop receive antenna that resonates at 27 MHz frequency and a band pass filter.

3.2 Theory of Circuit Operation

The operation of the circuit is described in following sections.

3.2.1 Transmitter

The transmitter section basically consists of two sections the oscillator and a 200 kHz tuned PCB printed loop antenna. The oscillator generates 200 kHz power signal. This signal is fed to the power coil.

3.2.1.1 200kHz Oscillator

In this oscillator circuit T1 drive transformer is used to drive oscillator circuit elements, Q1 and Q2 and also to give 200 kHz frequency feedback to the reader system. This 200 kHz feedback signal is used as reference frequency in the PLL circuit for DPSK demodulation inside the reader.

3.2.1.1.1 Drive Transformer

Figure 3-2 shows the drive transformer in which we have four coils. Coil between pin 7 and 8 inside drive transformer acts as primary coil. This is directly connected with 200 kHz power coil through nets F2 and F1 respectively where it gets 200 kHz signal.

The coil between pin 5 and 6 of drive transformer is a secondary coil. The purpose of this secondary coil is to get 200 kHz signal from primary coil and pass it to the reader through J4 connector, which is shown in **Error! Reference source not found.**.

Remaining two coils are also secondary coils but these are used to drive the transistors Q1 and Q2.

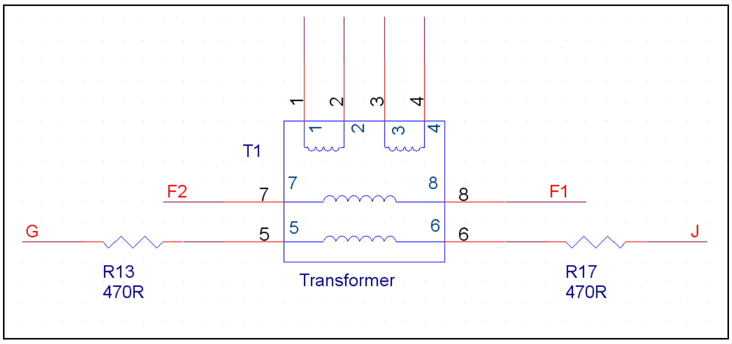

Figure 3-2 Drive Transformer

3.2.1.1.2 Theory of Oscillator Operation

Refer to Figure 3-3

The components R5, C4, R12, C8, R7, R10, C5 and C7 are used to stabilize the output 200 kHz frequency where as components R3, R4, D2, D4, C6 and D3 are used to start up the oscillator circuit.

As 72 VDC appear at node VA of oscillator, the base current of both transistors Q1 and Q2 will try to flow through R3, R4 D3 C6 and T1 coils (secondary coils at pin 1, 2 and 3, 4).

Suppose Q2 turns on first then VCE of this transistor decreases. This will develop voltage across pins 4 and 6 of power coil.

This power coil acts as auto transformer. The amplitudes and phases of these generated voltages depend on the power coils turn ratio and winding geometry.

The nodes F1 and F2 pick this voltage from power coil pins (4, 6) and give it to drive transformer `s primary coil. This primary coil produces voltage at secondary coils (at pin 1, 2 and 3, 4 of drive transformer).

Voltage generated at secondary coil at Pin 3, 4 of drive transformer is in phase with voltage at pin 4, 6 of power coil. Where as voltage at pin 1, 2 of drive transformer is 180^o out of phase with voltage pin 4, 6 of power coil. Due to this the base current of Q2 will further increase, which further decreases VCE of Q2 transistor to approx 0V. As a result more voltage develops at pin 4, 6 of power coil.

The resonance effects of power coil and C9 generates reverse polarity voltage at frequency of 200 kHz. This reverse polarity voltage also appear at secondary coils of Drive transformer. Due to this the Q1 will turn on and Q2 will turn off. When Q1 is turn on the VCE of this transistor will approx to 0V. This will develop voltage at pin3, 4 of power coil. This voltage will equal to voltage at pin 4, 6 of power coil but 180 out of phase. Q1 and Q2 turn on and turn off alternatively at frequency of 200 kHz as well as drive the power coil.

3.2.1.2 200 kHz power coil/Antenna

The Power coil consists of printed circuit copper loops. Power coil radiates the 200 kHz signal on to the track mounted transponder. This power coil along with capacitor C9 and C10 form resonance circuit of 200 kHz which are used to adjust output frequency. The effective gain of the power coil is less than unity.

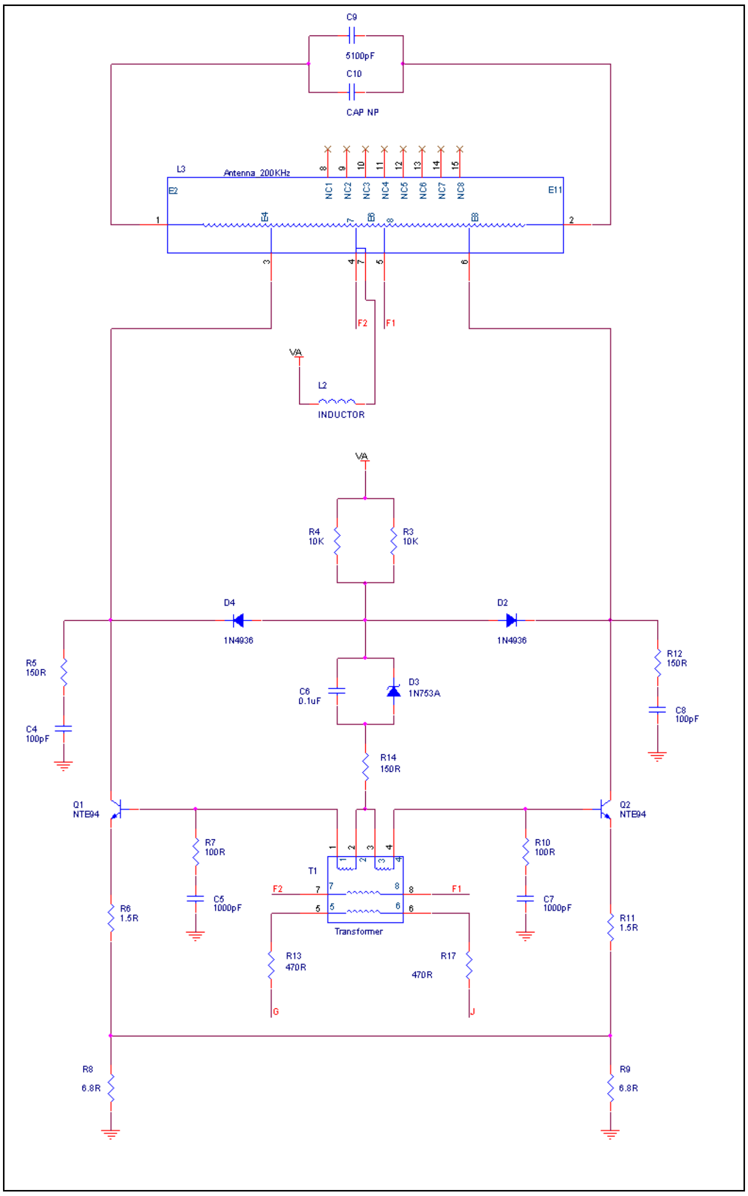

Figure 3-3 Oscillator Circuit

3.2.2 Receiver

The receiver printed circuit antenna incorporates circuitry to receive the high frequency 27 MHz transmission from the transponder

Refer to Figure 3-4, it shows receiver circuitry in which we have a RC band pass filter. Components R15 and C13 acts as low pass filter where as C11, C12 and R16 acts as high pass filter. These two filters are connected together so that they form a band pass filter. L4 is a 27 MHz receiving loop antenna realized on PCB.

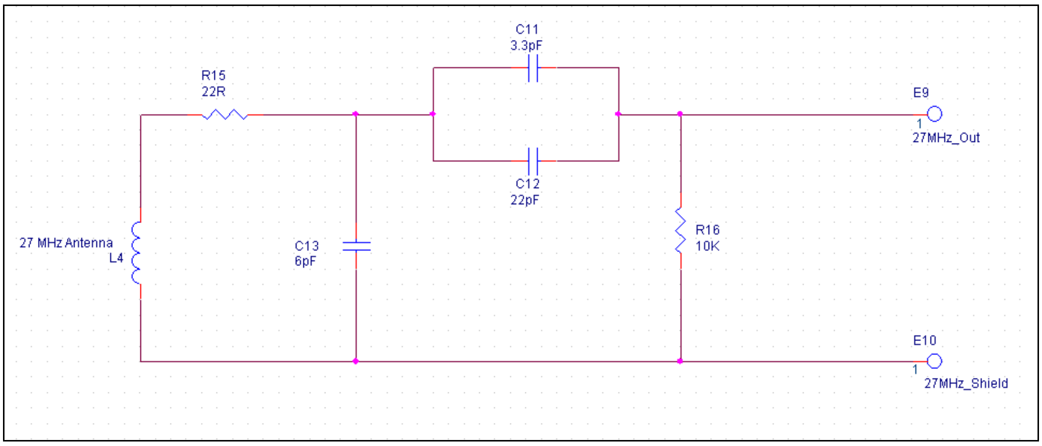

Figure 3-4 Receiver Circuitry

3.2.3 Power Supply

The Transponder antenna uses DC power to drive its oscillator which in turn generates the 200 kHz electromagnetic field.

The DC power supply (72 V nominal, 55V Min, 85 V max) passes through RC filter R2, R1 and C1.

MOV1 provides protection against any over voltage (more than 175 VDC).

D1 provides reverse voltage protection.

L1, C2 and C3 provide smoothing.

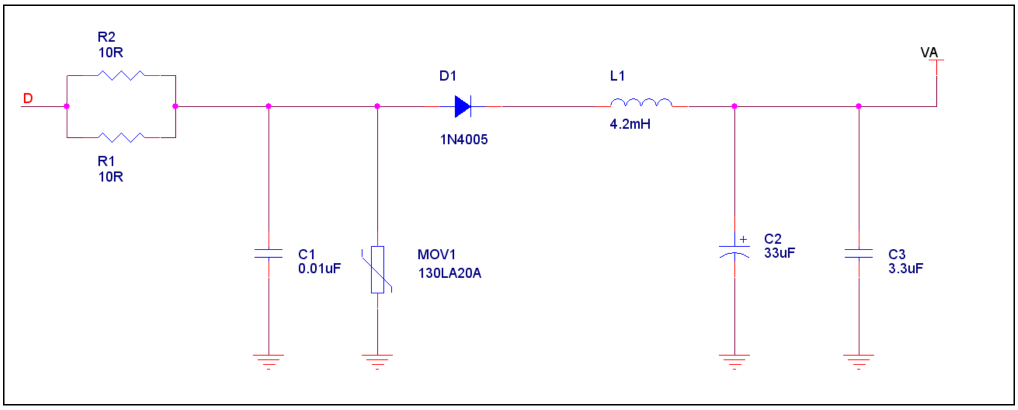

Figure 3-5 Power Supply Circuit