# Constructing a 1000 x 600 HF Antenna

## Technical Application Report

**11-08-26-007 August 2003**

***Radio Frequency Identification Systems***

## Contents



## Figures

# Edition One – August 2003

This is the first edition of this **Technical Application Report** called **Constructing a 1000 x 600 HF Antenna.**

It contains a description of how to build and tune a 1000 mm x 600 mm antenna for use at 13.56 MHz and should be used in conjunction with:

**Texas Instruments' S6500 Readers**

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## PREFACE

# Read This First

## About this Manual

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# *Constructing a 1000 x 6000 HF Antenna*

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## Abstract

This document describes the manufacture of a 1000 mm x 600 mm antenna for use as a single antenna, or one of a pair, in conjunction with Texas Instruments' S6500 High Power reader.

The document is full of pictures and constructional details for this antenna which, if properly constructed, meets the characteristics that Texas Instruments' RFID S6500 readers require:

1. Resonates at 13.56 MHz
2. Q = 20
3. 50 Ohms impedance

With the reader set to 4W, reading distances up to 800 mm are possible with a credit card sized inlay.

# 1 Construction Details

## 1.1 Main Loop

This antenna is constructed from 50mm (2") wide copper tape on 12 mm (½") thick Medium Density Fiberboard (MDF). Other non-metallic base materials can be used but should be rigid enough to prevent bending that can crease or stretch the tape. Plastic materials have the added advantage of not absorbing moisture in damp conditions.

Copper-sided tape is available with conductive and non-conductive adhesive. This antenna was made using the **conductive** type but the lower cost, **non-conductive** type can be used. Corners should be at 45º and soldered, with minimum overlap of the tape (to avoid creating capacitance). See Figure 1.

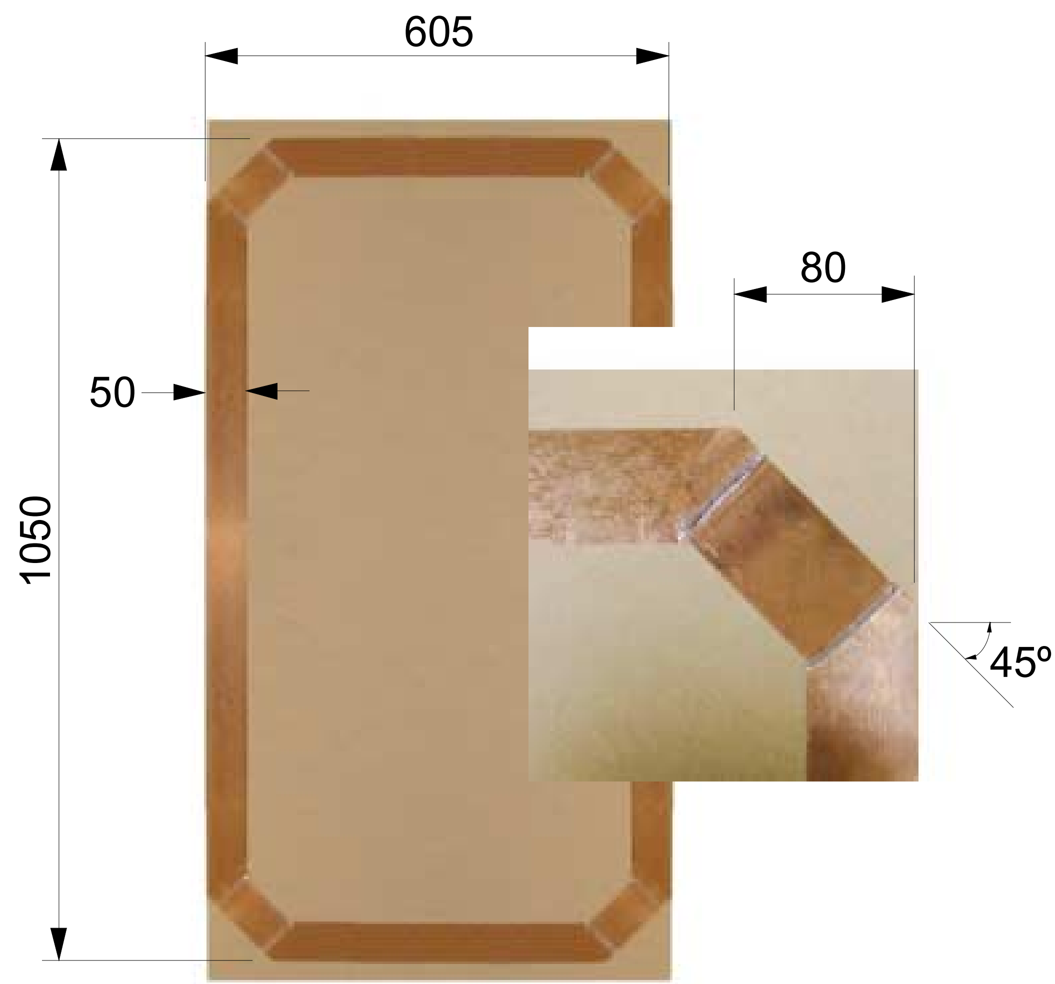


**Figure 1. Soldered Copper Tape Main Loop**

## 2 Tuning to Resonance

The main loop is cut at the top centre to form a 12 mm (½") gap, and if the inductance is now measured it will be about 2.2 µH. We have to add capacitance across the gap to make the loop naturally resonant of 13.56 MHz to satisfying equation [1]

$$f_{(res)} = \frac{1}{2\pi\sqrt{LC}} \qquad [1]$$

Where L = Inductance, C = Capacitance

This formula can be re-arranged so that we can calculate the capacitance required:

$$C_{(RES)} = \frac{1}{(2\pi f)^2 \times L} \qquad [2]$$

So for this antenna:

$$C_{RES} = \frac{1}{(2 \times 3.142 \times 13560000)^2 \times 0.0000022}$$

$$= 6.26 \times 10^{-11}$$

$$= 63 \text{ pF}$$

Rather than use a fixed value capacitor, we will use a variable (10 to 80 pF) mica capacitor, to allow for tuning the antenna. The capacitor legs are modified to allow them to be soldered to the tape


**Figure 2. Variable Mica Capacitor**

For fine tuning, a multi-turn air gap variable capacitor is used.

**Figure 3. Air Gap Variable Capacitor**

The one shown in figure 3 has a range 0.8 to 10 pF

## 3 Damping the Q

To reduce the Quality factor (Q) of the antenna, a 10K x 20 W thick film resistor is soldered across the gap. The resistor is modified by bending back one leg and soldering it to the heat sink.

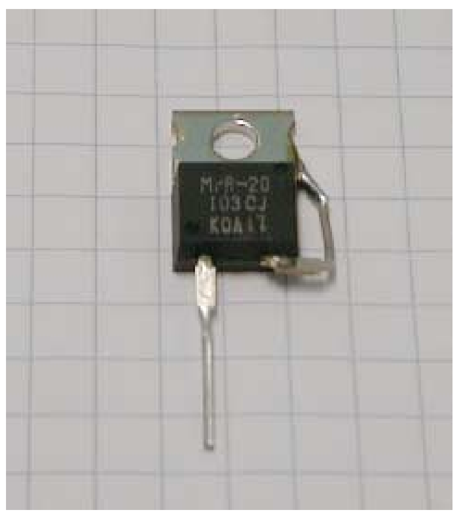

**Figure 4. 10K Thick Film Resistor**

The resistor is adequate for a reader configured to output up to 6W. If greater outputs are required, higher performance components must be used.

These components are shown soldered in position in figure 5. Note that the resistor's heat sink is bolted to the tape to ensure good heat transfer. .

**Figure 5. Resonant Capacitors and Damping Resistor**

**WARNING:**

High voltages exist at this point when the antenna is transmitting. Touching any of these components can result In RF burns or shock.

## 4 Matching the Loop to 50 Ohms

To achieve optimum performance the RG58 coax cable connecting the reader to the main loop should be a ¼ wavelength (3.63m) long and although we now have a main loop that will resonate at 13.56 MHz, it will not be at 50 Ohms impedance.

We will be using ‘T’ matching to ‘tap’ the main loop to give the correct 50 Ohm impedance.

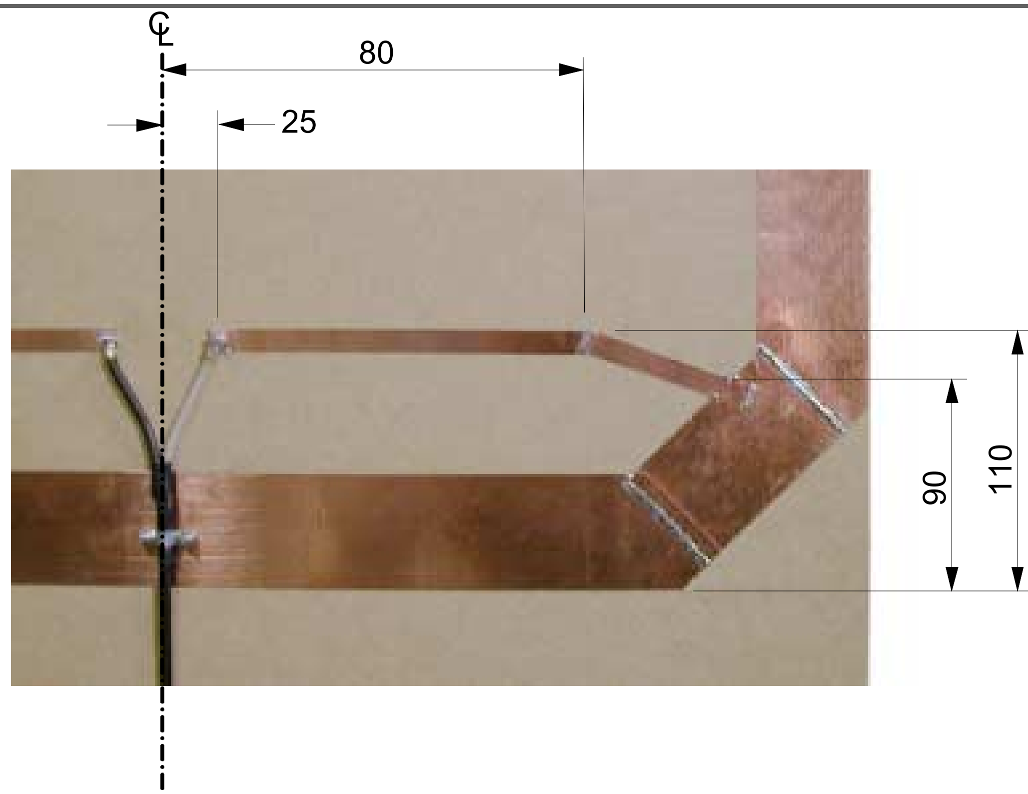


**Figure 6. Dimensions of Matching arms**

Using 12 mm wide copper tape, construct the matching arms EXACTLY as shown in figure 6. The RG58 coax cable is split into two wires (screen & core) which are terminated with eyelets and bolted to the matching arms. The cable is given extra security by using a small saddle to bolt it to the antenna. All matching arm joints are soldered

## 5 Tuning

The antenna is now complete and must be tuned.

**Figure 7. Completed Antenna**

Tuning is best done using a Voltage Standing Wave Ratio (VSWR) meter. The meter is connected between the antenna cable and the Reader. The capacitance is adjusted until a minimum needle deflection is achieved. This indicates that the antenna is close to 50 Ohms and little, or none, of the signal is being reflected because of a miss-matched antenna


**Figure 8. VSWR Meter**

## 6 Adding a Common Mode Choke

It is also recommended that a common mode choke is added to the coax cable. This can help increase reading reliability and the elimination of reading holes

**Figure 9. Common Mode Choke**

Pass the coax cable 8 times through the Ferroxcube (Philips) 4C65 grade ferrite ring core and secure with cable ties

## Materials

1. 6' x 4' x ½"  MDF or Plastic Sheet
2. Variable mica capacitor.  Arco Electronics  #462 (10 ~80 pF)
   http://www.arco-electronics.com/
3. Multi-turn air-gap capacitor (0.8 ~ 10 pF).  Tronser.  #60-0728-15010-000
   http://www.tronser.com/
4. 50 mm x 0.076mm Adhesive copper tape  Chomerics  #CCH-36-301-50.8
   http://www.chomerics.com/products/chofoil.htm
5. 12 mm x 0.076mm Adhesive copper tape  Chomerics  #CCH-36-301-12.7
   http://www.chomerics.com/products/chofoil.htm
6. 10K x 20W thick film resistor.  Vishay #RTO 20F 10K  http://www.vishay.com
7. RG58C/U coax cable.  http://www.nexans.com/
8. SMA plug Connectors for RG58 cable.   Tycho AMP #447647-1
   http://www.tycoelectronics.com/
9. Ferrite Ring Core   Ferroxcube #TN36/23/10-4C65   http://www.ferroxcube.com