TEXAS INSTRUMENTS

Technical Application Report

HF Reader Shielding

11-08-26-002 March 2001

Radio Frequency Identification Systems

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Edition One – March 2001

This is the first edition of this Technical Application Report on HF Reader Shielding**.**

It contains the description of how a HF Reader Antenna system was shielded and measurements taken for the electric and magnetic fields produced. This work has been completed using the following Regulatory Specifications:

- Europe: EN 300 330 and EN 300 683.
- USA: CFR 47 part 15.

Equipment used S6000 Reader and Antenna system for Conveyor applications.

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PREFACE

Read This First

About this Manual

This Application Report on HF Reader Shielding is for use by TI*RFID Customers who are engineers experienced with Radio Frequency Identification Devices (RFID).

Conventions

Certain conventions are used in order to display important information in this manual, these conventions are:

WARNING:

A warning is used where care must be taken or a certain procedure must be followed, in order to prevent injury or harm to your health.

CAUTION:

This indicates information on conditions, which must be met, or a procedure, which must be followed, which if not heeded could cause permanent damage to the system.

Note:

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HF Antenna Shielding Report

ABSTRACT

This report is based on work carried out at Texas Instruments facilities in Northampton and Bedford between 23 –27 November 1998.

A Reader with Antenna system, hereinafter called a read gate, was constructed using 13.56MHz HF readers. This read gate could be the basis of a system to be used in a conveyor application.

For such a read gate system it is important to understand its RFI signature conformance against the European Standards EN300-330, EN300-683 and US Standard CFR47 Part 15 with and without shielding against the performance requirement for a conveyor application.

The electric and magnetic field strengths of the read gate were measured at various positions in relation to the read gate's antennae, with and without shielding in order to get a comparison. In the conveyor application the electric field radiates up and down the length of the conveyor, whilst the magnetic field radiates at 90 degrees to it, across the conveyor.

In this type of application it important to read only the RFID Tags which pass through the read gate and not those which are being carried passed it. Therefore shielding is required to stop this interaction. Furthermore, many applications have power and communication conduits near by the antenna system therefore by shielding the read gate you effectively stop any RFI interaction in either direction.

This report shows clearly that shielding is effective and does reduce the RFI signature of the read gate down to regulated levels without any detrimental effect on the performance of the read gate.

It was also proven that when an extraneous RFID transponder was passed outside and in close proximity of the shield the transponder was not detected.

1 Introduction

1.1 General

For applications where items have to be sorted into groups or automatically read into a computer system using conveyor belts or tilt tray sortation systems, a specific reader antenna system had to be designed. Since this antenna system is rather large due to the physical constraints placed upon it, it was important to understand the RFI emissions and their relationship to the Europe and USA standards for RFID products using the frequency of 13.56MHz.

1.2 Outline

The read gate was built inside a large room where the RFI environmental conditions were measured. This was carried out to determine if there were any other radiating sources in the vicinity. Once this had been completed the test equipment was installed around the read gate at specified distances and the transmitter in the reader switched on so that the radiated characteristics of the antenna structure could be measured.

2 Antenna System

Below is a picture of the read gate under test. The design was specific to the needs of a tilt tray sortation system using 3 antennae called, loop, sides and top, each antenna was powered by an S6000 reader. This antenna combination gave a homogeneous magnetic field within the reader enclosure enabling the reading of random orientated Tag-it™ smart labels, which passed through it.

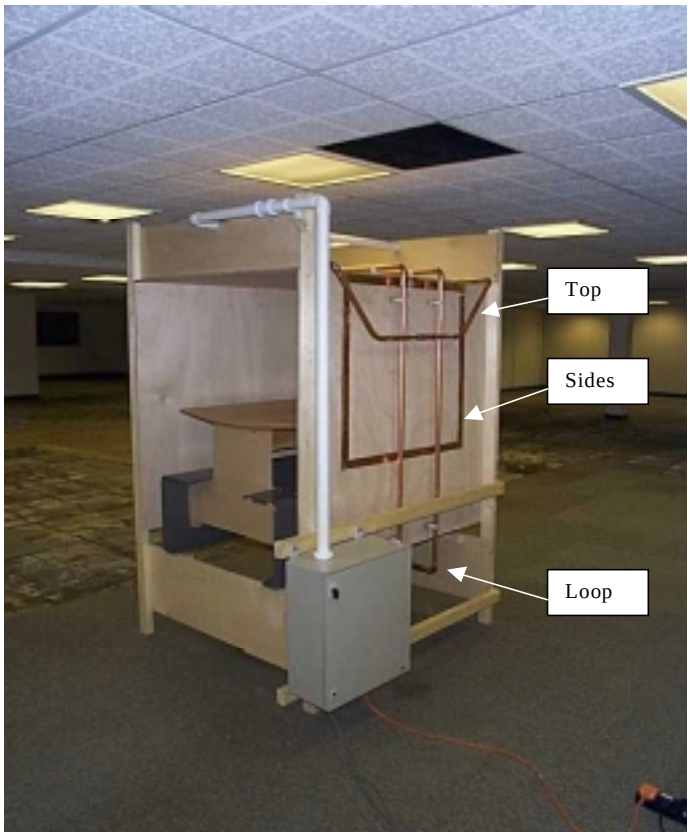

Figure 1. Antenna Array without Shielding

3 Test Setup and Test Equipment

The measurements were done at 10m distance from the antenna structure using the EMI receiver Schwarzbeck FMZB and the antenna FMLK.

All the results are relevant for 100% downlink modulation depth.

All Tag-it™ S6000 Readers were set to 1W output power into 50 Ohms.

Three positions were chosen for the measurements (at 10m distance):

- Position **(A)** in line to direction of the tilt tray system.
- Position **(B)**, 45 degrees to the direction of tilt tray system.
- Position **(C)**, 90 degrees to the tilt tray system.

Plan view

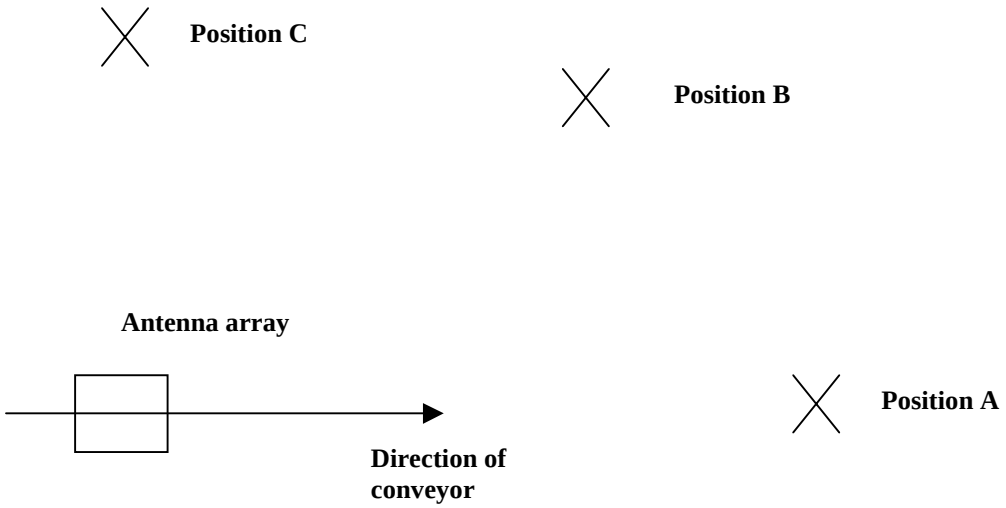

Figure 2. Diagram of test area and setup

Figure 3. Picture of test area and one measurement position

4 Measurement Results

4.1 Shielding of the Array

The shield was build of 1cm square wire mesh, fixed at a distance of 250mm from each antenna with an overall length of 2.1meters. This made the shielding 0.5m longer than the whole antenna structure.

A picture of the array with the shielding is shown below where you can see clearly the wire mesh shield surrounding the antenna. In this particular installation the shield goes the whole way around the antenna. It is important to earth the shield to the same earth plane as the antenna earth.

Figure 4. Antenna Setup with Shielding

5 Comparison of Unshielded vs. Shielded Emissions

Each antenna (Top-, Loop-, and Sides) Tag-it™ S6000 Reader's transmitter was set to CW mode (continuous wave = transmitter ON) and the resulting field strengths were measured at a distance of 10m from each antenna, as specified in the EN 300-330 standard.

The RFI measurements in CW mode were chosen because this represents the worst case emissions from the antenna system.

The Schwarzbeck EMI receiver FMZB and the antenna FMLK were used for the measurements.

The table below shows only the maximum levels measured (in dBµV/m).

	Top w/o shield	Top With shield	Loop w/o shield	Loop With shield	Side w/o shield	Side With shield
Pos. A	78	60	89	66	101	81 * max 29.5 dBµA/m
Pos. B	89	65 * max 13.5 dBµA/m	101	71 * max 19.5 dBµA/m	104	65
Pos. C	84	48	97	55	96	71

* All levels in dBµV/m, maximum values with shielding for each antenna also converted to dBµA/m

Table 1. Field strength, shielded and unshielded

The table above shows that the 'side' antenna generates the highest field strength of 101dBuV/m. The shielding reduces the worst case by 20dB down to 29.5dBµA/m.

	EN300330Limit	Top antenna	Loop antenna	Side antenna
Carrier frequency	42 dBµA/m	13.5 dBµA/m	19.5 dBµA/m	29.5 dBµA/m
Modulation frequencies	9 dBµA/m	- 7.5 dBµA/m	- 1.5 dBµA/m	8.5 dBµA/m

Table 2. Comparison with limits specified in standard EN300330 V1.2.1

The level for the modulation frequencies is calculated using the following equation:
Level of modulation frequencies = Level of carrier minus 21 dB [dBµA/m]
e.g. for the side antenna: 29.5 dBµA/m – 21 dB = 8.5 dBµA/m

To calculate the level of the modulation frequencies, the bandwidth measurement was used.

The system is at the limit of the EN 300-330 specification regarding allowed levels for modulation frequencies.
The measurement uncertainty is +/-3dB.

Separate measurements done in a shielded room show there is a maximum attenuation of 20 dB in direction of the opening of the shielding. It can be seen from figure 4 that the wire-mesh shield was bent in at 90 degrees toward the simulated conveyor. This was done to see if there was any difference in the RFI between this and straight ends. No difference could be observed between straight or bent-in ends of the wire-mesh shield at the ends of the read gate.

6 Field Strength

The field strength inside the array has been measured to determine the influence of the shielding to the charging of the Tag-it™ transponder inlay.

All measurements were made with the reader transmitter in CW mode for each antenna and directly above the center of the tilt tray / antenna array. The near field probe EMCO 2705 and a spectrum analyser were used for the measurements.

All measurements show that the resulting level is the vector sum of each antenna at that specific point.

The maximum values are:

	Without shield	With shield	Delta
Horizontal (Top antenna)	-28 dBm	-31 dBm	- 3 dB
Vertical (Side antenna)	-25 dBm	-27 dBm	- 2 dB
Orthogonal (Loop antenna)	-25 dBm	-24 dBm	- 1 dB

Table 3. Relative field strengths inside the array

The lower values are resulting from the influence of the shielding. A comparison to the values in Table 2 shows it is possible to increase the emissions from the top and loop antennae.

As can be seen from Table 2 the side antenna is already at the allowed EN300-330 limits, the power output can not be increased.

7 Comparison of CISPR and Peak detector

A relative measurement was made to determine the influence of the different detectors under various operating modes of the Tag-it™ S6000 Readers.

(**C**omate' **I**nternational **S**pecial des **P**erturbations **R**adio (CISPR) is an International body which derives methods of measurement of radio signals).

7.1 Test parameters:

Position A	**Equipment :**
Side antenna, shielded	Schwarzbeck FMLK / FMZB
Orientation 90 degrees	Rx Bw=9kHz

	CISPR dBµV/m	Peak dBµV/m
Navigator S/W, continuous mode, display on	80	82
Navigator S/W, continuous mode, display off	81	82
Transmitter on (CW)	82	82

Table 4. CISPR / Peak Comparison

Depending on command repetition rate, the use of a CISPR detector gives 1-2dB less reading than the Peak detector. As the repetition rate is set to maximum in the application, the normal operation is basically equivalent to continuous operation. In CW (i.e. continuous) mode the reading of a CISPR and Peak detector are identical. In the application, where all three antennae are used one after the other, the detector sees 3 different signal levels as each antenna takes its turn. Therefore the CISPR detector may have a lower reading than with each antenna measured separately.

8 Bandwidth of the Signal

For the EN300-330 regulations, the Tag-it™ system is limited by the modulation frequencies outside the ISM (**I**ndustrial, **S**cientific, **M**edical) band rather than by the maximum level for the centre frequency of 13.56 MHz.

The spectrum analyser used in the measurements had a resolution, which is too low for accurate bandwidth measurements. Therefore the spectrum was measured using the EMI receiver Schwarzbeck FMZB and the antenna FMLK. A receiver bandwidth of 9kHz and the CISPR detector were used. To get a stable reading, each reader's transmitter was set in continuous mode whilst the bandwidth was measured.

To get the spectrum, the measurements were made in steps of one kHz; the resulting graph is shown below:

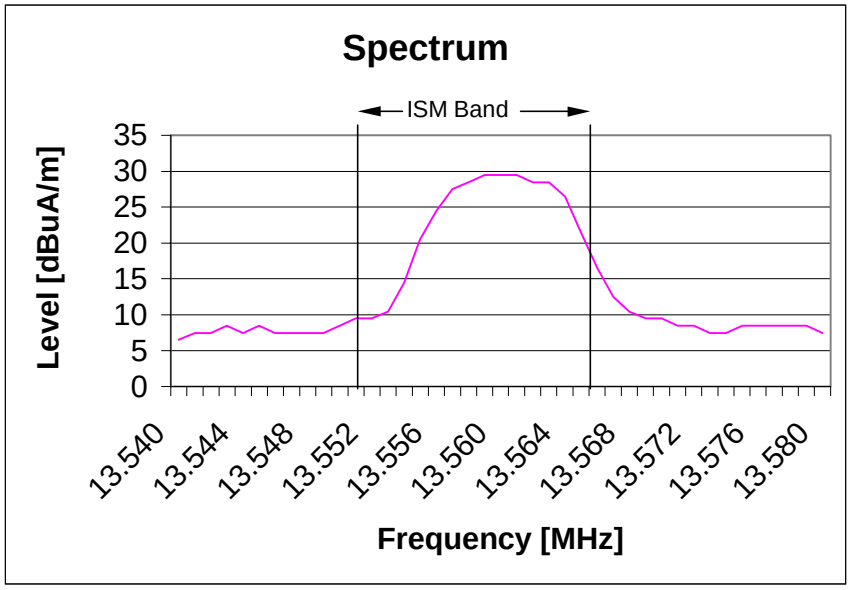

Figure 5. Tag-it System Spectrum

If the receiver is set to the borders of the ISM band, part of the energy emitted inside the ISM band is influencing the result. This is caused by the bandwidth of the receiver. Therefore an additional offset of half the bandwidth is necessary to determine the level emission caused by the downlink modulation frequencies.

The measured values are:

- Half receiver bandwidth	13.548 MHz	8.5 dBµA/m
Lower edge of ISM band	13.553 MHz	11.5 dBµA/m
ISM center frequency	13.560 MHz	29.5 dBµA/m
Upper edge of ISM band	13.567 MHz	13.5 dBµV/m
+ Half receiver bandwidth	13.572 MHz	8.5 dBµV/m

Table 5. Frequency / level distribution

The modulation frequencies are 21 dB lower than the emission of the carrier frequency.

9 Conclusion

It can be seen from Tables 1 and 2 that higher power levels, together with different antenna systems, can be used and still remain within ETSI limits for this type of product.

This is an important finding because it allows read-gates of this type to be deployed in applications where conveyor and tilt tray sortation system are used.

Although these findings have been carried out in the laboratory similar studies have been carried out on site with an exact antenna system and the results correlate. The use of shielding is very important to the operation of systems where discrete items have to be identified and sorted without interference from extraneous sources and other Tag-it™ transponders.

Note:

It must be pointed out that if the reader's transmitter power level and antenna system, deviates from the ETSI approved configuration, then the reader must gain approval by the appropriate regulatory authorities.