# Integrated TIRIS™ RF Module TMS3705A
# Introduction to Low Frequency Reader

# Application Note

**PRELIMINARY VERSION**

**TIRIS** *Technology by Texas Instruments*™

## Edition Two – October 1999

This is the second edition of the application note for the **Integrated TIRIS$^{TM}$ RF Module TMS3705A**.

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# Read This First

## About TIRIS

TIRIS (Texas Instruments Registration and Identification Systems) manufactures Radio Frequency Identification Devices (RFID) and systems.

## About This Application Note

The purpose of this note is to give an overview of the TMS3705A functionality.
It does not cover all the details of the comprehensive data sheet.

**NOTE**

Please see the following data sheet for further reference:

TMS3705A TRANSPONDER BASE STATION IC, Rev. 1.0 – June 1999

**Regulatory and safety notes that need to be followed are given in Chapter 5 – Regulatory Notices and Ordering.**

# Document Overview

This application note is composed of the following sections:

**Chapter 1**      **Introduction**

Gives a general description of the TIRIS System.

**Chapter 2**      **Key Features of the TMS3705A**

Outlines the key features of the TMS3705A, a base station IC for TIRIS.

**Chapter 3**      **Sequence Control**

Provides general hints for initialization of the IC.

**Chapter 4**      **Circuit Description of the Sample RF Module.**

Describes a sample circuit using the TMS3705A.

**Chapter 5**      **Regulatory Notices and Ordering**

Information on regulatory notices and ordering procedures.

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# Introduction

## INTRODUCTION

A TIRIS setup consists of one or more Transponders and a Reader. The Reader described in this application note normally contains the Reader Antenna, the RF Module and the Control Module.

A TIRIS RF Module is the interface between the TIRIS transponder and the Control Module (data processing unit) of a TIRIS Transponder Reading/Writing System. It has the capability to charge up a TIRIS transponder, to write to and program a read/write or multipage one, to receive the transponder response signal and to demodulate it for further digital data processing.

The Control Module in this application example operates as interface for a PC which takes over the display and command input functions. In such a configuration the Control Module handles most data protocol items and the detailed fast timing functions. In other applications like automotive immobilizers the Control Module can be part of the Engine Management Unit.
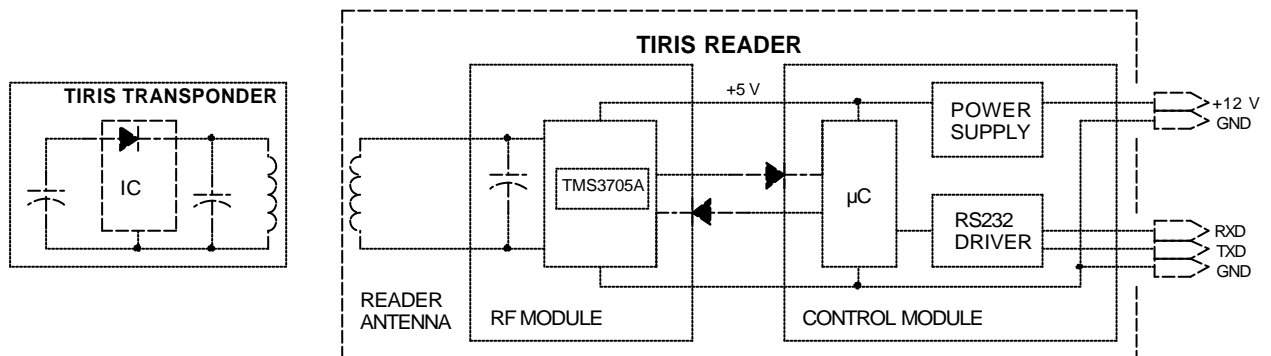
Figure 1: TIRIS Sample Setup Without PC

# Key Features of the TMS3705A

## PLL FOR THE SYSTEM CLOCK

An integrated PLL system generates the 16 MHz system clock which determines the different internal timings. Using the lower 2 or 4 MHz oscillator as reference for the PLL system minimizes the emissions of electromagnetic interference.

## CERAMIC RESONATOR FOR REFERENCE OSCILLATOR

The digital FSK demodulator of the TMS3705A can vary the discriminator level for its high respectively its low frequency. Therefore the use of a ceramic resonator becomes possible instead of the more expensive crystal.

## FULL BRIDGE DRIVER STAGE

The IC TMS3705A is manufactured in a CMOS process and contains all elements needed to build a TIRIS RF Module. This includes two push pull stages forming a full bridge to drive the antenna circuit directly. Their drive capability ($I\_OC\_min$) covers low range applications such as automotive immobilizer or contactless identification. In case of a short circuit producing a higher current than $I\_OC\_max$ the over current protection circuit disables the driver stages for a duration $t\_doc$.

## FULLY INTEGRATED BANDPASS AMPLIFIER

To amplify the low antenna signal to logic level the IC contains a pre-amplifier, two band pass amplifiers and a sensitive Schmitt Trigger stage. While the gain of the pre-amplifier can be adjusted with two external resistors, the following band pass stages are fully integrated.

## MULTIFUNCTIONAL TWO WIRE INTERFACE

All communication between the RF Module and the Control Module is done with only two signal lines. While one line carries the demodulated data from the transponder, the other line is used to control and to modulate the transmitter and to set the IC into the different modes by sending the mode byte in front of a transmitter activation.

# Sequence Control

## INITIALIZATION

For proper Mode Control Write, it is essential to know if the TMS3705A is in IDLE or SLEEP State.

Independent of the SLEEP or IDLE state of the IC, the timing in Figure 2 can be used. The timing is given for a Read Only transponder, but the wake sequence can also be used for other transponder types.
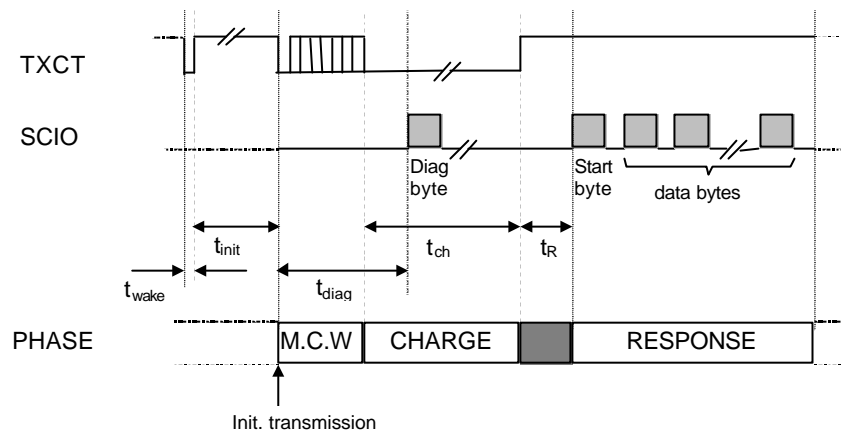


Figure 2: MCR Programming

The wake pulse (low) must be shorter than $t_{mcr}$ ($t_{wake} \ll t_{mcr}$; $t_{wake} =$ typ 50us) to avoid that the wake pulse is interpreted as a start of transmission.

After the wake pulse, the TXCT signal must be high for at least the maximum time of the minimum initialization time $t_{init\ min}$.

The proposed timing assures that an IC in Sleep Mode will switch to IDLE state. In case the IC was already in IDLE state, the wake pulse will not have an effect and it will remain in IDLE state.

# Circuit Description of the Sample RF Module

For the following discussion please refer to figure 3 with the schematic of a sample RF module.

## THE OSCILLATOR SYSTEM

The reference oscillator for the internal PLL system clock uses a 3 pin ceramic resonator. Those resonators are available with build-in load capacitors so that the capacitors C4 and C5 can be omitted. If crystals are used, C4 and C5 are needed and their value depend very much on the crystal itself. The PLL system allows the use of two different reference frequencies, either 4.0 MHz or 2.0 MHz. For a 4 MHz resonator the F_SEL input must be put to VDD level or to GND if a 2 MHz resonator is used. If one of these two frequencies are already available in the system and it has logic level then this signal with logic level can be fed directly into the OSC1 input.

With the higher frequency tolerance of the ceramic resonator the 16 MHz system clock gets also more variation and with this the transmission rate of the SCIO data output changes in asynchronous mode. If this variation cannot be tolerated by the Control Module, the data output stage can be switched into synchronous mode.

## ANTENNA CIRCUIT

The antenna circuit is mainly formed by the resonance capacitor C1 and the antenna coil which is connected to the connector J1. The antenna circuit is driven by the push-pull output stages at the terminals ANT1 and ANT2 which can be seen as fast digital switches. These produce harmonic interference. To minimize this interference each driver stage is fed to the antenna circuit via a low pass RC filter (R3/C3; R4/C2). These filters are helpful especially if the antenna coil and the RF Module are not combined. In such a case the line to the antenna coil could operate as antenna for the high frequency interference.

Because of the resistors R3 and R4 are in line with the antenna circuit, they reduce the quality factor of the resonance circuit so that the unloaded quality factor of the coil must be higher to achieve the same reading performance. Using additional resistors in line with antenna coil winded with copper wire can stabilize the quality factor of the antenna circuit versus temperature.

## PRE-AMPLIFIER

During receive phase both outputs ANT1 and ANT2 are switched to GND. The built-in pre-amplifier operates as internal biased operational amplifier. The resistors ratio R2/R1 determines the gain factor which should not be greater than 5. If the gain is higher than 5 the amplifier output can run into its upper limiting area due to the internal DC biasing.

## INTERFACE CIRCUIT TO THE CONTROL MODULE

The control input TXCTL of the RF Module activates the transmitter if it is low level. To prevent transmitting continuously if the line to the controller is accidentally interrupted the resistor R7 pulls up the signal to high level. This TXCTL control line transfers the modulation signal and the Mode Control Byte. To improve its electromagnetic susceptibility a low pass RC filter R6/C6 is introduced to this line.

The RX data output SCIO of the IC is protected against a short circuit to GND by the serial resistor R5.

In case of a very noisy environment and long signal lines between the RF Module and the Control Module additional circuitry might be needed to avoid damaging the IC terminals by overvoltage or mal functions by corrupted data.
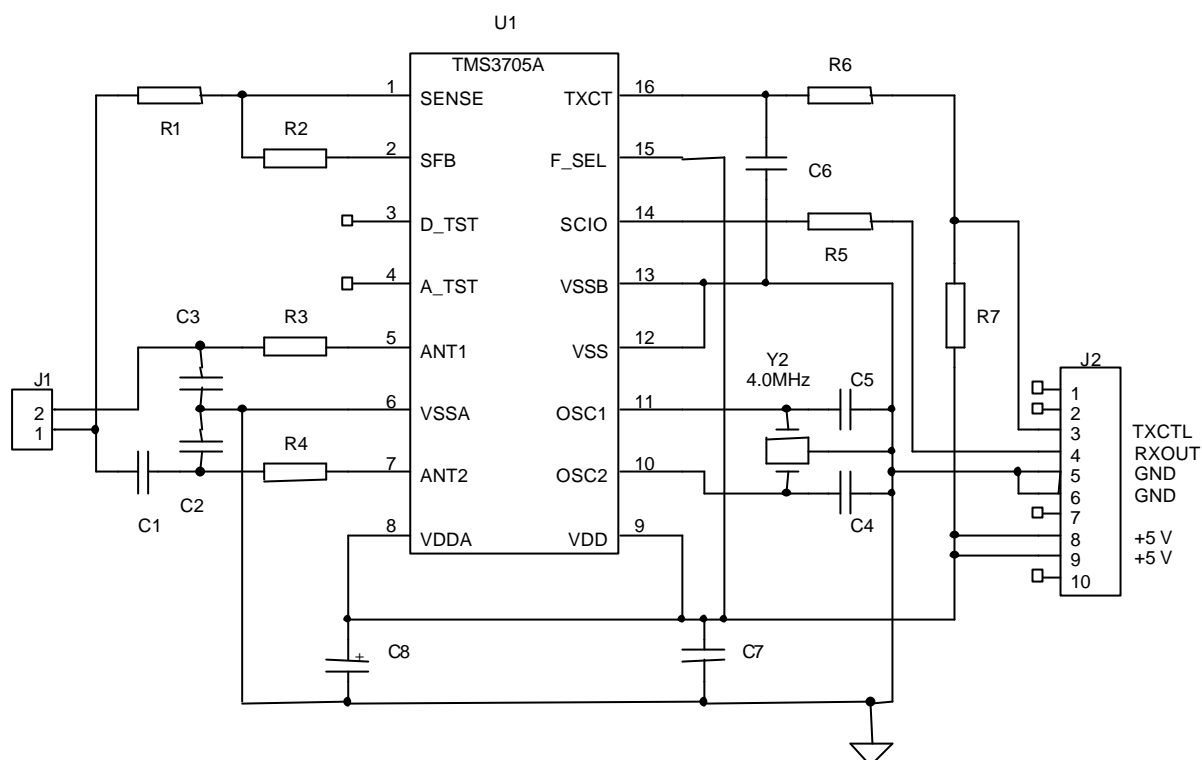
Figure 3:  Schematic Diagram for Sample RF Module

Table 1:  Component List for Sample RF Module

| Pos. | Ref. | Description | Shape | Value |
|------|------|-------------|-------|-------|
| 1 | U1 | TIRIS ASIC | SO16 | TMS3705AD |
| 2 | Y1 | Ceramic Resonator | 3pin | 4.0 MHz |
| 3 | C1 | Ceramic Capacitor | 1210 | 3.3nF, 50V, 2% matching with Antenna coil |
| 4 | C2 | Ceramic Capacitor | 0603 | 220 pF, 50V |
| 5 | C3 | Ceramic Capacitor | 0603 | 220 pF, 50V |
| 6 | C4 | Ceramic Capacitor | 0603 | (10 pF) see description |
| 7 | C5 | Ceramic Capacitor | 0603 | (10 pF) see description |
| 8 | C6 | Ceramic Capacitor | 0603 | 1 nF, 50V |
| 9 | C7 | Ceramic Capacitor | 1206 | 0.1 uF, 50V |
| 10 | C8 | Tantalum Capacitor | D | 22 uF, 16V |
| 11 | R1 | Resistor | 0603 | 47 kOhm |
| 12 | R2 | Resistor | 0603 | 150 kOhm |
| 13 | R3 | Resistor | 1206 | 4.7 Ohm |
| 14 | R4 | Resistor | 1206 | 4.7 Ohm |
| 15 | R5 | Resistor | 0603 | 220 Ohm |
| 16 | R6 | Resistor | 0603 | 1 kOhm |
| 17 | R7 | Resistor | 0603 | 10 kOhm |
| 18 | J1 | Connector | R= 2.54 mm | 2 pin female |
| 19 | J2 | Connector | R= 2.54 mm | 10 pin male |

Table 2:  Pin Assignment of the Connector J2 of the Sample RF Module

| Pin No | Pin Function |
|--------|--------------|
| 1 | not used |
| 2 | not used |
| 3 | TXCTL- |
| 4 | RXOUT |
| 5 | GND |
| 6 | GND |
| 7 | not used |
| 8 | +5 V |
| 9 | +5 V |
| 10 | reserved for +12 V |

## ANTENNA COIL

Figure 4 shows the Coil Former of the Sample Antenna.

Antenna Inductance  = ~440 µH
                Coil  = 66 turns,
                Wire  = enameled copper wire
    Wire diameter  = 0.18 mm diameter
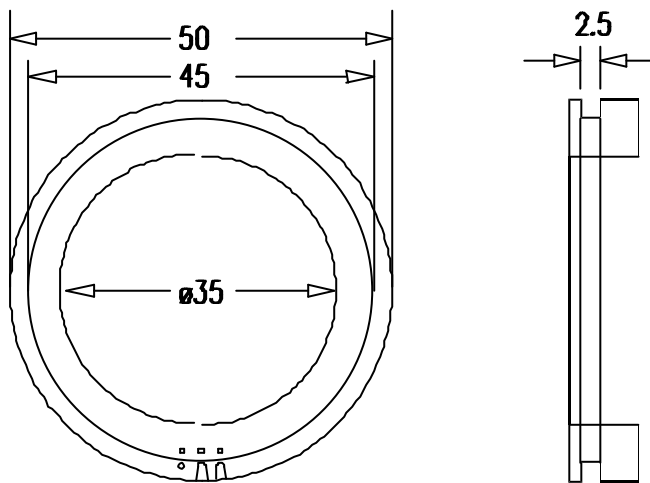


all dimensions in mm

Figure 4:  Sample Coil Former

***The antenna is designed for a free air application. A parallel resistor of 15kOhm should be connected to the antenna to reduce the quality factor. If the antenna is mounted on a keylock, the antenna parameters have to be redefined.***

# Regulatory Notices and Ordering

## REGULATORY NOTICES

A TIRIS RF Module generates RF emissions at 127 to 142 kHz. The radiation of the fundamental and the harmonics will vary with the type of antenna and other devices or functions connected to the RF module.

Prior to operating a TIRIS RF Module with antenna(s), power supply and a control module or other devices, the required FCC or PTT approvals must be obtained.

Sale, lease or operation in other countries may be subject to prior approval by the government or other organizations.

This reader can only be operated and/or marketed if the relevant FCC, PTT or other government agency has issued an equipment authorization for a complete system.

For marketing functional systems within the European Community, a Declaration of Conformity to European EMC laws is required.

## ORDERING

For ordering please contact your nearest TIRIS Sales and Application Center.

Application Centers are located in Europe, North and South America, the Far East and Australia to provide direct engineering support.

For more information, please contact your nearest TIRIS Sales and Application Center. The contact addresses can be found on our home page:

http://www.tiris.com