

# **Integrated TIRIS™ RF Module TMS3705 Introduction to Low-Frequency Reader**

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## **ABSTRACT**

This application report gives an overview of the TMS3705 functionality. For details of the device, refer to the [TMS3705 Transponder Base Station IC data sheet](#).

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## **Trademarks**

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## 1 Document Overview

This application report contains the following sections:

[Section 2, Introduction:](#) Gives a general description of the TIRIS™ system

[Section 3, Key Features of the TMS3705:](#) Outlines the key features of the TMS3705, a base station IC for TIRIS.

[Section 4, Sequence Control:](#) Provides general hints for initialization of the IC.

[Section 5, Circuit Description of the Sample RF Module:](#) Describes a sample circuit using the TMS3705A.

[Section 6, Regulatory Notices and Ordering:](#) Information on regulatory notices and ordering procedures.

## 2 Introduction

A TIRIS application consists of one or more transponders and a reader. The reader described in this application report 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 can charge a TIRIS transponder, write to and program a read/write or multipage transponder, receive the transponder response signal, and demodulate the signal for further digital data processing.

The control module in this application example operates as interface for a PC that manages 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.

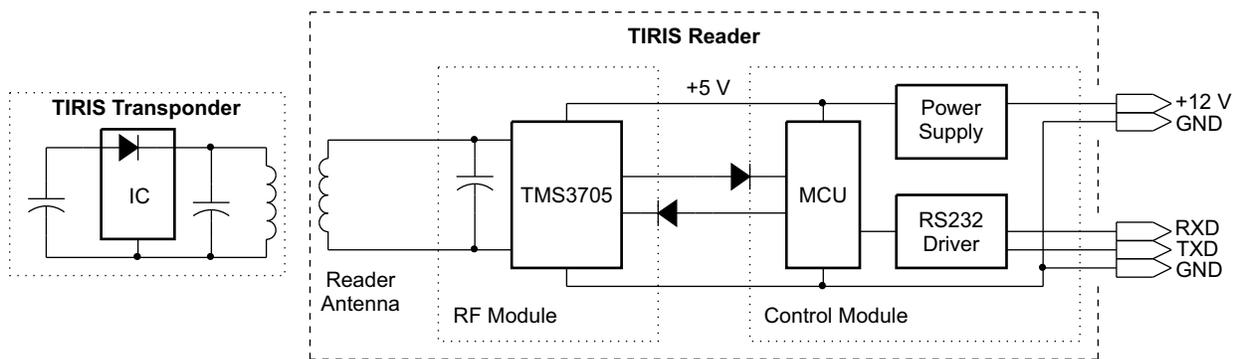


Figure 1. TIRIS Sample Setup Without PC

## 3 Key Features of the TMS3705

### 3.1 PLL for the System Clock

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

### 3.2 Ceramic Resonator for Reference Oscillator

The digital FSK demodulator of the TMS3705 can vary the discriminator level for its high and low frequencies. Therefore, a ceramic resonator can be used instead of a more expensive crystal.

### 3.3 Full-Bridge Driver Stage

The TMS3705 IC is manufactured in a CMOS process and contains all elements needed to build a TIRIS RF module. These elements include two push-pull stages that form a full bridge to drive the antenna circuit directly. Their drive capability ( $I_{OC\_min}$ ) supports short-range applications such as automotive immobilizers or contactless identification. If a short circuit produces a current higher than  $I_{OC\_max}$ , the overcurrent protection circuit disables the driver stages for the time  $t_{doc}$ .

### 3.4 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.

### 3.5 Multifunctional 2-Wire Interface

All communication between the RF module and the control module is done with only two signal lines. One line carries the demodulated data from the transponder, and 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 before a transmitter activation.

## 4 Sequence Control

### 4.1 Initialization

For proper mode control write, it is essential to know if the TMS3705 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.

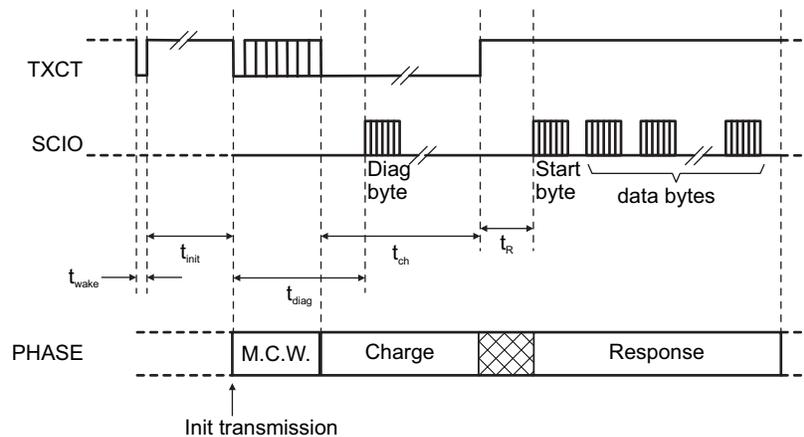


Figure 2. MCR Programming

The wake pulse (low) must be shorter than  $t_{mcr}$  ( $t_{wake} \ll t_{mcr}$ ;  $t_{wake} = 50 \mu s$  typical) to avoid the wake pulse being interpreted as a start of transmission.

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

The proposed timing assures that an IC in sleep mode switches to idle state. If the IC was already in idle state, the wake pulse has no effect and the IC remains in idle state.

## 5 Circuit Description of the Sample RF Module

The descriptions in the following sections refer to the schematic of a sample RF module in [Figure 3](#).

### 5.1 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 a crystal is used, C4 and C5 are required, and their values depend 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 set to VDD level. For a 2-MHz resonator, the F\_SEL input must be set to GND level. If one of these two frequencies is already available in the application and it has logic level outputs, this signal can be fed directly into the OSC1 input.

With the higher frequency tolerance of the ceramic resonator, the 16-MHz system clock also varies more, which changes 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 set to synchronous mode.

### 5.2 Antenna Circuit

The antenna circuit is formed by the resonance capacitor C1 and the antenna coil that 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 through a low-pass RC filter (R3/C3 and R4/C2). These filters are particularly helpful 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 high-frequency interference.

Because resistors R3 and R4 are inline 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 inline with antenna coil wound with copper wire can stabilize the quality factor of the antenna circuit during temperature fluctuations.

### 5.3 Pre-Amplifier

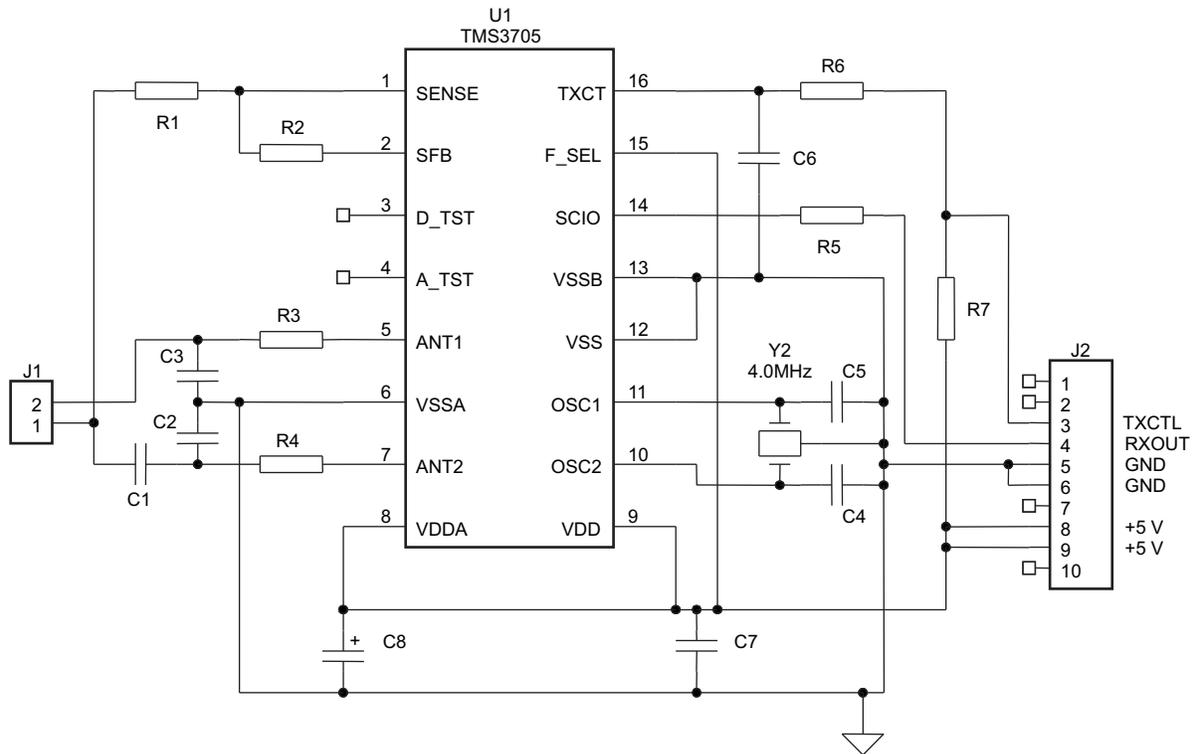
During receive phase, outputs ANT1 and ANT2 are held at GND. The built-in pre-amplifier operates as internal biased operational amplifier. The resistor ratio of R2/R1 determines the gain factor, which should not be greater than 5. If the gain is higher than 5, the amplifier output can reach its upper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

### 5.4 Interface Circuit to the Control Module

The RF module control input TXCTL activates the transmitter if it is low level. To prevent transmitting continuously if the line to the controller is accidentally interrupted, resistor R7 pulls the signal up 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 malfunctions by corrupted data.


**Figure 3. Schematic Diagram for Sample RF Module**
**Table 1. Component List for Sample RF Module**

Position	Reference	Description	Shape	Value
1	U1	TIRIS ASIC	SO16	TMS3705
2	Y1	Ceramic resonator	3 pin	4.0 MHz
3	C1	Ceramic capacitor	1210	3.3 nF, 100 V or higher, NPO, COG, 2% matching with antenna coil
4	C2	Ceramic capacitor	0603	220 pF, 50 V
5	C3	Ceramic capacitor	0603	220 pF, 50 V
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, 50 V
9	C7	Ceramic capacitor	1206	0.1 uF, 50 V
10	C8	Tantalum capacitor	D	22 uF, 16 V
11	R1	Resistor	0603	47 k $\Omega$
12	R2	Resistor	0603	150 k $\Omega$
13	R3	Resistor	1206	4.7 $\Omega$
14	R4	Resistor	1206	4.7 $\Omega$
15	R5	Resistor	0603	220 $\Omega$
16	R6	Resistor	0603	1 k $\Omega$
17	R7	Resistor	0603	10 k $\Omega$
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 Number	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

### 5.5 Antenna Coil

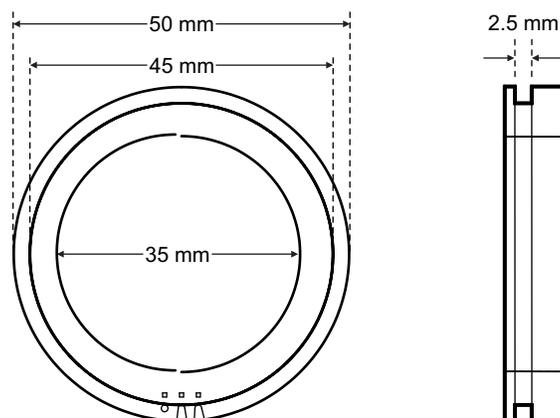
Figure 4 shows the coil former of the sample antenna.

Antenna inductance  $\approx 440 \mu\text{H}$

Coil = 66 turns

Wire = enameled copper wire

Wire diameter = 0.18 mm



NOTE: The antenna is designed for a free-air application. Connect a parallel resistor of 15 k $\Omega$  to the antenna to reduce the quality factor. If the antenna is mounted on a keylock, the antenna parameters must be redefined.

**Figure 4. Sample Coil Former**

## **6 Regulatory Notices and Ordering**

### **6.1 Regulatory Notices**

A TIRIS RF module generates RF emissions at 127 to 142 kHz. The radiation of the fundamental and harmonic frequencies varies with the type of antenna and other devices or functions connected to the RF module.

Before operating a TIRIS RF module with an antenna, 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 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.

### **6.2 Ordering**

To order, visit <http://www.ti.com/product/TMS3705>.

## Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

<b>Changes from October 1, 1999 to March 6, 2020</b>	<b>Page</b>
• Changed the device name from TMS3705A to TMS3705; general edits throughout document; layout updates throughout document; removed former preface .....	1
• Changed <a href="#">Figure 2</a> , <i>MCR Programming</i> .....	3
• Changed the value of C1 in <a href="#">Table 1</a> <i>Component List for Sample RF Module</i> .....	5
• Updated the link in <a href="#">Section 6.2</a> <i>Ordering</i> .....	7

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