Application Report

SCBA031 – August 2012

TMS3705 Range Extender Power Solution Using UCC27424-Q1

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ABSTRACT

This application report provides supplementary information about the Texas Instruments 134.2 kHz RFID Base Station IC TMS3705x in combination with an external driver IC. In particular, the document shows a low cost and easy-to-implement solution to improve the communication distance between the transaction processor (TRP) and the Reader unit.

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1 Introduction

The Texas Instruments low-frequency transponder Base-Station IC supports all TI low-frequency transponders types. For certain applications, a higher filed strength is required in order to extend the communications distance or increase the charge current in applications where a wireless battery charge is used. With the combination of the two TI devices, an easy implementation is possible.

In addition, faster down-link modulation can be realized by using the TMS3705x as an oscillator only and performing the modulation with the enable input of the UCC27424. In this way a minimum transmitter on-off time is possible (15 µs @ 134.2 kHz).

The UCC27423, UCC27424 and UCC27425 high-speed dual MOS field effect transistor (MOSFET) drivers can deliver a large peak current into capacitive loads. For the specific application, the dual non-inverting type is used.

2 Main Features

- Drive of higher antenna current
- Increase of communication distance
- Use of low-inductance antennas because of higher driver current capability
- Few additional components necessary
- Reference designs are available
- Realization of rechargeable applications (for example, PaLFI)
- Use for active hands-free access systems (motor bikes, machine access)

2.1 Conventional System

The circuitry in Figure 1 shows the standard TMS3705x schematic if “no” antenna cable is used. For more information, see the *TMS3705 Transponder Base Station IC Datasheet* (SCBS881).

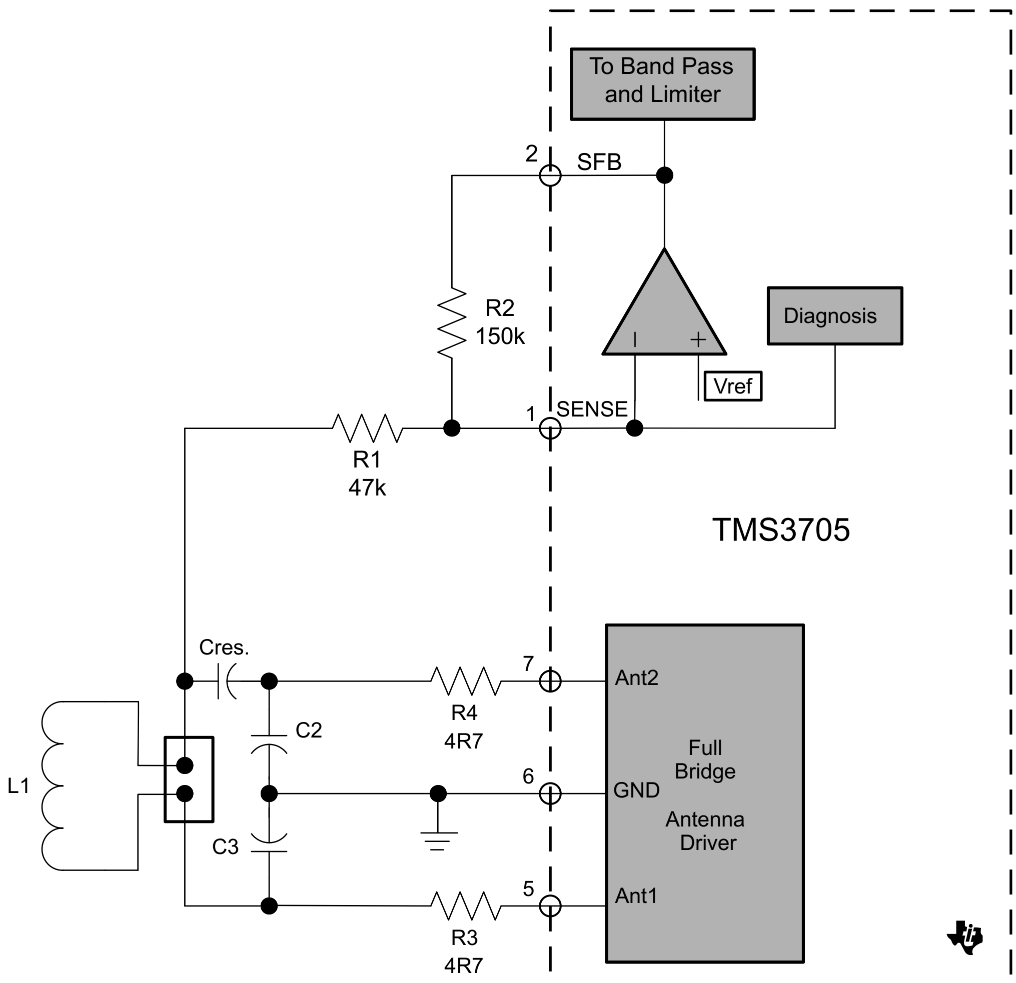

Figure 1. Standard HDX RFID Reader Configuration

2.2 System Using an External Full Bridge Amplifier

The circuitry in Figure 2 shows the combination of the TMS3705 plus an external amplifier. The outputs of the TMS3705 are simply connected to the inputs of the amplifier. Since the amplifier is supplied by a higher supply voltage, a higher antenna current can be driven.

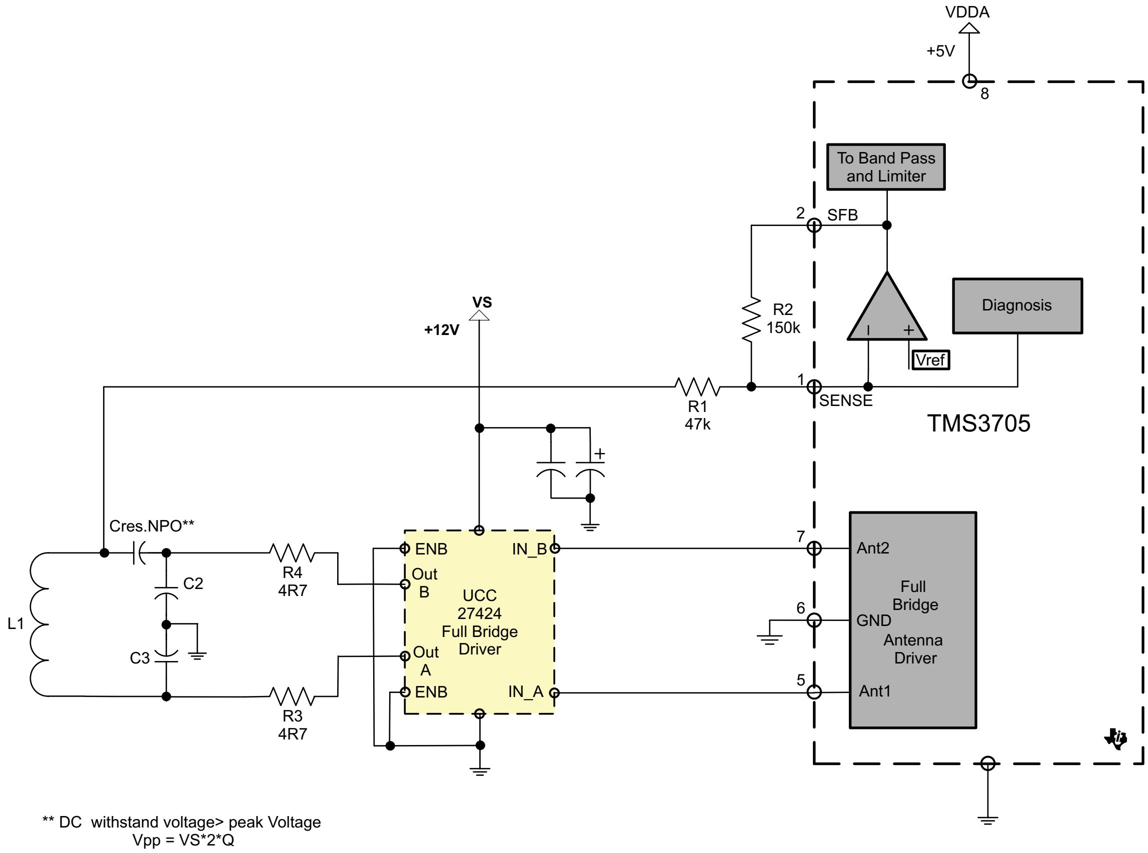

Figure 2. TMS3705x With External Amplifier

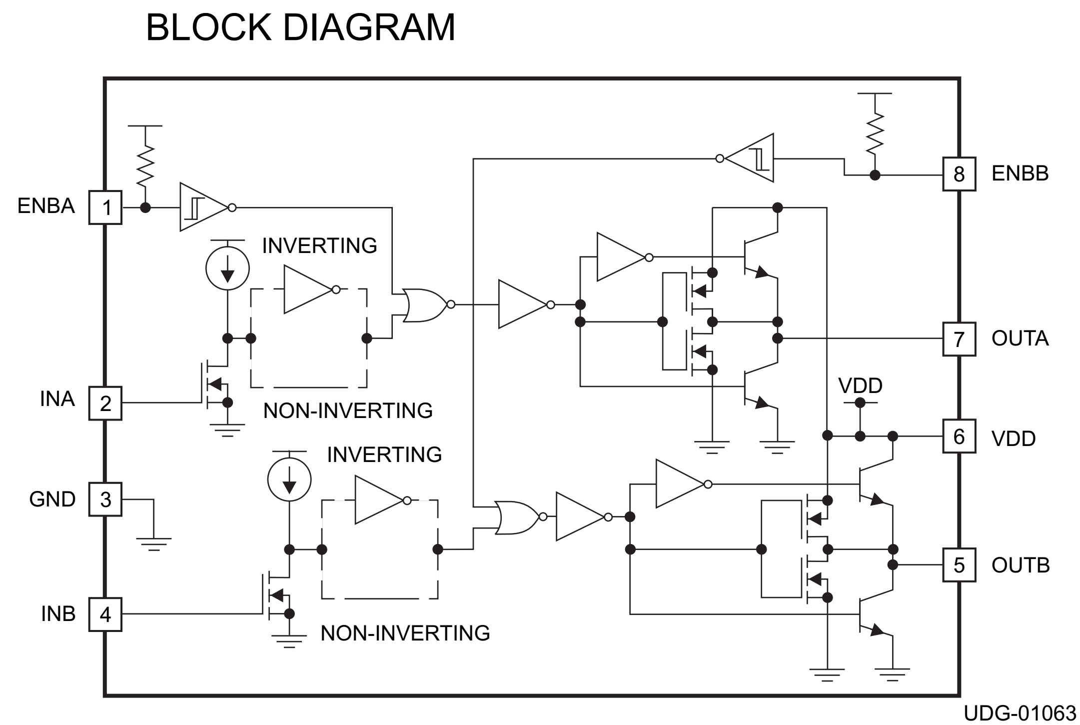

Figure 3. Circuit Block Diagram of External Amplifier UCC27424

2.3 System Considerations

An active identification system is located on the base station side of a low frequency transmitter and a UHF receiver, while the identification device (Key) has a low frequency receiver (3D Analog Front End) in combination with a Micro controller and a UHF Transmitter.

2.4 Typical Base Station for a Hands-Free System

Figure 4 shows a typical system for realizing a hands-free system that can be used for access of machines, for example, motor bikes. Also a wireless anti-theft system can be realized in combination with an active key fob.

Depending on the transmit antenna parameters, as well as the fob antenna parameters, a wake up distance up to two meters can be reached.

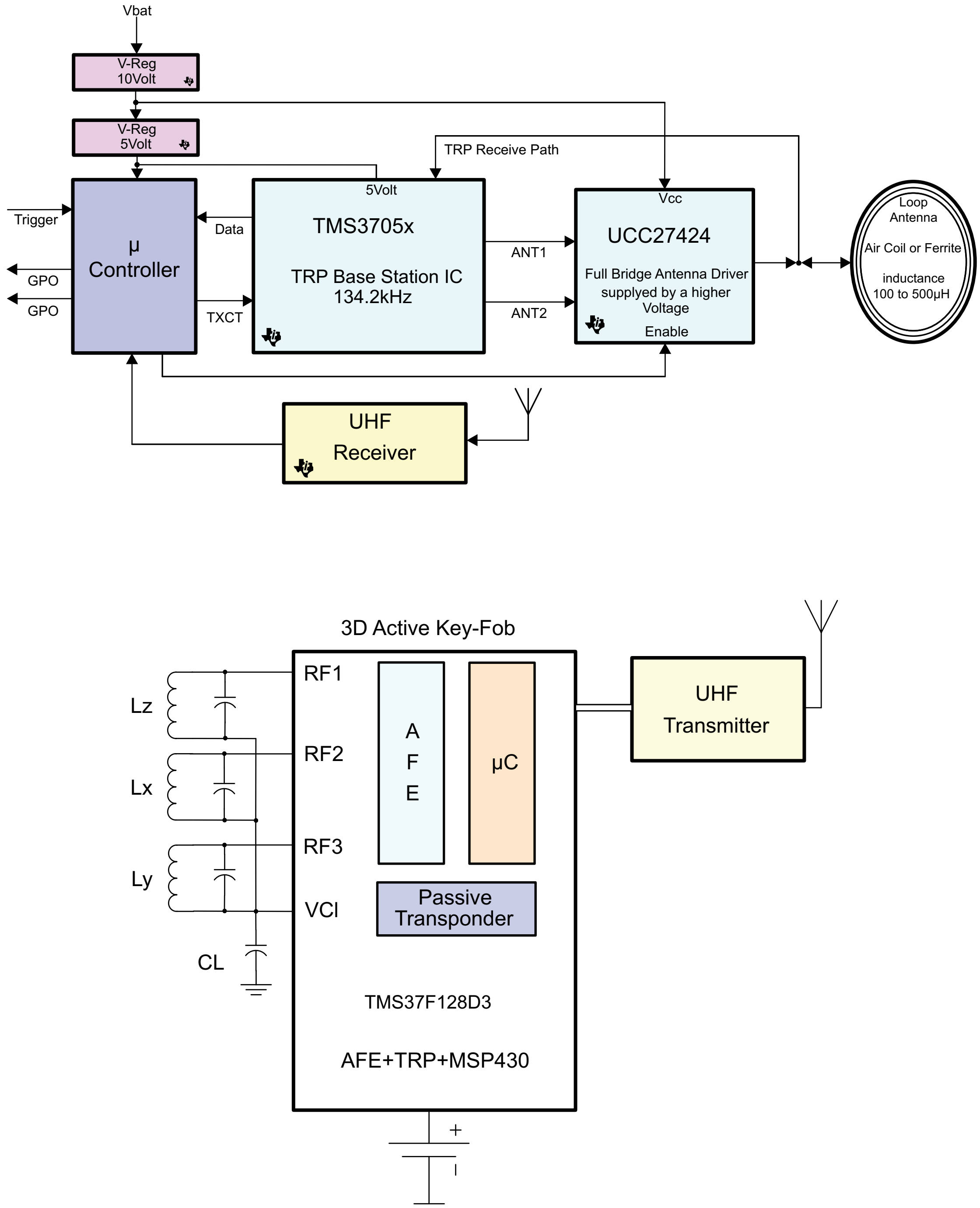

Figure 4. Typical LF-UHF Hands-Free System

3 System Options

3.1 Remote Antenna System – "Long" Antenna Cable

The extended power solution can also be combined with the long antenna cable system as shown in Figure 6.

The generic circuitry for the "long" cable application shows the additional recommended components that are needed.

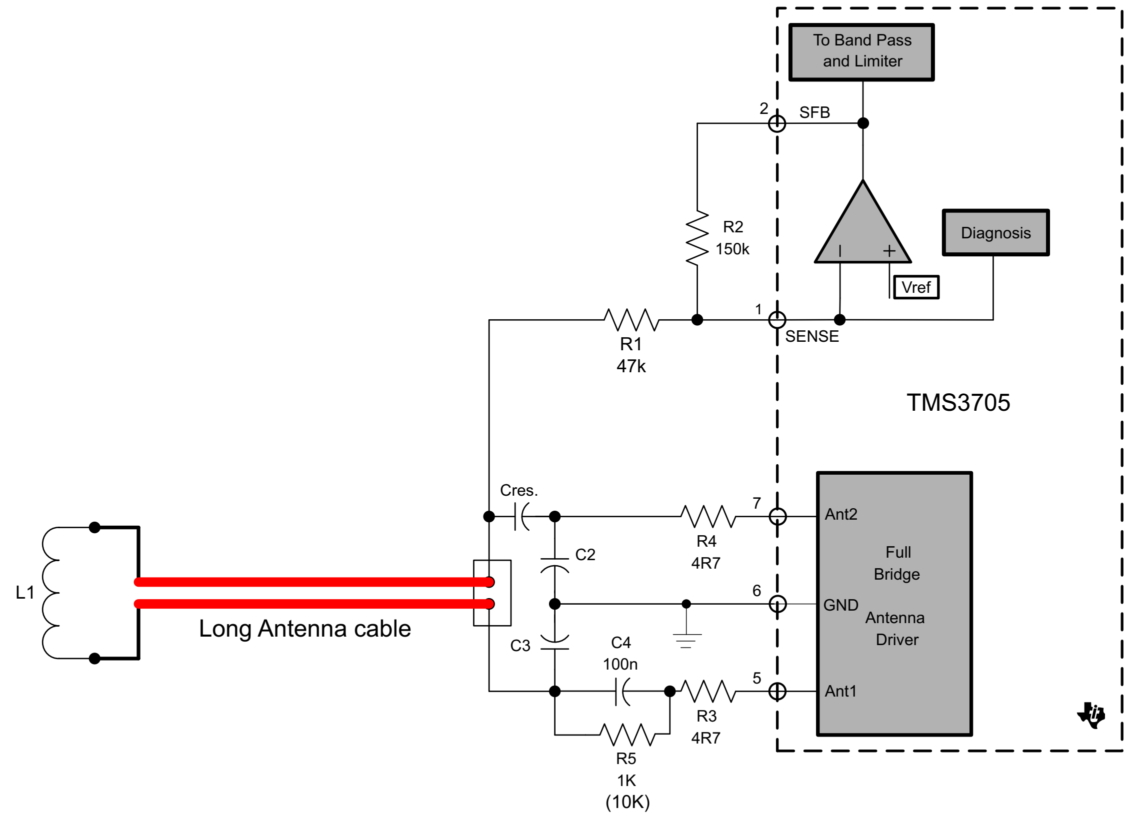

Figure 5. Conventional “Long” Antenna Cable Solution

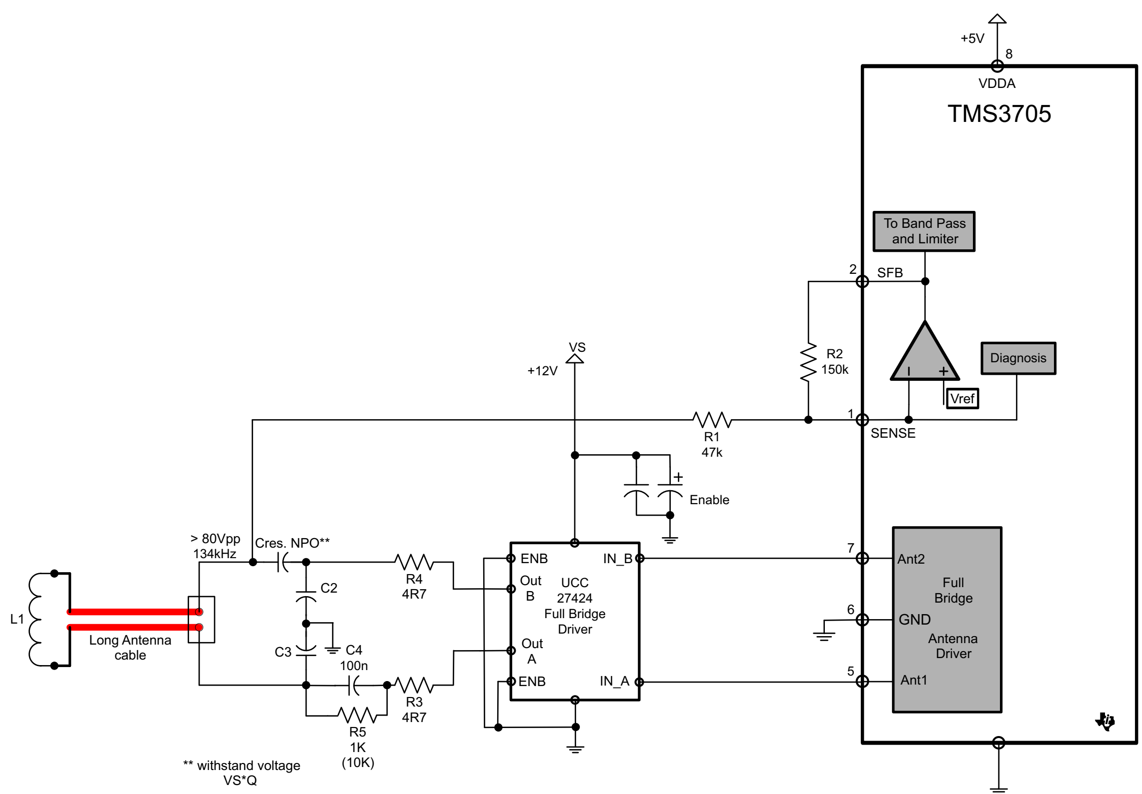

Figure 6. Extended Power Configuration with “Long” Antenna Cable

3.2 Transmitter Modulation

The following block describes the different possibilities to modulate the low frequency field.

3.2.1 Normal Modulation Using the 3705 TXCT Input

The data transmission in the direction of the transponder (downlink) is done with 100% AM modulation. The coding is transponder specific and requires transponder-specific timing. Data coding is, for example, pulse width modulation (PWM) or pulse position modulation (PPM).

The specific downlink coding is defined in the transponder specification. In general, it is always a particular transmitter ON-OFF sequence.

For the TMS3705x, the minimum transmitter ON and OFF time is 100 µs. This is determined by the t_{dwrite} signal delay for controlling the full bridge antenna driver.

For more information, see the *SWITCHING CHARACTERISTICS* section in the *TMS3705 Transponder Base Station IC Data Sheet* (SCBS881).

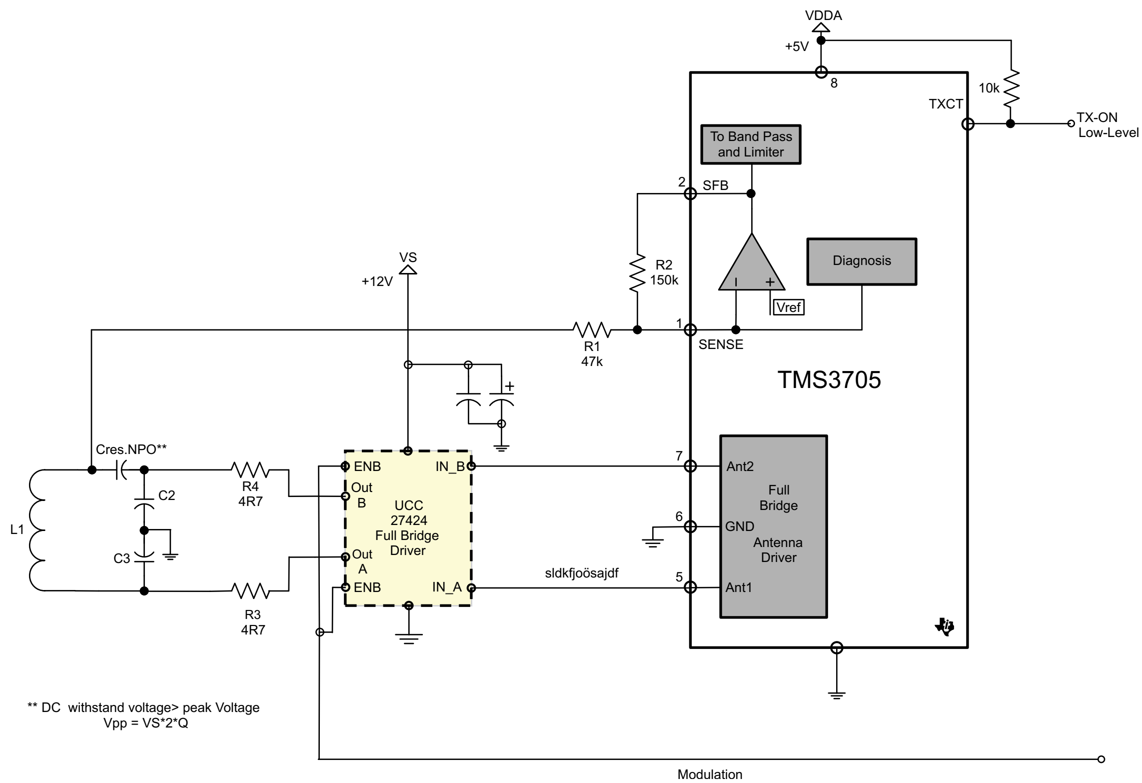

Figure 7. Schematic Connection of the Driver IC (UCC27424)

Typical Pulse-Width downlink telegram (Read page3, 0x0C).

Timing:

High Bit:	Low Bit:
170 µs off	480 µs off
330 µs on	520 µs on

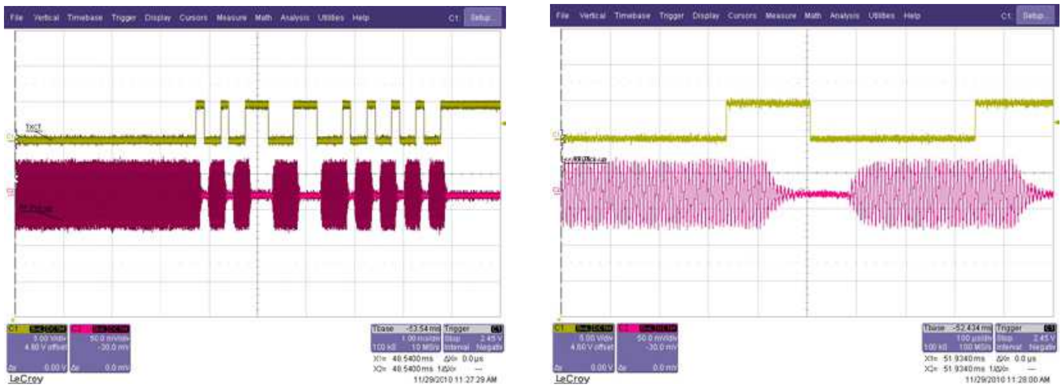

Figure 8. Pulse Width Downlink Telegram

3.2.2 Transmitter ON-OFF Delay of the TMS3705x

The screen shots in Figure 9 show the ON propagation delay of the TXCT signal that limits the downlink timing. This does not impact a normal TRP operation.

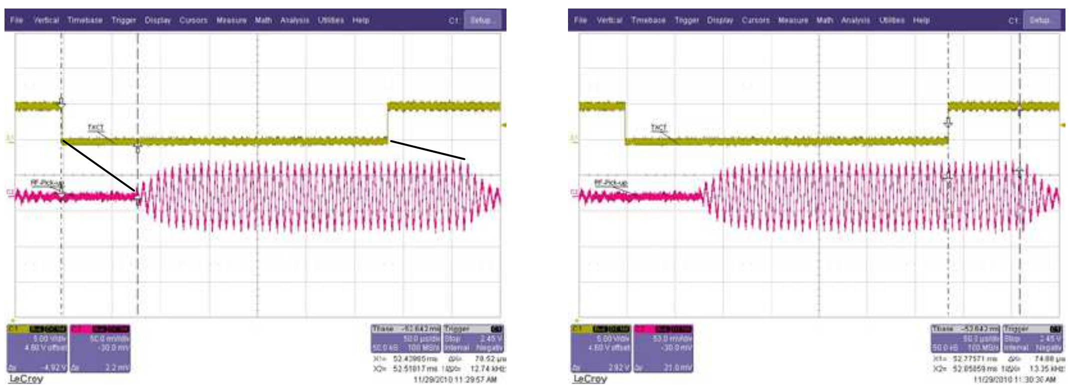

Figure 9. Detailed Downlink Telegram With TMS3705 Modulation (TXCT)

3.2.3 Modulation Using the Enable Input of the UCC27424 for High Baud Rate

In case a higher downlink baud rate is required, the TMS3705x can be used as an oscillator only while modulation is performed by the enable pins of the UCC27424. This allows a transmitter on time of as little as two RF cycles (15 µs at 134 kHz). Of course the time until the maximum resonance voltage is reached depends on the resonance Q-factor, since the higher the Q, the longer it takes to reach maximum amplitude.

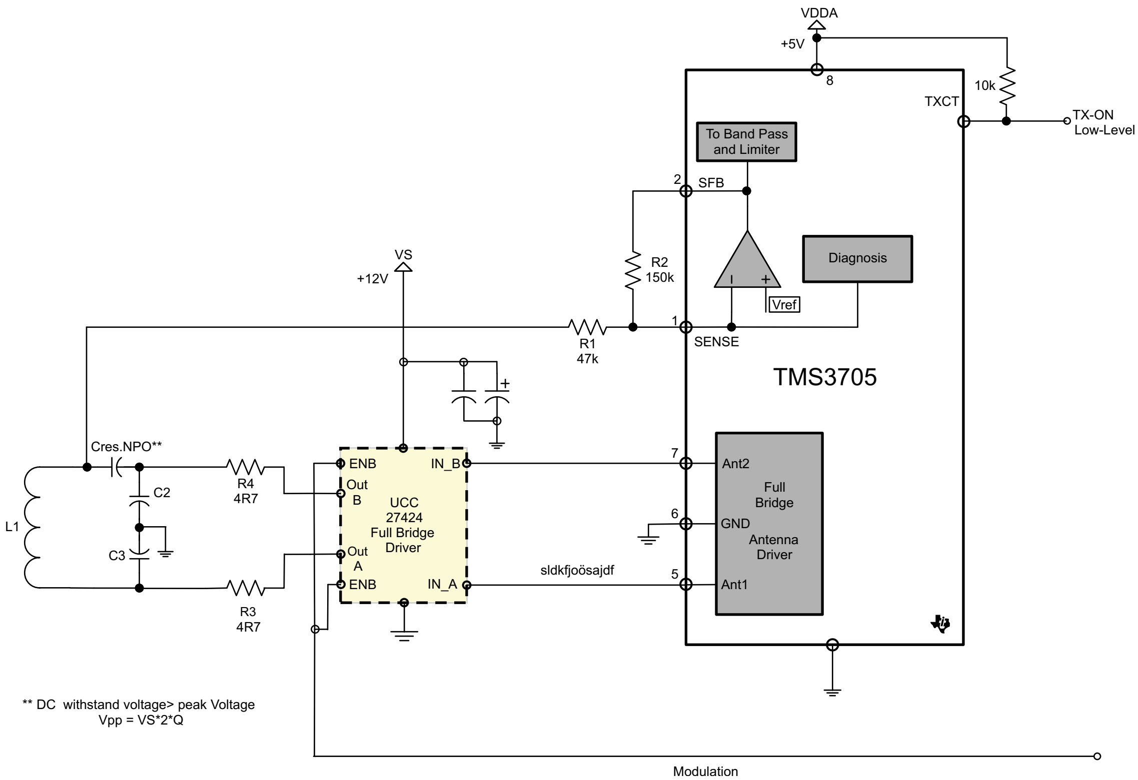

Figure 10. Schematic Connection of the Driver IC (UCC27424)

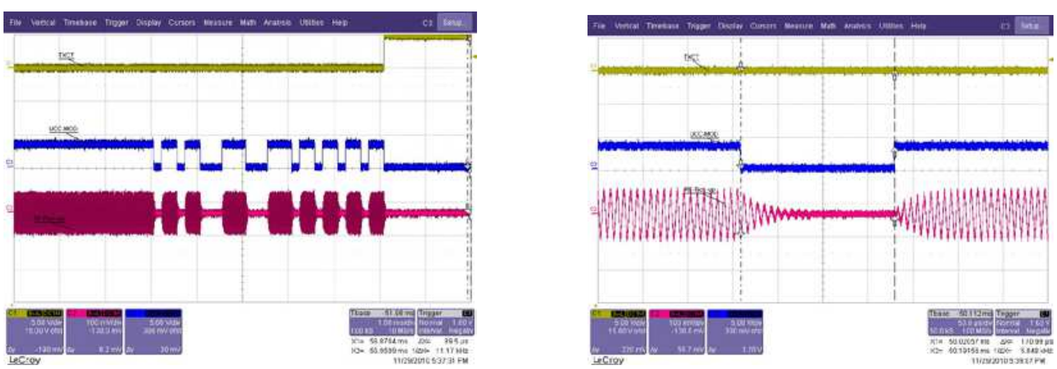

Figure 11. Down-Link Telegram With UCC Modulation

NOTE: Since the enable pin logic is active high, the modulation signal must be inverted in respect to the TXCT modulation signal of the 3705. The UCC enable pins must be activated for the 20 ms receive time after the TXCT was set to high.

3.3 Multiplexer Solution Using Multiple UCC27424 Devices

Figure 12 shows an easy to realize multiplexer solution using one TMS3705x and multiple boost amplifiers. By using the individual enable inputs, the different channels can be selected. The selected channel is not affected by the de-selected channels and visa-versa.

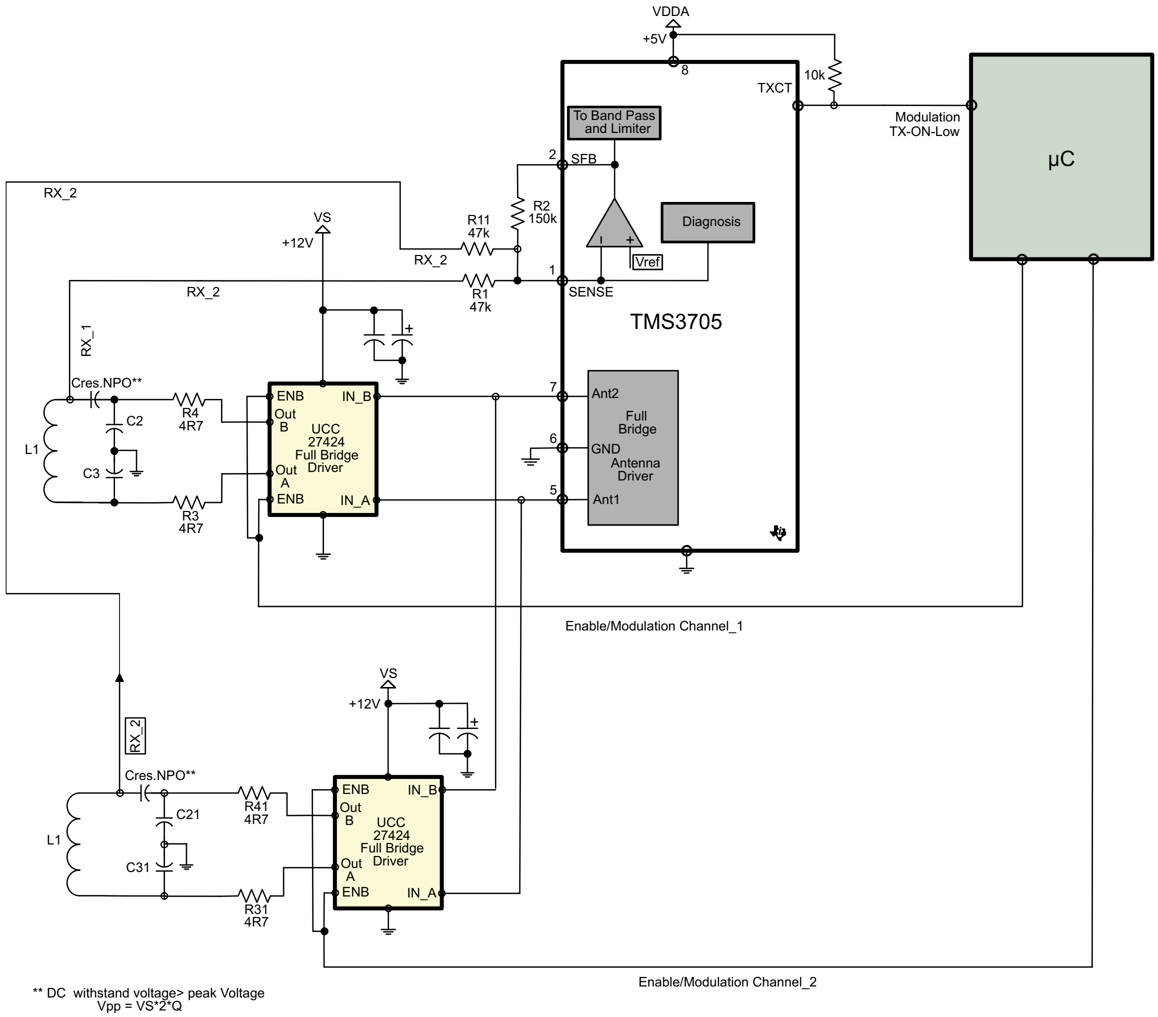

Figure 12. Multiplexer Solution Using Multiple UCC27424 Devices

NOTE: Since Out A and Out B of the non-enabled driver are set to a low level, the antenna Lx and the resonance capacitor Cres are switched in parallel resonance; noise at the RX-path can influence the read performance of the selected channel.

3.4 Timing Diagram Sequence - Read Two Channels (Modulation With TXCT)

Figure 13 shows the sequence of using two amplifiers for a second reading point while only one TMS3705 device is used. The selection of the specific channel is done by the enable input of the amplifier.

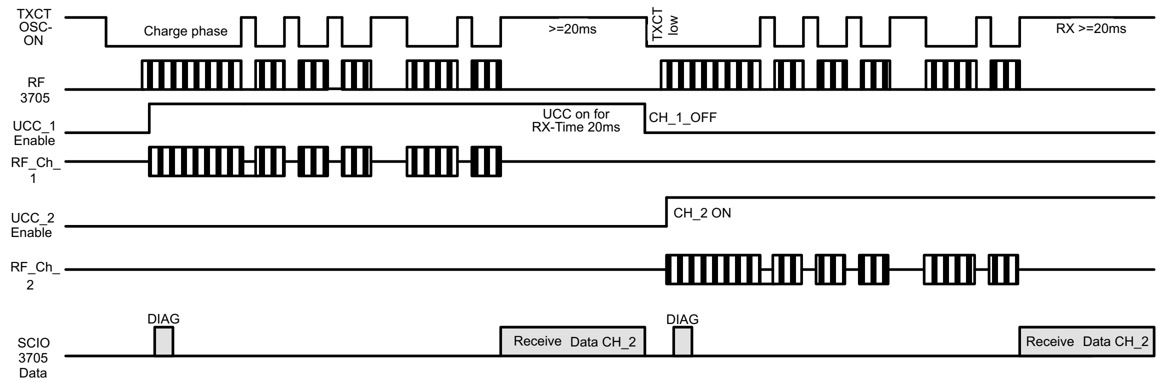

Figure 13. Timing Diagram MUX 2-Channel

3.5 CAUTION

For exact timing, see the device-specific TRP specification as well as the *TMS3705 Transponder Base Station IC Data Sheet* (SCBS0881).

3.6 ESD

It is recommended to protect all pins of the device with additional ESD diodes for higher ESD immunity. The device itself withstands ESD strikes only up to ± 2kV (MIL STD 883).

In case of a long cable system, **do not connect the ESD diode at the resonance pin**. It should be connected as shown in Figure 14

3.7 Resonance Capacitor

The resonance capacitor has to withstand the peak RF voltage if the power stage is supplied with a voltage higher than 5 V.

The peak-peak voltage is calculated as follows:

V_{PP} = VUCC * 2 * Q

The multiplication by two is used because of the full bridge operation. The full bridge amplifier doubles the voltage compared to a single-ended push-pull stage.

3.8 Application Schematic With TMS3705 Modulation

Figure 14 is the version using the TXCT of the TMS3705 for the 100% AM modulation. The enable signals (ENBA,ENBB) of the amplifier(IC2) is set to high permanently.

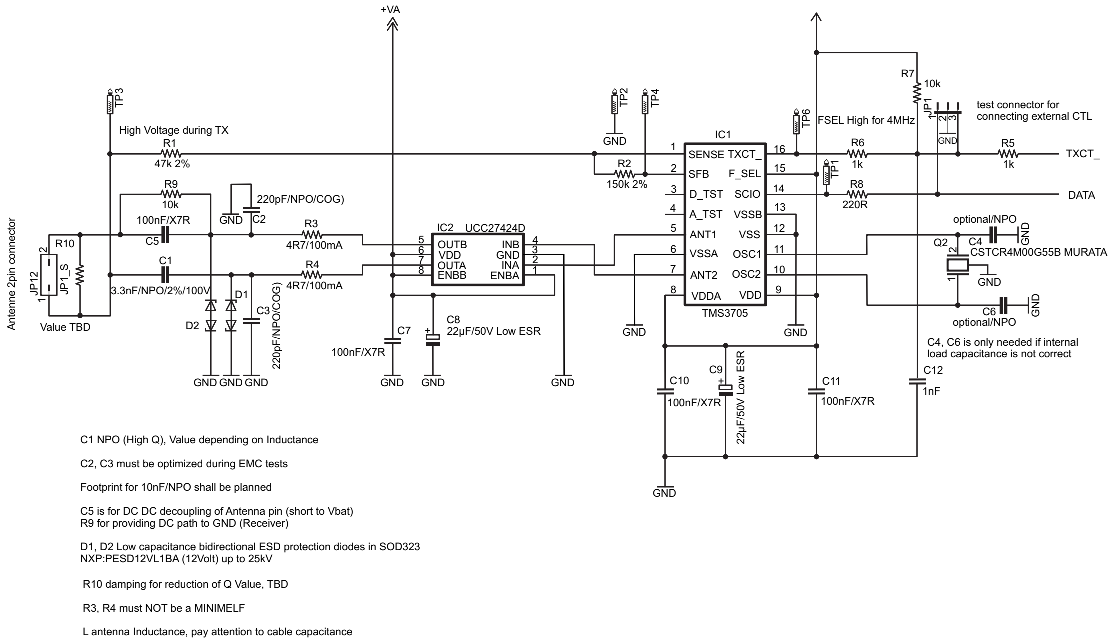

Figure 14. Application Schematic With TMS3705 Modulation

NOTE: You have to consider the antenna cable capacitance if the long cable system is used, which will have an impact on resonance. The cable capacitance is cable specific.

For more information, see *TMS3705 Passive Antenna Solution* (SCBA027).

3.9 Fast Prototyping and Important Information

Figure 15 shows the communication between the TRP and the Reader. The diagram is applicable for the MUSA transponder General Read page 3.

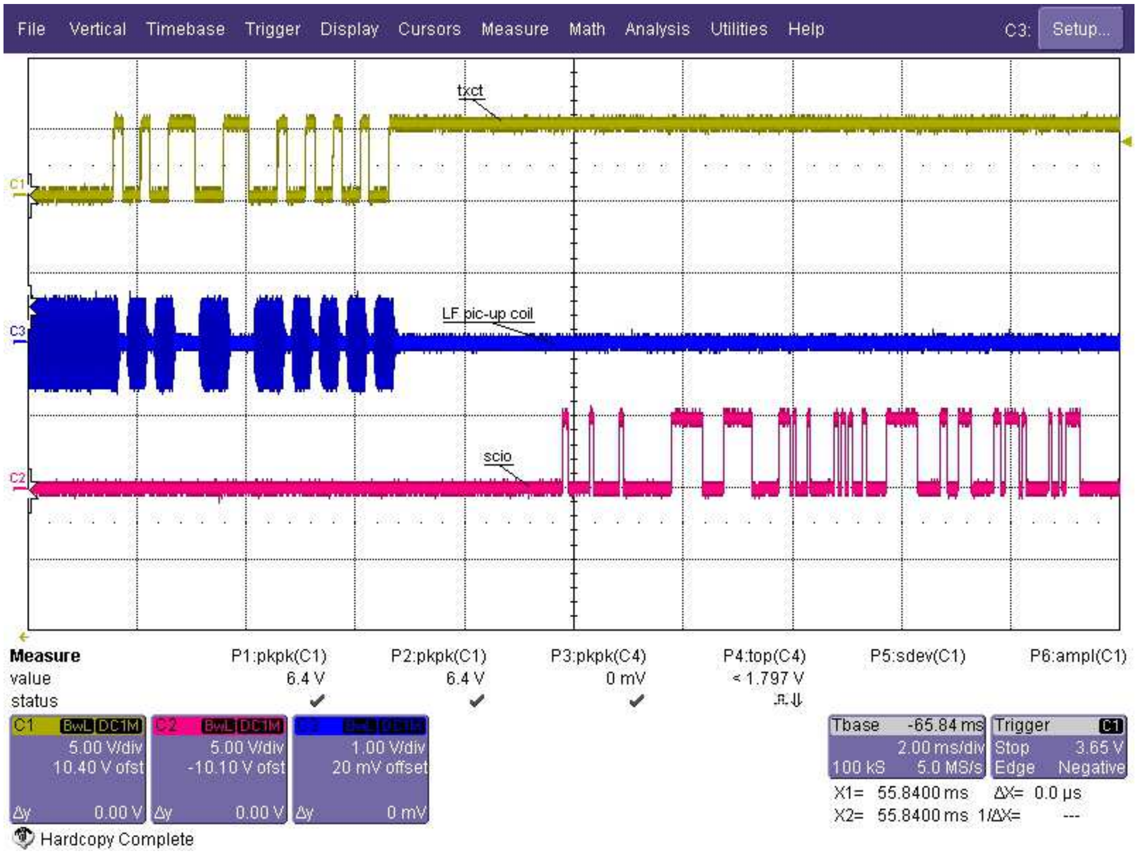

Figure 15. Complete Transponder Communication

For a charge-only transponder, the 8-bit command is not necessary. After the charge phase of 50 ms, the read-only (R/O) TRP sends back its telegram. The telegram length of the R/O and MUSA transponders are different.

3.9.1 Start Value Cyclic Redundancy Check (CRC)

Please notice that the start values of the CRC are different.

- MUSA: 0x3791
- DST: 0x3791 (all DST-based products)
- R/O: 0x0000
- R/W: 0x0000

3.9.2 Block Schematic of CRC Generator

A cyclic redundancy check (CRC) generator is used in the transponder during receipt and transmission of data to generate a 16-bit block check character. For more details, see the device-specific transponder specification. For M (BCC), applying the CRC-CCITT algorithm (see Figure 9).

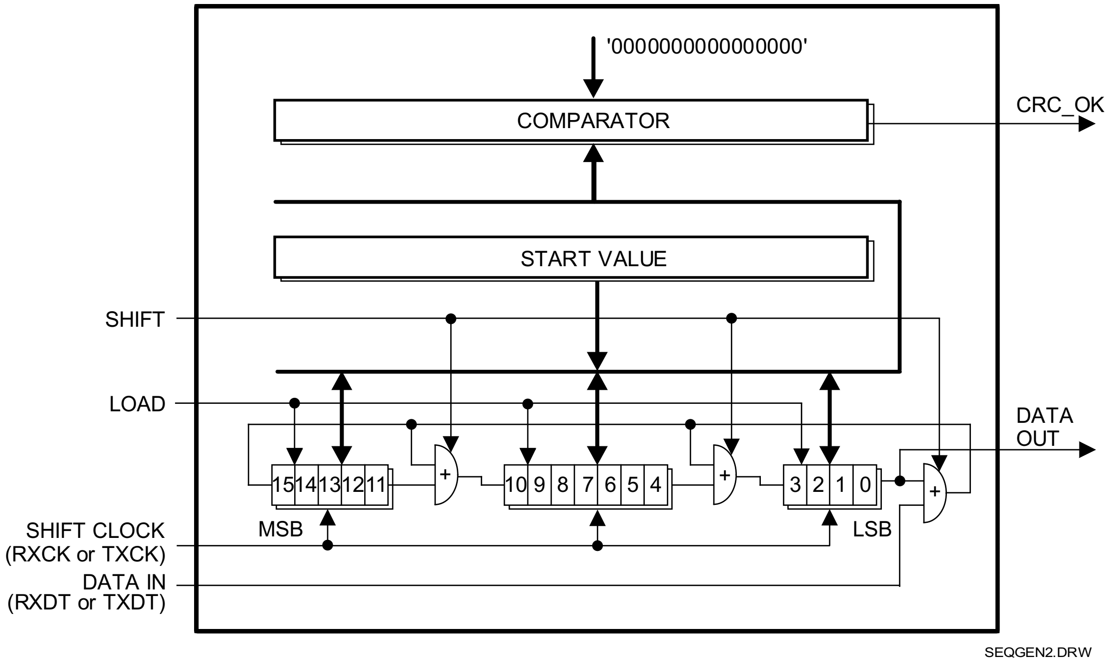

Figure 16. Block Schematic of CRC Generator

3.9.3 Telegram Length

The total transponder telegram length (without the 16 pre-bits) is 80 bits starting with the start-byte and ending with the 16-bit block check character (BCC). The 16 bit pre-bit phase sent by the transponder must not be included in the CRC. The pre-bits are only used internally by the TMS3705.

3.9.4 Data Direction

Attention should be paid to the data direction. From the transponder side, all data are handled with LS-bit and LS-byte first.

The serial communications interface (SCI) encoder uses an 8-bit shift register to send the received data byte-wise (least significant bit (LSB) first) to the microcontroller with a transmission rate of 15.625 kbaud: one start bit (high) and one stop bit (low). A high level on the SCIO pin indicates the start of transmission of the data byte. The data bits at the SCIO output are inverted with respect to the corresponding bits sent by the transponder.

3.9.5 Simple C-Code for Receiving Transponder Data at the SCIO

```
#define SCIO  (P2IN & 0x02) //SCI input Port2.1

// variables
unsigned char RX_buff[10];                      //
unsigned char trp_data[11];                     //
unsigned int  BCC_rx;                           //
unsigned char bit_count_8;                      //
unsigned char byte_count;                       //

void RX_80bit(void)
{
unsigned int count;                                        // variable for counter used at
SCIO
count = 1500;                                              // 3.2ms Time out counter value
for first Byte Startbyte 3ms
for (byte_count = 0; byte_count <=0x0A; byte_count+=1)       // Loop Byte counter # of Rx bytes.
 {
    unsigned char temp;
    temp = 0;
     while ((!SCIO) & (count--!=0));                       // wait for SCIO High
    {
      count = 660;                                         // 520us Time out counter value
interbyte (between 2 bytes)
      Delay_us(83);                                        // 64 +32 us  start bit + 0.5 bit
1st bit
      for (bit_count_8 =0; bit_count_8 <=7; bit_count_8 +=1) // Loop bit read asynch mode
(15625 baud 64us)
       {
          temp = SCIO;                                     // RX_bit to temp register Px.1
          temp <<=6;                                       // temp bit shifted 6-
times(x) to left because P6.1(c)
                                                           // starting with MSB x000 000c0
          trp_data[byte_count] >>=1;                       // shift RX-bit by 1 to right
          trp_data[byte_count] += temp;                    // add RX-bit to byte
          Delay_us(54);                                    // delay for next bit next bit |-
 64us-|-64us-|-64us-|..
       }
     }
    trp_data[byte_count] =~trp_data[byte_count];           // inverts 3705 data to TRP real
TRP format
    BCC_rx = trp_data[9];
    BCC_rx =( BCC_rx << 8) + trp_data[8];                  // BCC_RX xxxx yyyy; TRP
data[8]&[9]
   }
  Delay_us(1);                                             // for break point
```

3.9.6 Variable Assignment MUSA/DST

```
void Clear_buffer(void)              //RX Data format MUSA & DST Read Page_3
{
  trp_data[0]  = 0x00; // Start Byte
  trp_data[1]  = 0x00; // selective address
  trp_data[2]  = 0x00; // usr data 1
  trp_data[3]  = 0x00; // mfg Code
  trp_data[4]  = 0x00; // ser#1
  trp_data[5]  = 0x00; // ser#2
  trp_data[6]  = 0x00; // ser#3
  trp_data[7]  = 0x00; // read address
  trp_data[8]  = 0x00; // BCC DST/MUSA
  trp_data[9]  = 0x00; // BCC DST/MUSA
  trp_data[10] = 0x00; // empty
}
```

NOTE: The C-code is only a sample used for demonstration purpose.

4 References

- *TMS3705 Transponder Base Station IC Datasheet* (SCBS881)
- *TMS3705 Passive Antenna Solution* (SCBA027)

IMPORTANT NOTICE

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