Application Note

RKE Design Kit (U2741B, U3741BM)

Table of Contents

1. Introduction

The RKE Design Kit supports the development of RKE systems with Atmel Wireless & Microcontrollers' UHF FSK/ASK remote control transmitter U2741B and the UHF FSK/ASK remote control receiver U3741BM.
The RKE Design Kit contains a basic application board, an RF receiver (receiver application board) and an RF transmitter (transmitter application board).
The configuration of the RF receiver and transmitter is programmable via the PC with the receiver application software and the transmitter application software. With these programs, parameters like baudrate, modulation, testword etc. can be changed in a very quick and comfortable way. In addition, the receiver application software provides some tools to evaluate the data transmission (histogram, timing list). The data communication between the PC and the application boards occurs via the serial port (RS232).
To configure the RF transmitter or receiver, the appropriate board must be connected to the basic application board RS232.

Note:
This application note is dedicated to the Ux741B(M) chipset, however, the entire description is also valid for the consumer version Ux745B(M). The following shows the relevant restricted features: Tx/Rx: no FSK option usable, Rx: no sensitivity reduction.

2. Hardware Components

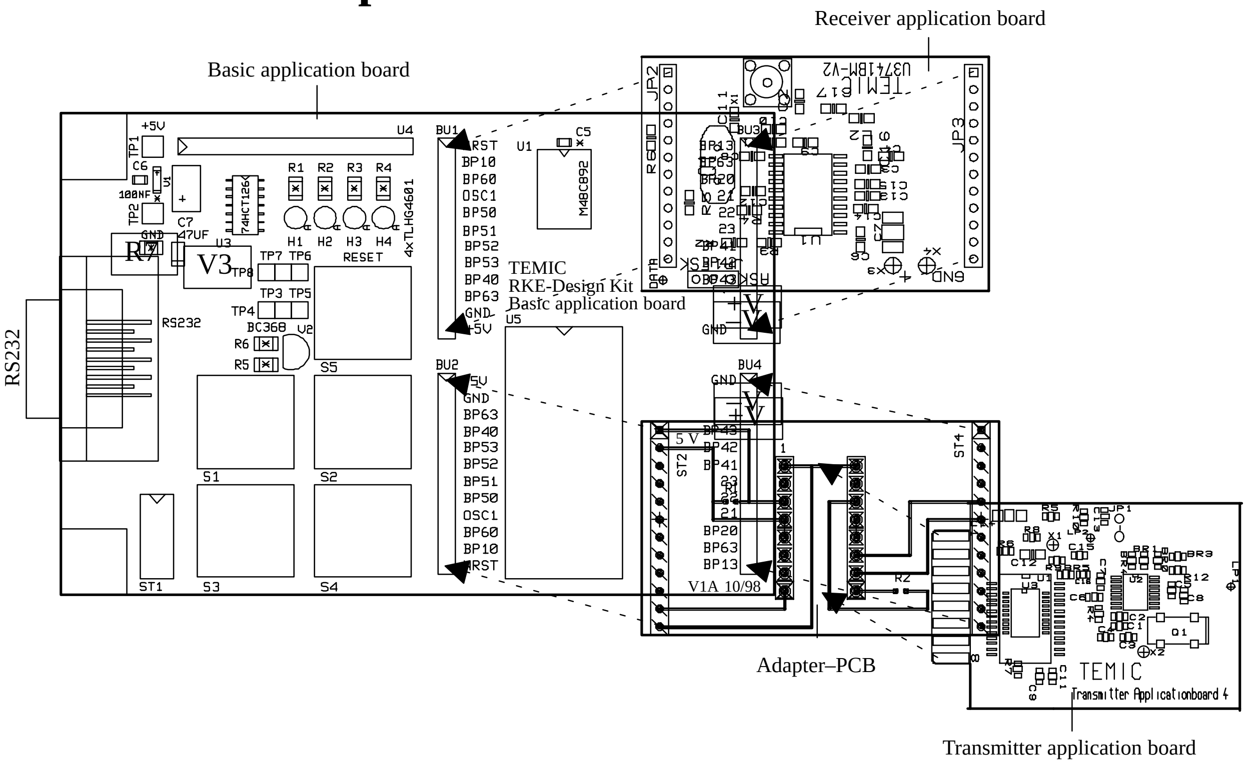


Figure 1. RKE Design Kit

Note the correct position of the application boards !

List of Components

- 1 basic application board
- 1 receiver application board (RF receiver)
- 1 adapter – PCB
- 1 transmitter application board (RF transmitter)
- 1 AT-XT/PS2 link cable (RS232)
- 1 CR 2025 (lithium battery)
- 1 multiflex antenna 400 MHz to 470 MHz
- 1 SMB cable assembly (female contact)
- Adapter: 1 SMB (male) to BNC (female)
1 SMB (female) to BNC (male)
- 1 modem adapter DB9 F – DB25 M
- 3 disks 3.5"

2.1 Basic Application Board

To configure the RF transmitter or receiver, the appropriate board must be connected to the basic application board (see figure 1). To prevent damaging, the application boards must be in the correct position! Via a serial port (RS232) the basic application board must be connected to the PC. The configuration will be done by the transmitter- resp. receiver application software.
During configuration, the microcontroller M48C892 on the basic application board handles the data communication with the PC, the receiver application board and the transmitter application board.
When configured, the transmitter application board operates stand-alone and can be removed.

Basic Function

The receiver application board operates only in conjunction with the basic application board.
After power on, the microcontroller M48C892 on the basic application board configures the RF receiver and enables it by setting Pin ENABLE to '1' (see figure 2). Then the receiver is in the polling mode and verifies the presence of a valid transmitter signal. The parameters for the bitcheck (BR_Range, Nbitcheck, Tsleep, Lim_min, Lim_max) are programmable with the receiver application software. If a valid transmitter signal is detected, the receiver remains active and transfers the data stream to the connected microcontroller M48C892 on the basic application board.
The microcontroller measures continuously the distance between 2 signal edges (= 1 sample). If the distance t > = 1/Baudrate, the following 64 samples will be stored in the RAM of the microcontroller (start of measurement / end of measurement, figure 2). Then the RF receiver will be disabled by setting Pin ENABLE to '0'. The timing limits of 1/Baudrate is programmable in the receiver application software (see 'Evaluation -µC_Limits', chapter 3.2.4).
The 64 samples will be examined to distinguish between a valid signal from a corresponding transmitter and signals due to noise. This is done by a time frame check where the samples are continuously compared to a programmable time window (µC_Limits).
If the samples are within the time window, this will be indicated by the LED H1.
If the received data stream is equal to a programmable testword (Testword), this will be indicated by the LED H2. After the evaluation of the received data stream, the RF receiver will be enabled by setting Pin ENABLE to '1'.
The timing information (64 samples) also can be evaluated with the functions 'Testword', 'Histogram' and 'Timing_List' in the receiver application software.

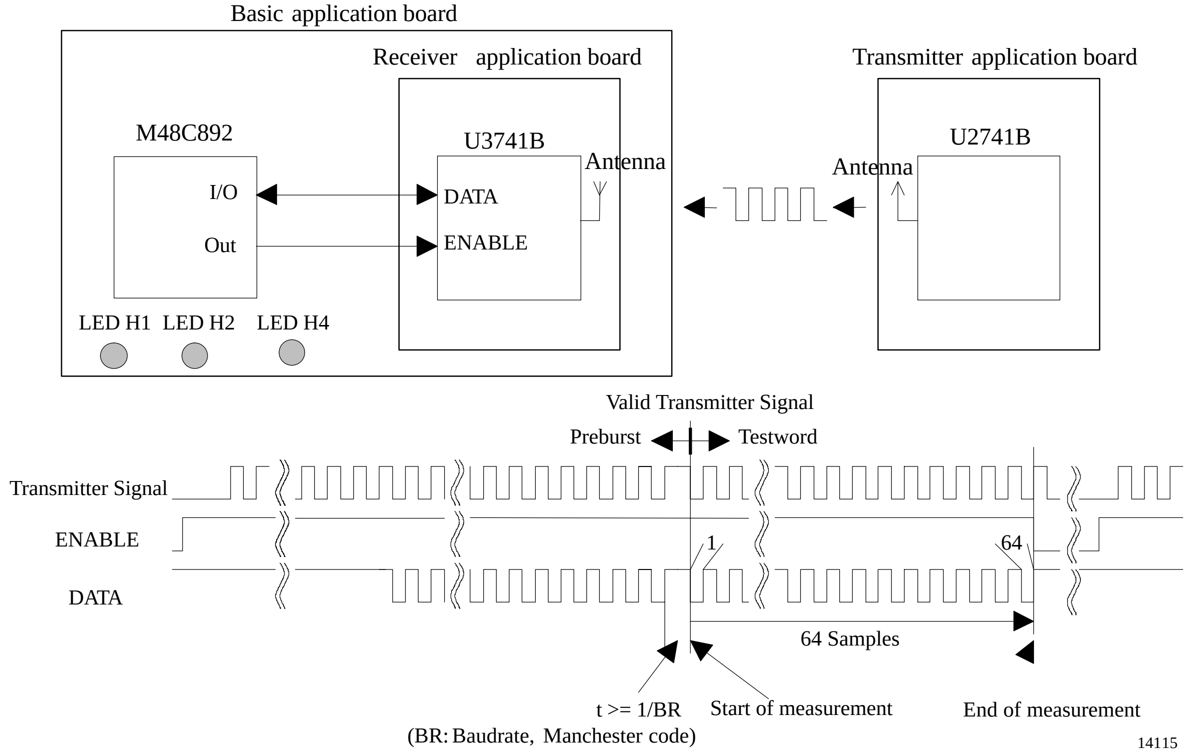


Figure 2. Principle function

Technical Features

- Power supply: V_{CC} = +5 V
- 2 connectors (BU1/BU3, BU2/BU4) to connect the transmitter- and the receiver application board.
- Key S5 generates a reset for the microcontroller on the basic application board. If the transmitter application board is connected to the basic application board, the reset will also be generated for this board.
- LED H4 indicates the voltage on BU1/5V and BU2/5V (power supply for the transmitter- and the receiver application board).
  Voltage on —> LED H4 off
  Voltage off —> LED H4 on
- LED H2 indicates the receipt of a valid testword (see ‘Telegram Testword’, chapter 3.2.4).
- LED H1 indicates whether the timing of the received data stream is within the programmable µC_Limits (see ‘Telegram Testword’, chapter 3.2.4).
- Jumper setting on the basic application board (see figure 3)

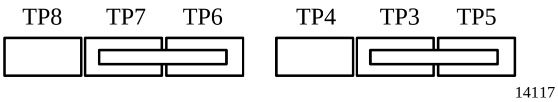


Figure 3. Jumper setting

2.2 Transmitter Application Board

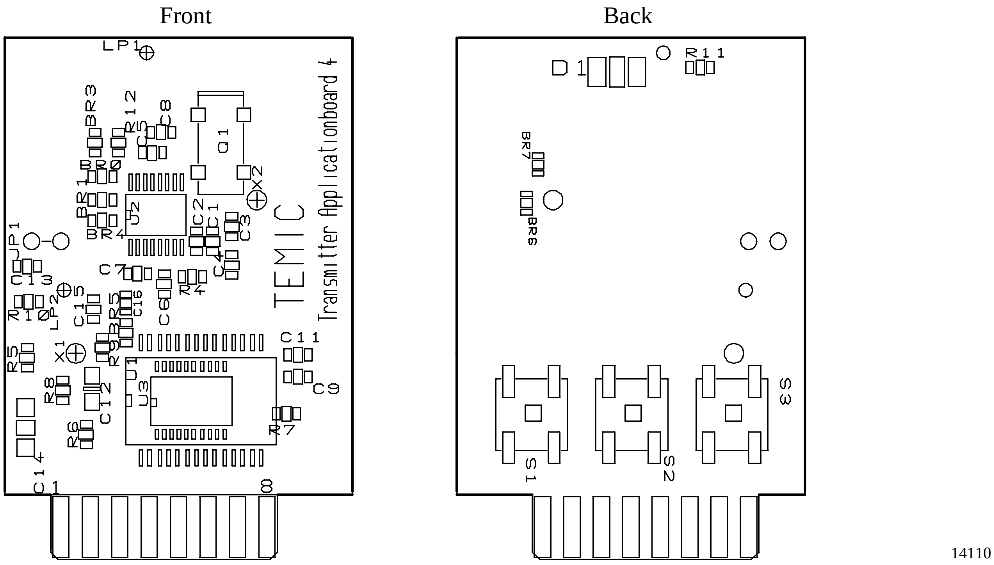


Figure 4. Transmitter application board
U2: U2741B, U1: M48C892/ M44C892, S1: Button 1, S2: Button 2, S3: Button 3

2.2.1 General Description

Table 1 List of available transmitter application boards

Transmitter Application Board [f_{send} / Modulation]	C3 [pF]	C4 [pF]	C8 [pF]	C9 [pF]	C11 [pF]	Q1 [MHz]
433.92 MHz/ ASK	not mounted	8.2	8.2	5.6	5.6	13.56
433.92 MHz/ FSK	6.8	3.9	8.2	5.6	5.6	13.56
315 MHz/ ASK	not mounted	12	18	10	12	9.8438
315 MHz/ FSK	15	2.7	18	10	12	9.8438

Basic Function

The transmitter application board is a programmable, stand-alone-operating RF transmitter containing the UHF FSK/ASK remote control transmitter U2741B and the microcontroller M48C892/ M44C892. The power supply of the board is provided by a 3-V lithium battery. The operating frequency, f_{send}, of the transmitter depends on the frequency of the quartz Q1 (see table 1).

Technical Features

- Power supply: 3-V lithium battery
- The function of the buttons S1, S2 and S3 is programmable with the transmitter application software (see ‘Button’, chapter 3.1.4).
- The function will be started by pressing button S1, S2 or S3 and will be indicated by the LED (D1). The end of all continuous functions also will be indicated by the LED (D1).
- Operating frequency f_{Send}: 433.92 MHz
315 MHz
- Effective radiated power ERP:
–21 dBm (433.92 MHz)
≈ –20 dBm (315 MHz)

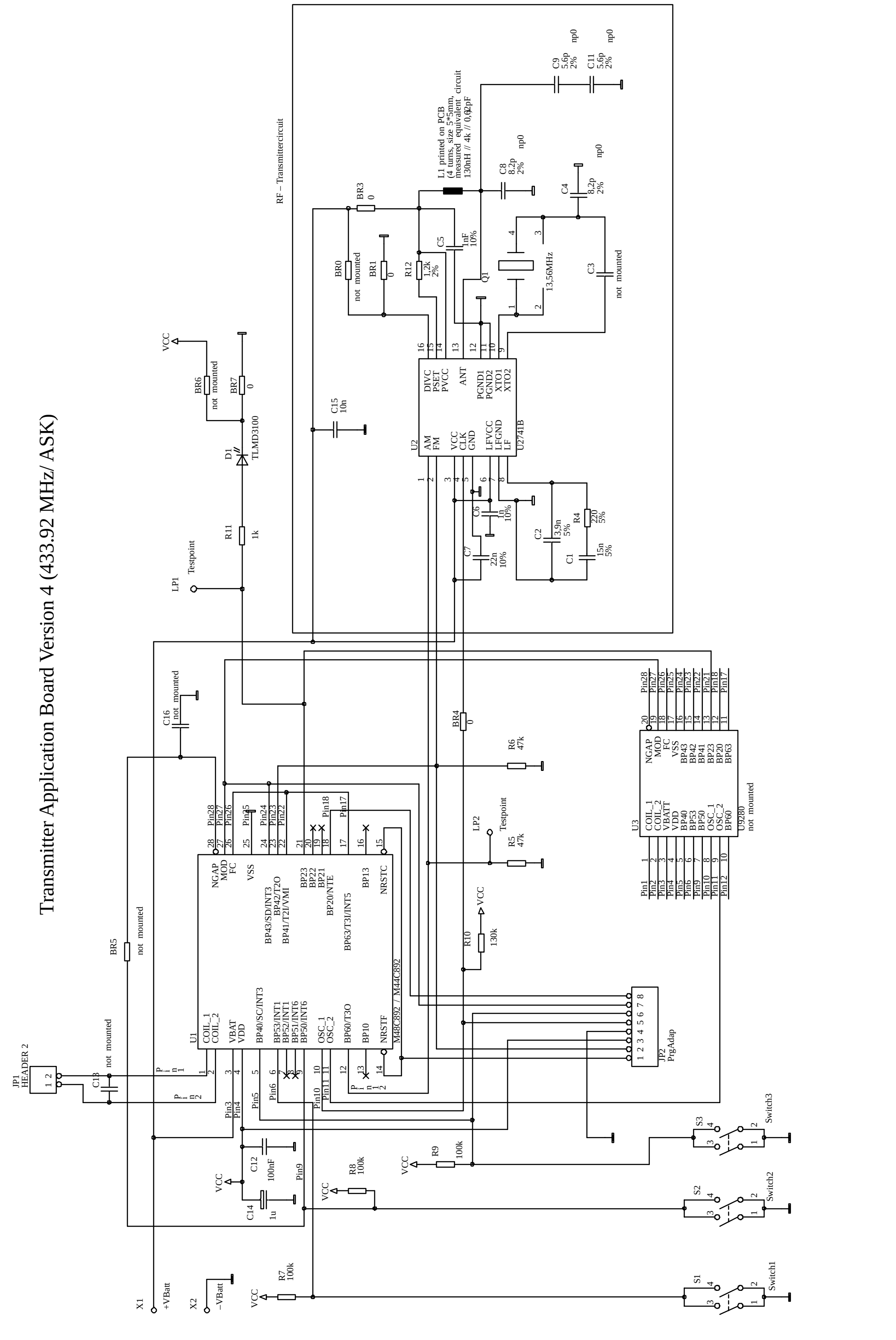
Programming of the RF Transmitter

Starting of the RKE Design Kit

1. Switch on the PC and start the operating system.
2. Remove or insulate the 3-V lithium battery in the transmitter.
3. Assemble the RKE Design Kit as shown in figure 1.
4. Switch on the 5-V power supply of the basic application board.
5. Connect the serial link cable (RS232) to an unused serial port (Com1, Com2).
6. Press the reset button (Key S5).
7. Start the transmitter application software (U2741B.EXE).
8. Program the transmitter and the receiver with the target values.
9. Switch off the 5-V power supply of the basic application board and remove the transmitter from the adapter PCB.
10. Insert the 3-V lithium battery in the transmitter.
11. To activate the transmitter, press button S1 or S2.

Reprogramming of the Transmitter

- Switch off the 5-V power supply of the basic application board.
- Remove or insulate the 3–V lithium battery from the transmitter.
- Connect the transmitter to the adapter PCB.
- Switch on the 5-V power supply of the basic application board.
- Press the reset button (Key S5).
- Program the transmitter with the target values.
- Switch off the 5-V power supply of the basic application board and remove the transmitter from the adapter PCB.
- Insert the 3-V lithium battery in the transmitter.
- Press button S1 or S2 to activate the transmitter.



14111

Figure 5. Schematic transmitter application board: 433.92 MHz / ASK

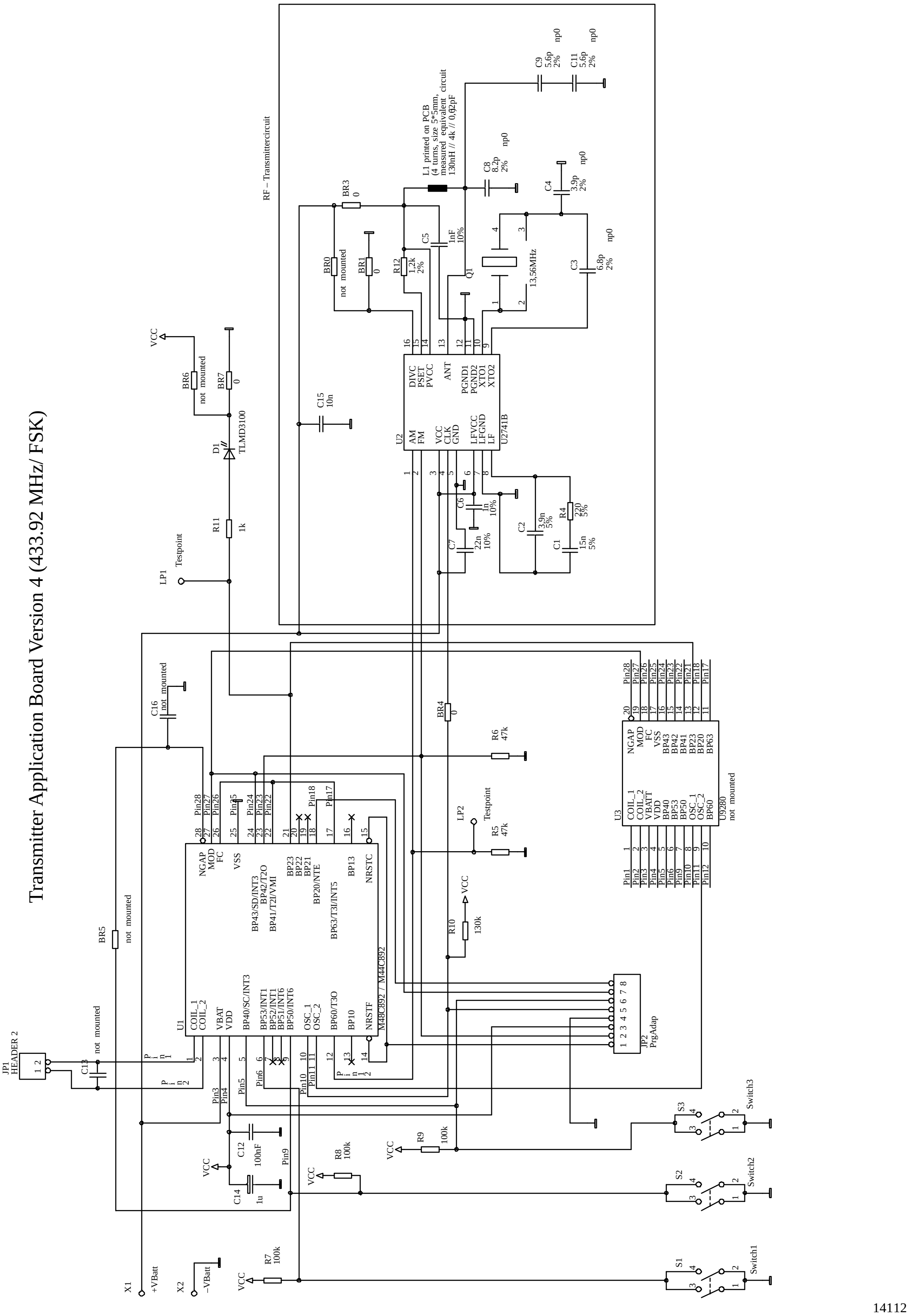


Figure 6. Schematic transmitter application board: 433.92 MHz / FSK

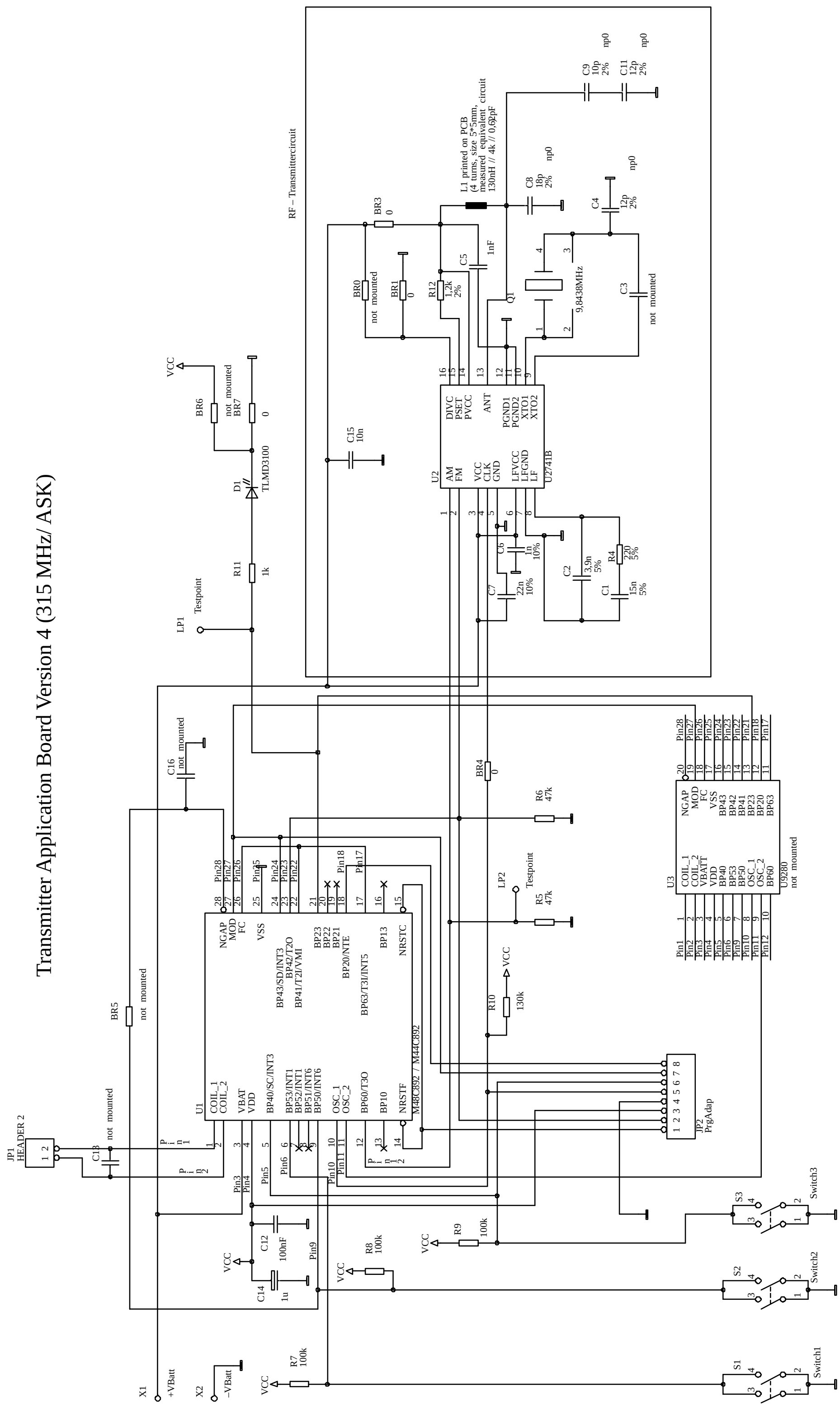


Figure 7. Schematic transmitter application board: 315 MHz / ASK

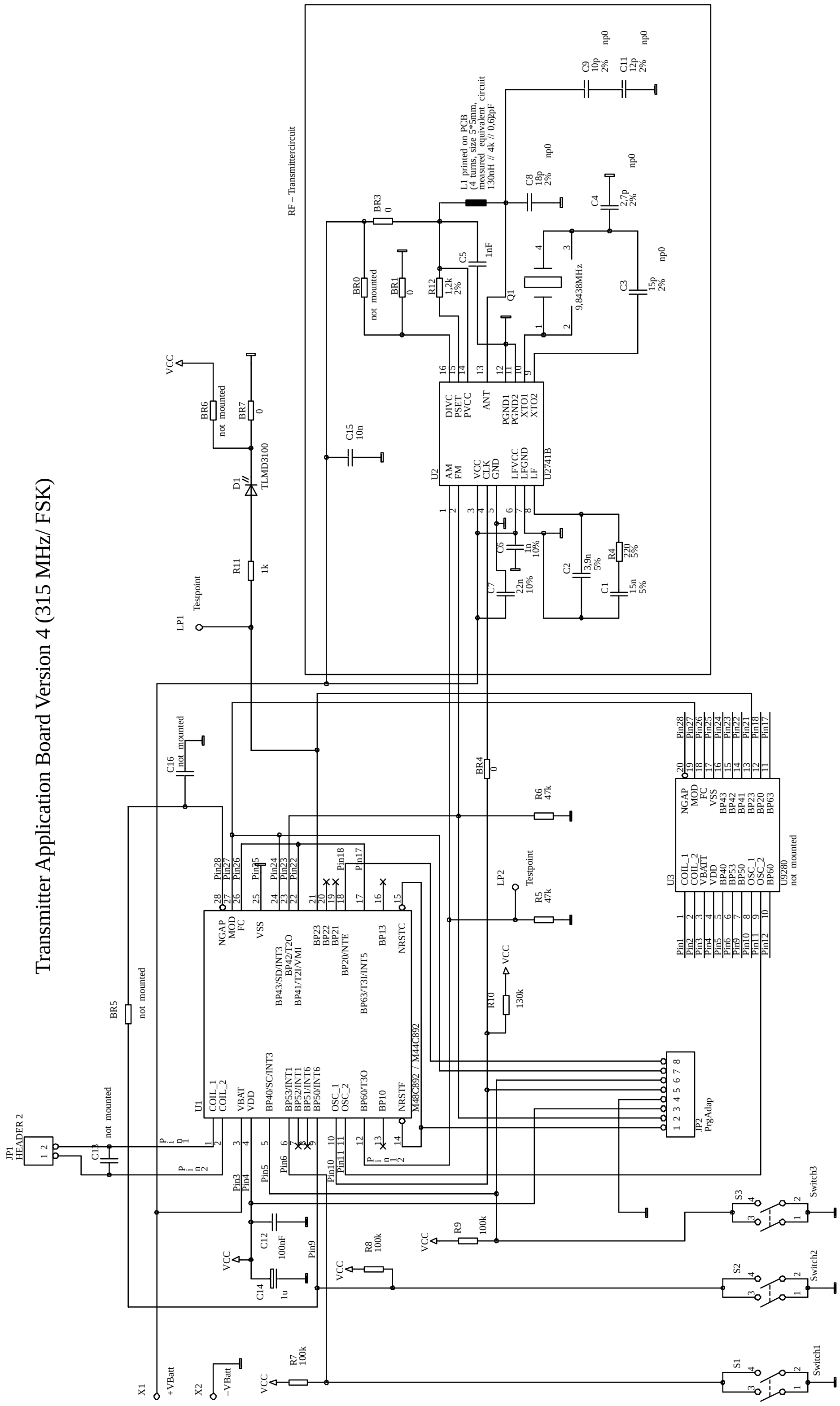
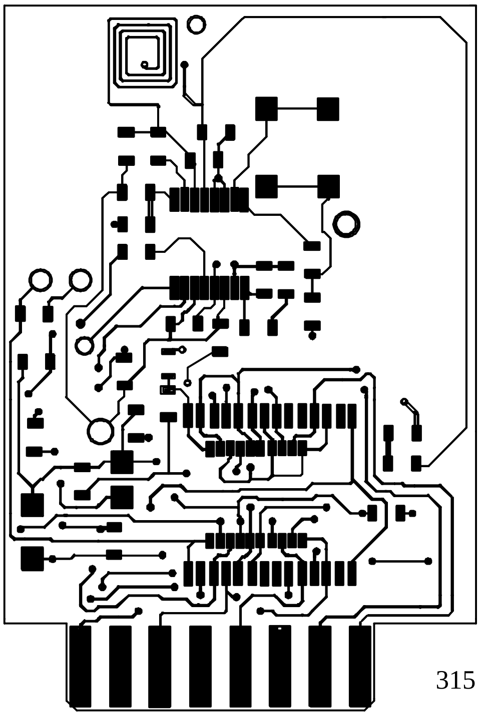
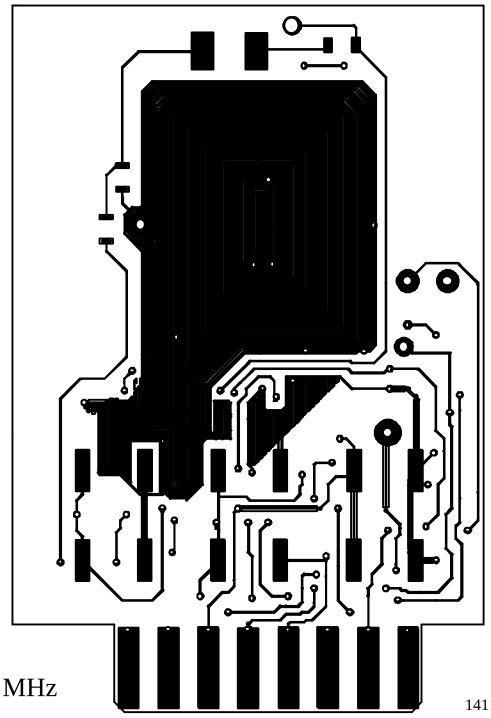


Figure 8. Schematic transmitter application board: 315 MHz / FSK



315 MHz / 433.92 MHz
ASK / FSK



14116

Figure 9. Layer 1 transmitter application board
Scale 1.7:1

Figure 10. Layer 2 transmitter application board
Scale 1.7:1

Table 2 Bill of Materials

Components	Pcs	315 MHz/ ASK	315 MHz/ FSK	433.92 MHz/ ASK	433.92 MHz/ FSK	Value	Tolerance	Material	Housing	Manufacturer/ Distributor
D1	1	X	X	X	X	TLMD3100			TOPLED	Vishay TELEFUNKEN
U1	1	X	X	X	X	M48C892/ M44C892			SSO28	Atmel Wireless & Microcontrollers
U2	1	X	X	X	X	U2741B–MFP			SSO16	
U3						U9280B			SSO20	
C1	1	X	X	X	X	15nF/63nF	5%	X7R Ceramic	Size 0603	
C2	1	X	X	X	X	3.9nF/63V	5%	X7R Ceramic	Size 0603	
C3	1		X		 X	15pF/63V, 6.8pF/63V	2%	NP0 Ceramic	Size 0603	Murata
C4	1	X	 X	 X	 X	12pF/63V, 2.7pF/63V, 8.2pF/63V, 3.9pF/63V	2%	NP0 Ceramic	Size 0603	Murata
C5	1	X	X	X	X	1nF/63V	10%	X7R Ceramic	Size 0603	
C6	1	X	X	X	X	1nF/63V	10%	X7R Ceramic	Size 0603	
C7	1	X	X	X	X	22nF/63V	10%	X7R Ceramic	Size 0603	
C8	1	X	X	 X	 X	18pF/63V, 8.2pF/63V	2%	NP0 Ceramic	Size 0603	Murata
C9	1	X	X	 X	 X	10pF/63V, 5.6pF/63V	2%	NP0 Ceramic	Size 0603	Murata
C11	1	X	X	 X	 X	12pF/63V, 5.6pF/63V	2%	NP0 Ceramic	Size 0603	Murata
C12	1	X	X	X	X	100nF/63V	10%	X7R Ceramic	Size 0805	
C13										
C14	1	X	X	X	X	1µF	20%	Tantal	Size 1206	
C15	1	X	X	X	X	10nF/63V	10%	X7R Ceramic	Size 0805	
C16										
Q1	1	X	X	 X	 X	9.8438MHz, 13.56MHz			Order No.: 473 000 7281 Order No.: 473 000 7282	ACAL
BR0	1					0R/0.1W			Size 0603	
BR1	1	X	X	X	X	0R/0.1W			Size 0603	
BR3	1	X	X	X	X	0R/0.1W			Size 0603	
BR4	1	X	X	X	X	0R/0.1W			Size 0603	
BR5	1					0R/0.1W			Size 0603	
BR6	1					0R/0.1W			Size 0603	
BR7	1	X	X	X	X	0R/0.1W			Size 0603	
R10	1	X	X	X	X	150k/0.1W	5%		Size 0603	
R11	1	X	X	X	X	1k/0.1W	5%		Size 0603	
R5, R6	2	X	X	X	X	47k/0.1W	5%		Size 0603	
R7, R8, R9	3	X	X	X	X	100k/0.1W	5%		Size 0603	
R12	1	X	X	X	X	1.2k/0.1W	2%		Size 0603	
S1, S2, S3	3	X	X	X	X	KSC241JB				ITT
Battery	1	X	X	X	X	Battery CR2025			Order No.: 596–090	RS Comp.
Battery Case	1	X	X	X	X	Battery Case			Order No.: 596–090	RS Comp.
Board	1	X	X	X	X	Transmitter Board		FR4	Thickness 1.2mm	

2.2.2 Application Hints U2741B/U2745BM

As usual with RF design, the peripheral circuit and layout are very important. It is recommended to adapt the individual design to the application suggestion.

- **Antenna Design and Matching**

In applications with limited space – possible antenna length l << wavelength λ – a magnetic loop antenna is recommended to avoid that the radiated field is affected by the user’s hand. The major parameter of these antennas is the need for a strong current in order to create a magnetic field in an area inside the loop.

Some characterizing values:

$$R_{rad} = 31\ k\Omega \times \left(\frac{A}{\lambda^2}\right)^2$$

R_{rad} = radiation resistance of the antenna
A = area inside the loop antenna
λ = wavelength to transmit

The transmitted power is related to the value of R_{rad}. The radiated power P_{rad} is the product of I_{Loop}^2 and R_{rad}.

$$\eta = f\left(A^{\frac{3}{2}}\right)$$

η = antenna efficiency
A = area inside the loop antenna

The antenna efficiency η is a function of the area A and means the relation between the effective radiated power and the driven power $P_{out\ IC}$ of the output.

$ERP = \eta \times P_{out\ IC}$

ERP = effective radiated power
η = efficiency

Equivalent Circuit of the Loop Structure

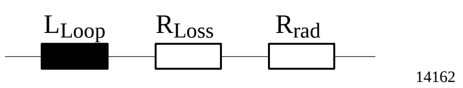


Figure 11. Equivalent circuit of the loop structure

$L_{Loop} \approx 8\ nH / cm \times l\ (w = 1\ mm) \approx 30$ to $60\ nH$

$$Q_L = \frac{\omega\ L_{Loop}}{R_{Loss}} \approx 30 \text{ to } 50 \text{ (estimated)}$$

R_{Loss} = loss resistance
R_{rad} = radiation resistance

The equivalent circuit (see figure 11) shows the parts that have to be considered in calculations. The range of possible inductor values is related to the condition: looplength << wavelength. R_{Loss} stands for the loss of the inductor.

Design & Layout

In order to optimize the performance, the following rules have to be observed:

– The area enclosed by the antenna loop has to be as large as possible.

– The field density increases towards the loop edges. Therefore, the design of the obligatory ground plane of the entire circuit has to be carried out so that there is enough space to the loop’s edges.

– The design shape should be similar to a square (not a rectangle).

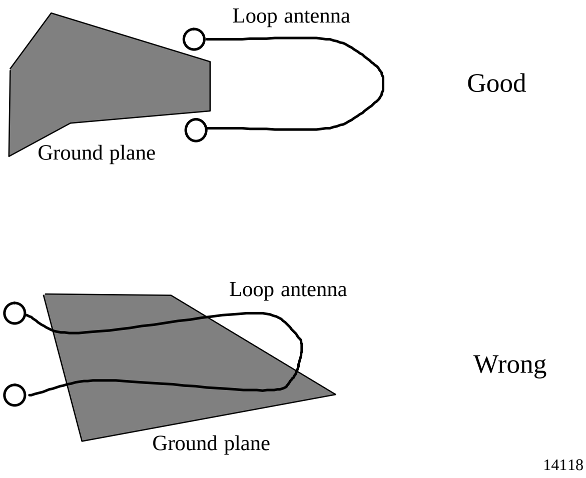


Figure 12. Antenna design shapes

Besides, the principles of layouting RF circuits as well as the blocking concepts (see next page) must be observed.

Matching

The impedance of the designed antenna has to be matched to the driving current source to the optimum load impedance: ≈500 Ω. Together with the pin capacitance of about 0.9 pF, this results in the described value $Z_{load\ opt}$:

$Z_{load\ opt\ 433.92\ MHz} = 185 + j268$
$Z_{load\ opt\ 315\ MHz} = 260 + j330$

Since the inductance of the RF choke compensates the pin capacitance, the antenna circuit has actually to be matched to ≈500 Ω.

The matching circuit can be described as follows:

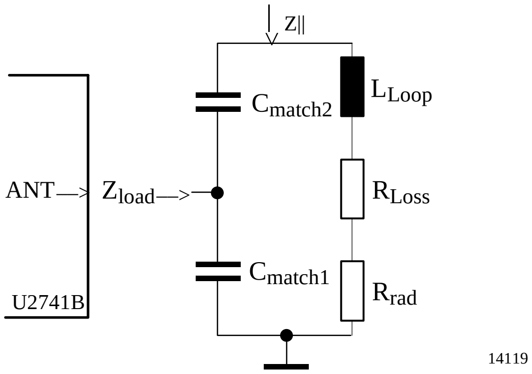


Figure 13. Matching circuit

Transform $Z_{||}$ (parallel resonance impedance) to $Z_{load} = R_{load\ opt}$. The capacitors C_{match1} and C_{match2} perform the transformation according to the equations below:

(r = ratio)

(M.1) $Z_{||} = Q \times 2\pi f \times L_{Loop}$

(M.2) $Z_{||} \approx r^2 \times Z_{out}$

(M.3) $C_{||} = \dfrac{1}{\omega_0^2 \times L_{Loop}} = \dfrac{C_{match1} \times C_{match2}}{C_{match1} + C_{match2}}$

(M.4) $r = \dfrac{C_{match1} + C_{match2}}{C_{match2}} \rightarrow C_{match1} = r \times C_{||}$

Example (Atmel Wireless & Microcontrollers' Transmitter Board)

antenna loop length: 5 cm
antenna area: 4.5 cm^2
L_{Loop} = 40 nH
Q_L = 40 (estimated)
R_{loss} = 2.7 Ω
R_{rad} = 0.026 Ω
$\eta \approx R_{rad} / R_{loss} \approx 1\%$
$Z_{||}$ = 4.4 kΩ
with (M.2): $r \approx 3$; with (M.3): $C_{||}$ = 3.38 pF

$\rightarrow C_{match\ 1} \approx 10$ pF
$\rightarrow C_{match\ 2} \approx 5$ pF

These values are theoretical. The chosen values are different and the influence of parasitic capacitors is obvious. Thus, continue the matching procedure by using two equivalent transmitters with different part values according to the following list:

C_{match1} = 6.8 / 8.2 / 10 / 12 /15 pF (2%)
C_{match2} = Trimmer 2 to 6 pF

Example:
Transmitter 1 with C_{match1} = 10 pF and trimmer versus transmitter 2 with C_{match1} = 8.2 pF and trimmer.

Try to find the optimum and bear in mind the small range of adjustable power maximum and the condition of $Z_{load} = R_{load\ opt.}$

Replace the trimmer with 2% capacitors and compare it with the results with trimmer.

- **Blocking Concepts**

The design of the layout includes considerations to the blocking concepts in order to minimize ripples on the power supply. The following are the most important ones:

– Battery input ports: place capacitor (100 nF ceramic) in between to prevent voltage break-in and ripples.

– Power-supply chip inputs: place capacitor (about 10 nF ceramic) in between to prevent ripples. Make sure that every single supply voltage (VCC, LFVCC, PVCC) is led separately from the input ports and the blocking is done to its ground (GND, LFGND, PGND1,2).

– Try to layout a ground plane on the back side and use this with vias for blocking purpose.

- **Peripheral Circuit**

– In mixed-signal circuits, the separation of digital and analog groups is obligatory. So design the microcontroller separately from the RF part of the transmitter.

– Loop filter: use the dimensions of the data sheet and place the ground part of the filter close to LFGND.
In order to protect the sensitive loop filter structure against currents of the blocking capacitor (LFVCC vs. LFGND), place this component exceptionally not directly in between.

– Quartz:
FSK: The determination of the frequency deviation is done by the combination quartz Q_1 and capacitor C_4 ($f = f_0 + \Delta f$) or Q_1 and C_3, C_4 ($f = f_0 - \Delta f$), respectively.
ASK: The determination of the transmitter frequency is done by the combination quartz Q_1 and capacitor C_4.
Bear in mind the tolerances of the quartz (up to 100 ppm). The prototype must have a defined frequency.

– Printed inductor L_1:
This part works as a feed inductor.
Some additional remarks regarding this part as an RF part and the dimensions of the inductors' layout:
The inductance of such a printed inductor is calculated using the following formula:

$L \approx 49.2 \times N^2 \times r_{av}$ [nH]
N = number of turns
r_{av} = radius (average) [in cm]
(used area: about 5 mm^2)

The RF value of L_1 at 433.92 / 315 MHz of the Atmel Wireless & Microcontrollers board is about: 130 nH // 0.6 pF // 4 kΩ. Design this inductor together with the parasitic capacitance of the antenna output in parallel resonance so that the antenna matching procedure is still valid in good approximation.

– Antenna: (see paragraph ‘Antenna Design and Matching’).

- **FSK: Frequency Deviation**

The recommended frequency deviation is
$\Delta f \approx$ 25 to 30 kHz.

The determination of C_3, C_4 depends on the used quartz. Use the capacitors to tune the circuit according to the desired transmitter frequencies (f_0 +/– Δf).

Bear in mind the tolerances of the quartz (up to 100 ppm). The prototype must have a defined frequency.

- **Quartz: Frequency Pulling**

Quartz circuits are essential to achieve stable and accurate frequency performance. The use of a load capacitor C_L in conjunction with the quartz determines the actual frequency. Since parasitic capacitors cause differences according to the nominal transmitter frequency in a range up to 100 ppm and more, it might be useful to apply the pulling concept.

The compensation of parasitic parallel capacitances, e.g., 4.7 pF, is achieved by reducing the load capacitor from 8.2 pF down to 5.6 pF. This causes a shift towards the nominal transmitter frequency and is to be adapted to the chosen application.

- **ASK and FSK**

The U2741B can be used in both ASK and FSK systems. The following section describes the clocking concept of the microcontroller and its cooperation with the U2741B/ U3741BM.

ASK Transmission

As shown in figure 14, the transmitter IC is activated with $V_{FSK} = V_S$, V_{ASK} remains 0 V. Then the IC is enabled and the XTO and PLL settles. After 5 ms, the output power can be modulated by means of Pin ASK. In this case, V_{FSK} remains = V_S during the message.

To stop the transmission set V_{ASK} = 0 V, then disable the transmitter with V_{FSK} = 0 V.

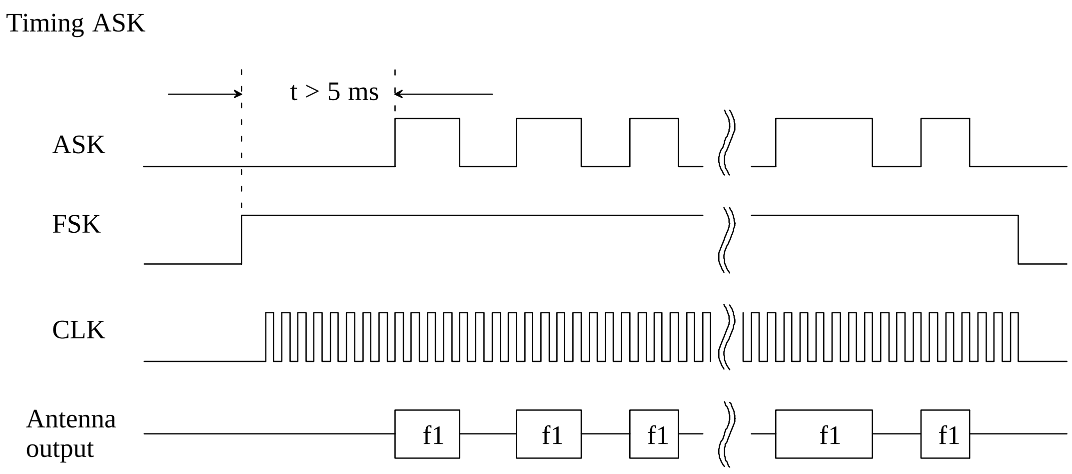


Figure 14. Clocking concept ASK

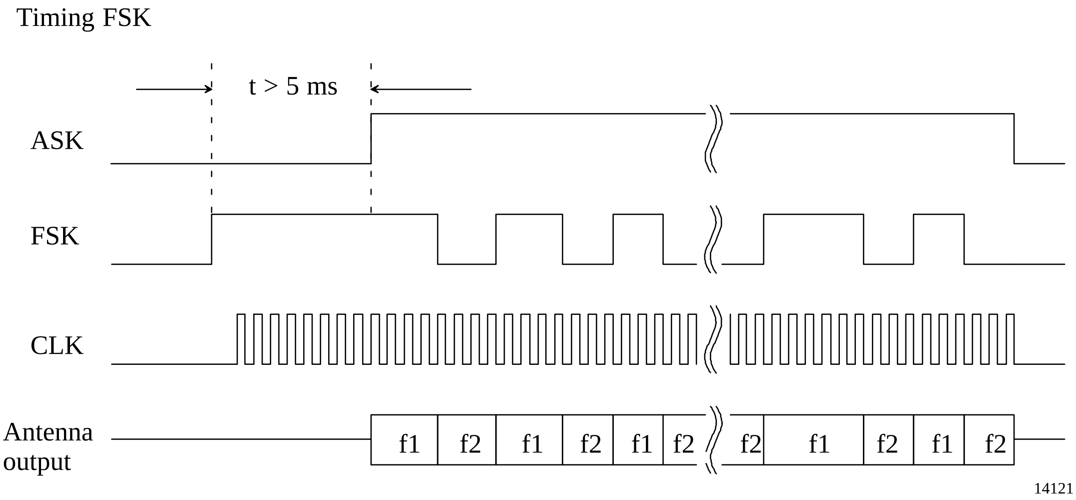


Figure 15. Clocking concept FSK

FSK Transmission

As shown in figure 15, the transmitter IC is switched on with $V_{FSK} = V_S$,V_{ASK} remains 0 V. Then the IC is enabled and the XTO and PLL settles. After 5 ms, V_S is applied to V_{ASK} to turn on the power amplifier. The output can then be modulated by means of Pin FSK. In this case, V_{ASK} remains = V_S during the message.

To stop the transmission set V_{FSK} = 0 V, then disable the transmitter with V_{ASK} = 0 V.

Take Over the Clock Pulse in the µC (MARC4)

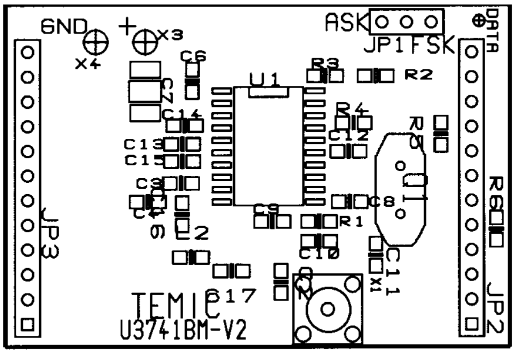
The divided clock of the crystal oscillator of the U2741B f_{CLK} is used for clocking the µC. The µC (M48C892/ M44C892) has the special feature of starting with an integrated RC oscillator to switch on the U2741B with V_{FSK} = V_S. After 5 ms, the CLK of the U2741B is definitely stable. The µC can use it now to send the message with crystal accuracy.

The frequency f_{CLK} depends on the crystal frequency f_{XTO} and the input level of Pin DIVC.

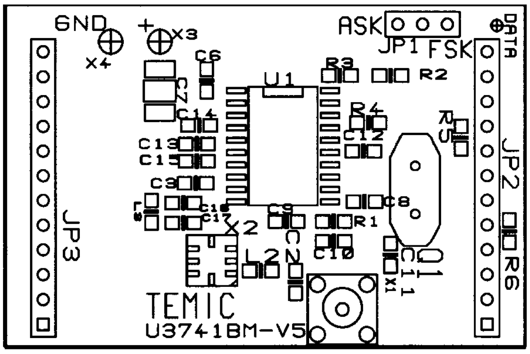
Table 3 Function of Pin DIVC

DIVC = ‘0’	$f_{CLK} = f_{XTO} / 4$
DIVC = ‘1’	$f_{CLK} = f_{XTO} / 2$

2.3 Receiver Application Board



Version2(V2): Without SAW



Version5(V5): With SAW 14122

Figure 16. Receiver application board

2.3.1 General Description

Basic Function

The receiver application board is a programmable RF receiver containing the UHF FSK/ASK remote control receiver U3741BM. Atmel Wireless & Microcontrollers provides 8 different types of the receiver application board (see table 4).

The boards differ in the board version (with/without SAW), the operating frequency (433.92 MHz/315 MHz) and the IF bandwidth of the U3741BM (300 kHz/ 600 kHz).

For operation, the receiver application board must be connected to the basic application board.

The configuration of the U3741BM is done by the microcontroller M48C892 on the basic application board.

After power on, the RF receiver verifies the presence of a valid transmitter signal. If a valid signal is detected, the receiver remains active and transfers the data stream to the connected microcontroller M48C892 on the basic application board.

After receiving the data stream, the microcontroller disables the RF receiver (ENABLE = ‘0’) and verifies the received data stream. If the data stream is equal to a programmable testword, stored in a non-volatile memory, this will be indicated by the LEDs H1 and H2 on the basic application board.

Table 4 List of available receiver application boards

Receiver Appl. Board	433.92 MHz/300 kHz/SAW	433.92 MHz/600 kHz/SAW	315 MHz/300 kHz/SAW	315 MHz/600 kHz/SAW
Version	V5	V5	V5	V5
R5 [kΩ]	10	10	not mounted	not mounted
R6 [kΩ]	not mounted	not mounted	10	10
C2 [pF]	8.2	8.2	10	10
C3 [pF]	22	22	47	47
C11 [pF]	5.6	5.6	8.2	8,2
C17 [pF]	8.2	8.2	22	22
L2 [nH]	33	33	82	82
L3 [nH]	27	27	47	47
Q1 [MHz]	6.76438	6.76438	4.90625	4.90625
X2	B3555	B3555	B3551	B3551
Receiver Appl. Board	433.92 MHz/300 kHz/ no SAW	433.92 MHz/600 kHz/ no SAW	315 MHz/300 kHz/no SAW	315 MHz/600 kHz/no SAW
Version	V2	V2	V2	V2
R5 [kΩ]	10	10	not mounted	not mounted
R6 [kΩ]	not mounted	not mounted	10	10
C2 [pF]	not mounted	not mounted	not mounted	not mounted
C3 [pF]	15	15	33	33
C11 [pF]	5.6	5.6	8.2	8.2
C17 [pF]	3.3	8.2	22	22
L2 [nH]	22	22	39	39
Q1 [MHz]	6.76438	6.76438	4.90625	4.90625

Technical Features

- The power supply is provided by the basic application board (+5 V)
- Power supply if using the receiver application board stand alone: Connectors X4 (GND) and X3 (+5 V).
- Sensitivity:

315 MHz no SAW	–111 dBm
433.92 MHz no SAW	–110 dBm
315 MHz SAW	–106 dBm
433.92 MHz SAW	–105 dBm

- The reduced sensitivity can be set with the resistor R2. For more information, see data sheet U3741BM.
- For measurement purposes, the Pin DATA (U3741BM) is available on JP2.
- Jumper setting on the receiver application board

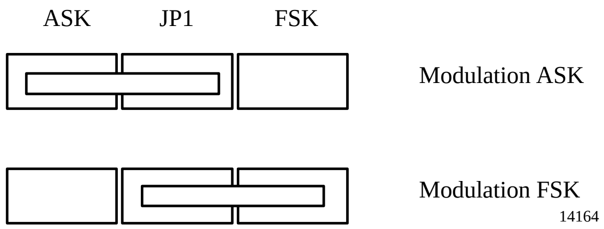


Figure 17. Jumper setting

Programming of the RF Receiver

Starting of the RKE Design Kit

1. Switch on the PC and start the operating system
2. Assemble the RKE Design Kit as shown in figure 1.
3. Switch on the 5-V power supply of the basic application board.
4. Connect the serial link cable (RS232) to an unused serial port (Com1, Com2).
5. Press the reset button (Key S5).
6. Start the receiver application software (U3741BM.EXE).
7. Program the receiver with the target values.

Reprogramming of the Receiver:

1. Press the reset button (Key S5).
2. Program the receiver with the target values.

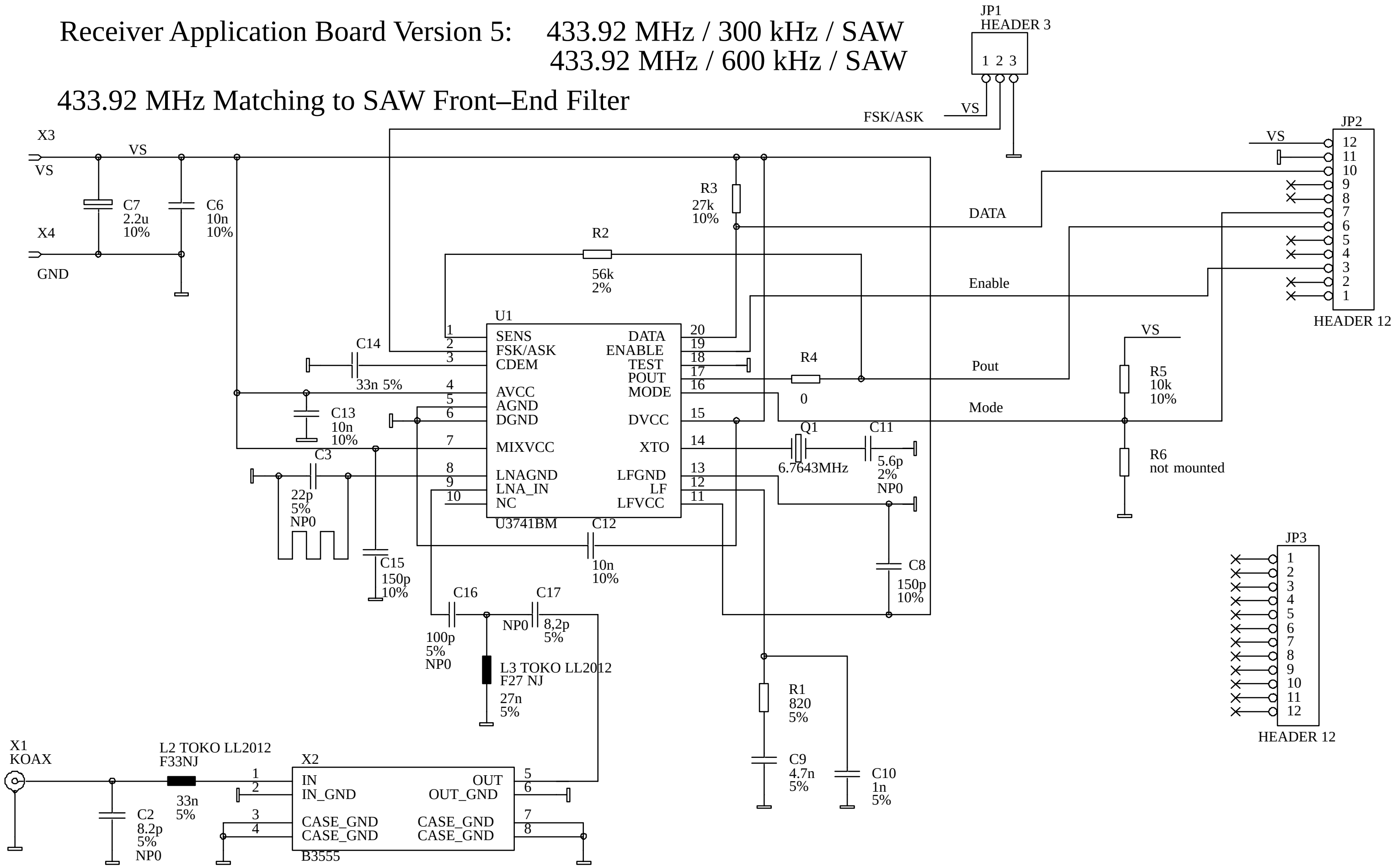


Figure 18. Schematic receiver application board
V5: 433.92 MHz/ 300 kHz/SAW; 433.92 MHz/ 600 kHz/SAW

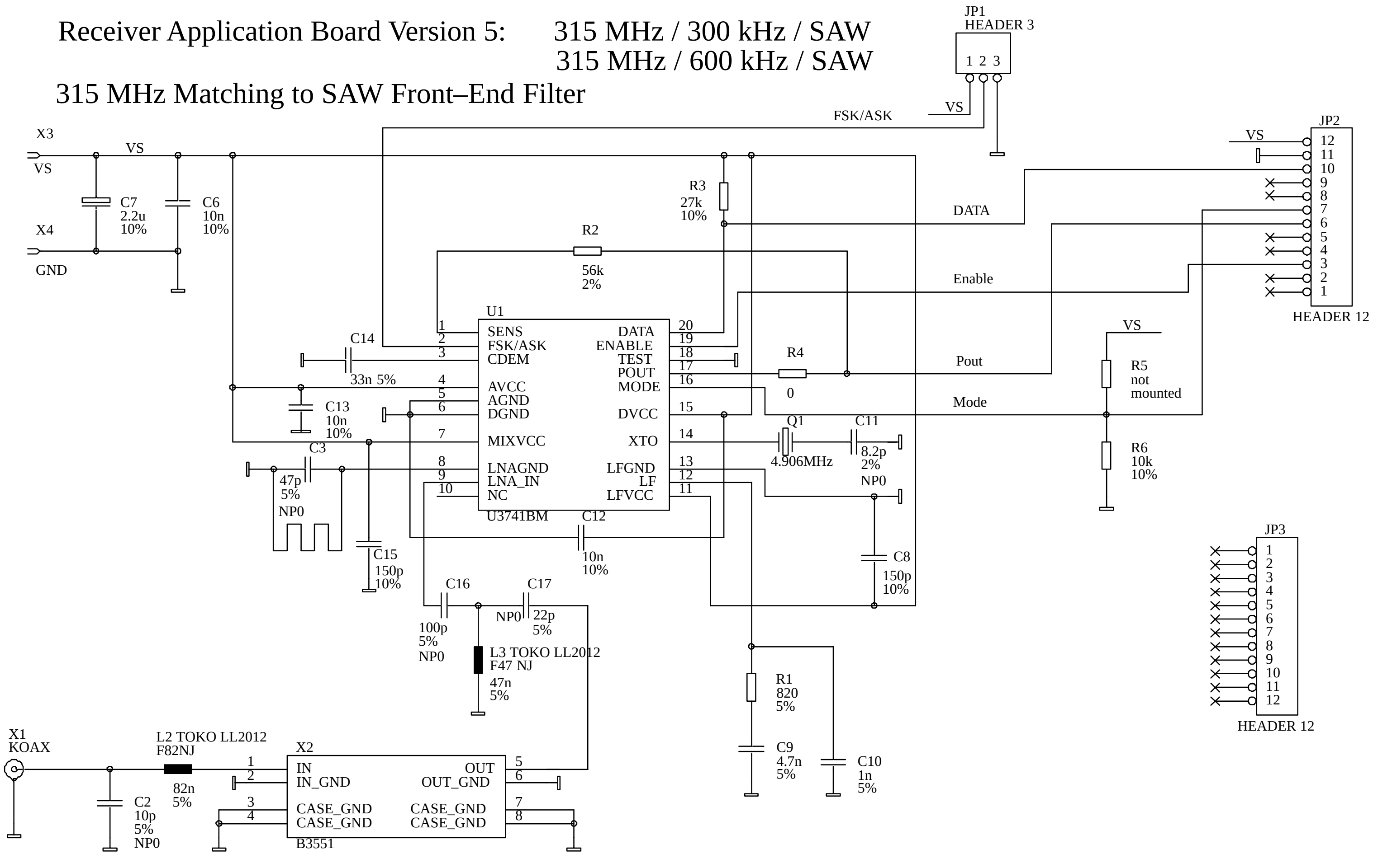


Figure 19. Schematic receiver application board V5: 315 MHz/ 300 kHz/SAW; 315 MHz/ 600 kHz/SAW

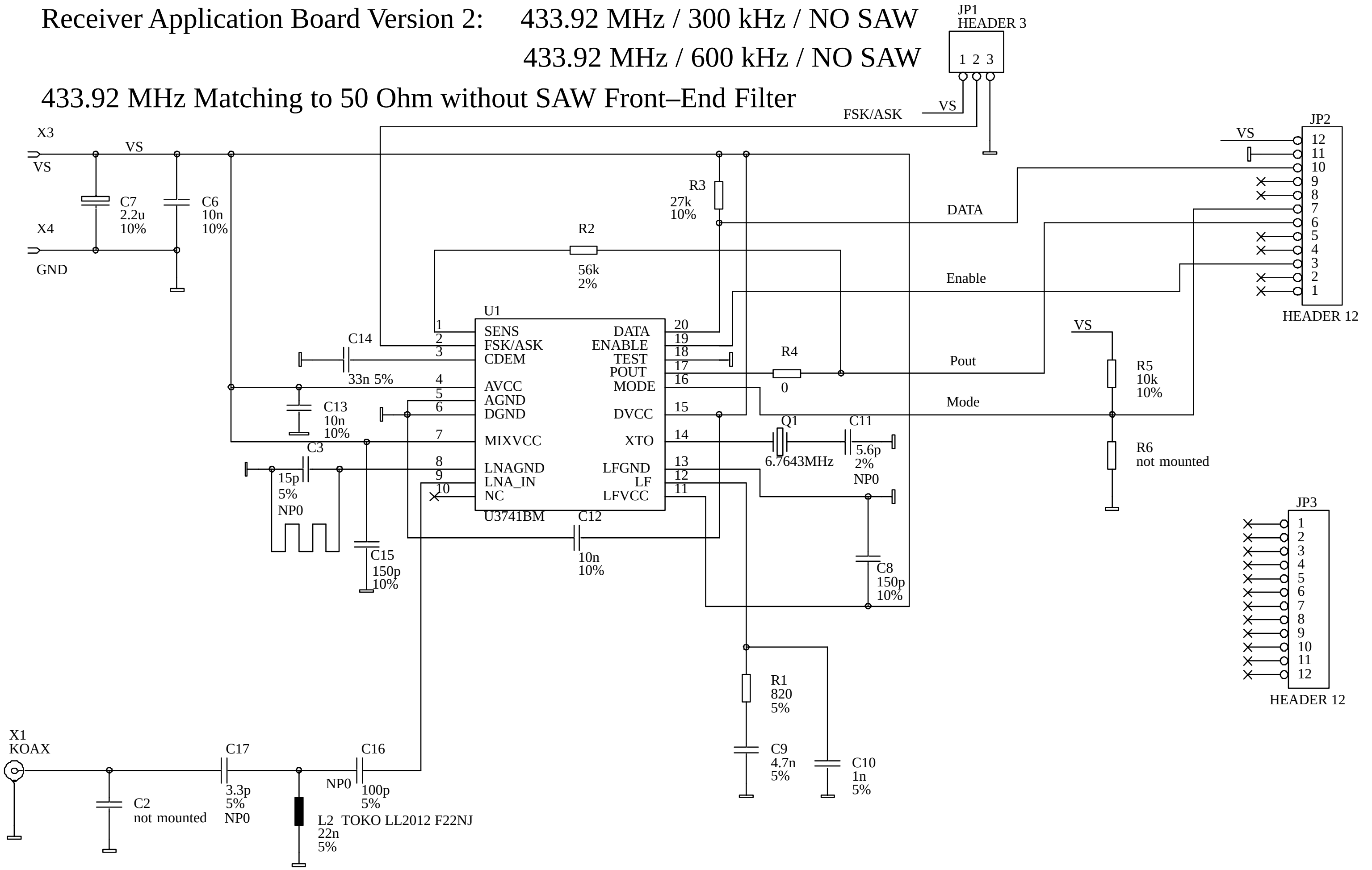


Figure 20. Schematic receiver application board
V5: 433.92 MHz/ 300 kHz/ NO SAW ; 433.92 MHz/ 600 kHz/ NO SAW

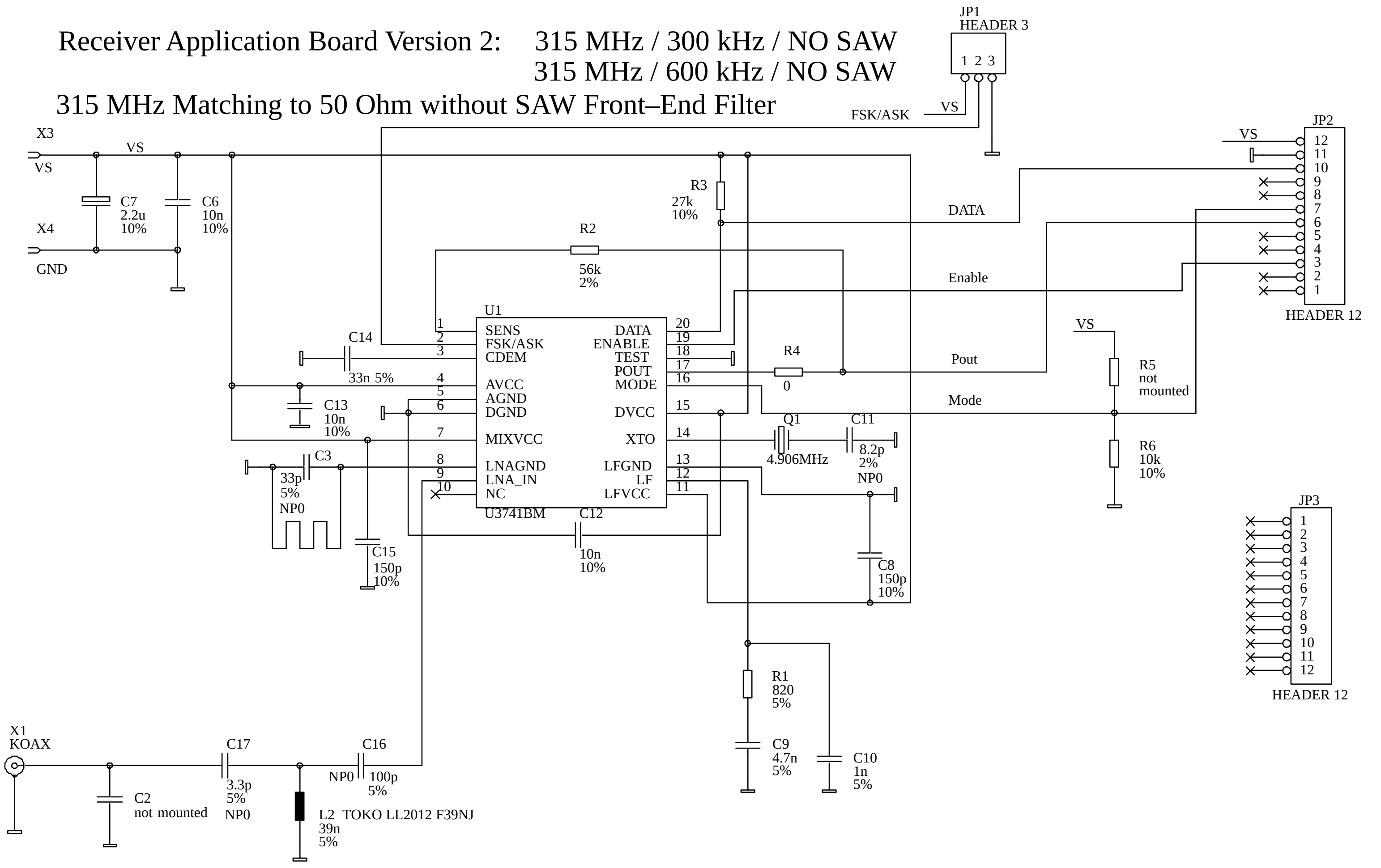
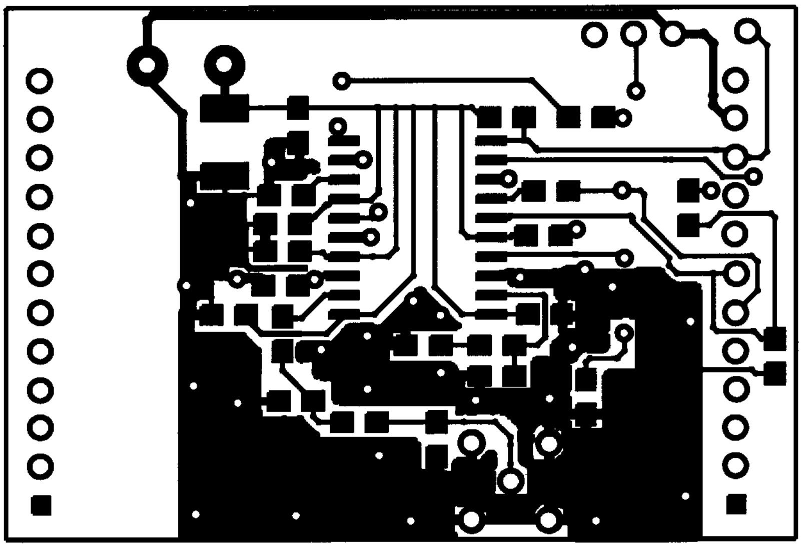
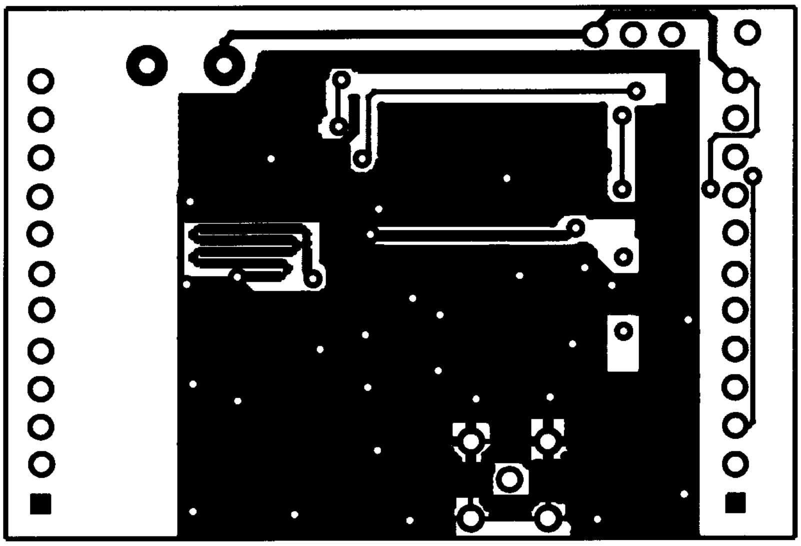


Figure 21. Schematic receiver application board
V5: 315 MHz/ 300 kHz/ NO SAW; 315 MHz/ 600kHz/ NO SAW



14127

Figure 22. Layer 1 receiver application board
V2: 433.92 MHz/ 300 kHz/ NO SAW; 433.92 MHz/ 600 kHz/ NO SAW;
315 MHz/ 300 kHz/ NO SAW; 315 MHz/ 600 kHz/ NO SAW; scale 1.7:1



14128

Figure 23. Layer 2 receiver application board
V2: 433.92 MHz/ 300 kHz/ NO SAW; 433.92 MHz/ 600 kHz/ NO SAW;
315 MHz/ 300 kHz/ NO SAW; 315 MHz/ 600 kHz/ NO SAW; scale 1.7:1

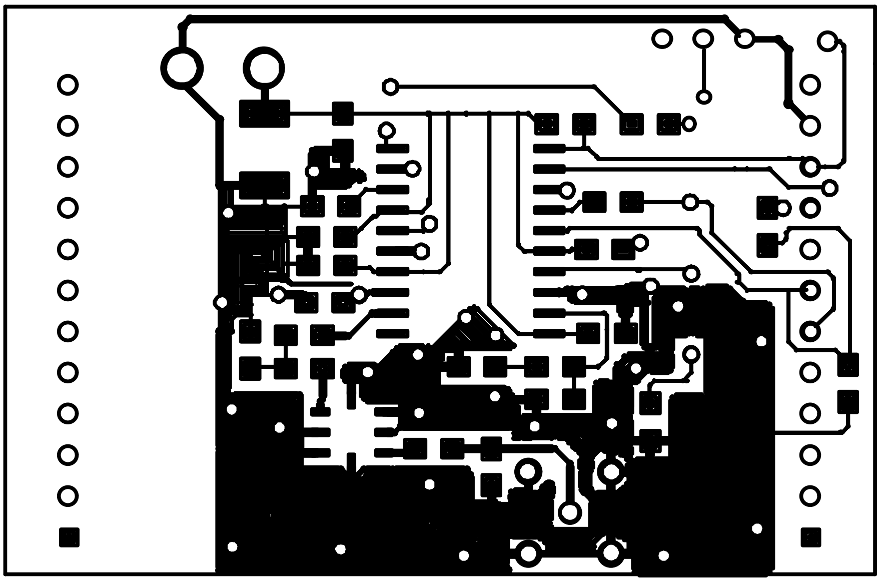


Figure 24. Layer 1 receiver application board
V5: 433.92 MHz/ 300 kHz/ SAW; 433.92 MHz/ 600 kHz/ SAW;
315 MHz/ 300 kHz/ SAW; 315 MHz/ 600 kHz/ SAW; scale 1.7:1

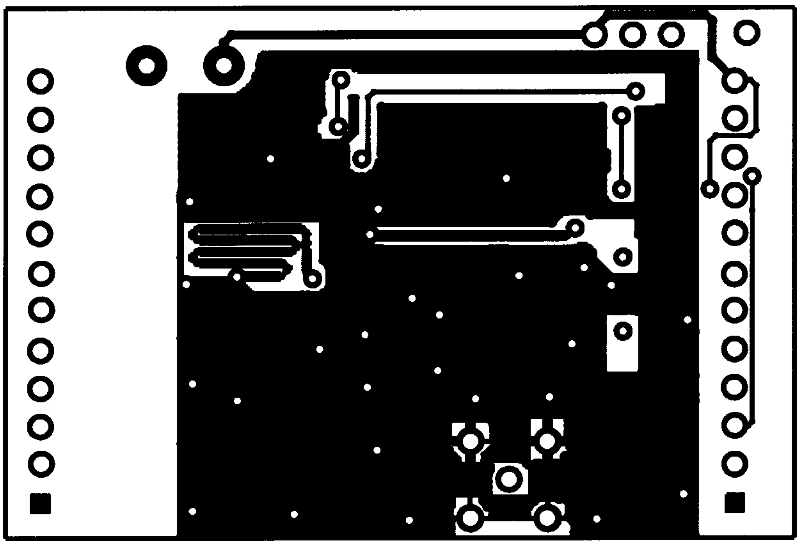


Figure 25. Layer 2 receiver application board
V5: 433.92 MHz/ 300 kHz/ SAW; 433.92 MHz/ 600 kHz/ SAW;
315 MHz/ 300 kHz/ SAW; 315 MHz/ 600 kHz/ SAW; scale 1.7:1

Table 5 Bill of Materials

Components	Pcs	A*	B*	C*	D*	E*	F*	G*	H*	Value	Tol.	Material	Housing	Manufacturer
U1	1	X	X	X	X	X	X	X	X	U3741BM-A2FP U3741BM-A3FP			SO20	Atmel Wireless & Microcontrollers
X2	1					X	X	X	X	B3551 B3555		B39421-B3551-Z10 B39431-B3555-Z10	QCC8	S + M Components
C2	1					X	X	X	X	8.2pF/25V 10p/25V	5%	NP0 ceramic	Size 0603	
C3	1	X	X	X	X	X	X	X	X	33p/25V 15p/25V 47p/25V 22p/25V	5%	NP0 ceramic	Size 0603	
C11	1	X	X	X	X	X	X	X	X	5.6pF/25V 8.2p/25V	2%	NP0 ceramic	Size 0603	Murata
C17	1	X	X	X	X	X	X	X	X	3.3p/25V 22pF/25V 8.2pF/25V	5%	NP0 ceramic	Size 0603	
C6, C12, C13	3	X	X	X	X	X	X	X	X	10nF/25V	10%	X7R ceramic	Size 0603	
C7	1	X	X	X	X	X	X	X	X	2.2µF/6.3V	10%	Tantal	Size 1812	
C8, C15	2	X	X	X	X	X	X	X	X	150p/25V	10%	X7R ceramic	Size 0603	
C9	1	X	X	X	X	X	X	X	X	4.7nF/25V	5%	X7R ceramic	Size 0603	
C10	1	X	X	X	X	X	X	X	X	1nF/25V	5%	X7R ceramic	Size 0603	
C14	1	X	X	X	X	X	X	X	X	33nF/25V	5%	X7R ceramic	Size 0603	
C16	1	X	X	X	X	X	X	X	X	100pF/25V	5%	NP0 ceramic	Size 0603	
R1	1	X	X	X	X	X	X	X	X	820R/0.1W	5%		Size 0603	
R2	1	X	X	X	X	X	X	X	X	56k/0.1W	2%		Size 0603	
R3	1	X	X	X	X	X	X	X	X	56k/01W	2%		Size 0603	
R4	1	X	X	X	X	X	X	X	X	0/0.1W			Size 0603	
R5	1			X	X			X	X	10k/0.1W	10%		Size 0603	
R6	1	X	X			X	X			10k/0.1W	10%		Size 0603	
L2	1	X	X	X	X	X	X	X	X	22nH 33nH 39nH 82nH	5%	LL2012–F<value> NJ	LL2012	Toko
L3	1					X	X	X	X	27nH 47nH	5%	LL2012–F<value> NJ	LL2012	Toko
Q1	1	X	X	X	X	X	X	X	X	4.906MHz 6.7643MHz		Order-No. 10141392 Order-No. 10141393		Jauch
Connector	1	X	X	X	X	X	X	X	X	male			Contact	Radiall
Antenna	1	X	X	X	X	X	X	X	X	Antenna 400 to 470 MHz		Type No. K71 32 29 Order-No. 510 195	BNC connector 165 mm	Antennengesellschaft Ulm
JP1	1	X	X	X	X	X	X	X	X	3 pins			Row connector	
Jumper	1	X	X	X	X	X	X	X	X	for JP1				
JP2, JP3	1	X	X	X	X	X	X	X	X	12 pins			Row connector	
X3, X4	2	X	X	X	X	X	X	X	X	Connector pin				
Board	1	X	X	X	X	X	X	X	X	U3741BM-V2 U3741BM-V5		FR4	Thickness 1.5 mm	

Note:
A* = 315 MHz/ 300 kHz/ NO SAW
B* = 315 MHz/ 600 kHz/ NO SAW
C* = 433.92 MHz/ 300 kHz/ NO SAW
D* = 433.92 MHz/ 600 kHz/ NO SAW
E* = 315 MHz/ 300 kHz/ SAW
F* = 315 MHz/ 600 kHz/ SAW
G* = 433.92 MHz/ 300 kHz/ SAW
H* = 433.92 MHz/ 600 kHz/ SAW

2.3.2 Application Hints U3741BM/U3742BM/U3745BM

As usual with RF design, the peripheral circuit and layout are very important. It is recommended to adapt the individual design to the application suggestion.

- **Blocking Concepts**

The design of the layout includes considerations to the blocking concepts in order to minimize ripples on the power supply. The following are the most important ones:

– Power supply input ports: place capacitors (about 2.2 µF // 10 nF ceramic) in between to prevent voltage break-in and ripples.

– Power supply chip inputs: place capacitor (about 10 nF ceramic) in between to prevent ripples. Make sure that every single supply voltage (AVCC, LFVCC, DVCC, MIXVCC) is led separately from the input ports and the blocking is done to its ground (AGND, LFGND, DGND).

– Try to layout a ground plane on the back side and use this with vias for blocking purpose.

- **Peripheral Circuit**

– In mixed-signal circuits, the separation of digital and analog groups is obligatory. So bear in mind the separation of the DATA signal from the RF part like XTO and loop filter. The harmonics of the quartz frequency of the microcontroller must be includes in the spectral calculations.

– Loop filter: use the dimensions of the data sheet and place the ground part of the filter close to LFGND.

– LNAGND: the lead frame and bond wire inductance towards the LNA ground are compensated by C_3, this capacitor forms a series resonance circuit together with these inductances.

  The inductance L = 25 nH is a feed inductor to form a DC path. Its value is not critical but must be large enough not to detune the series resonance circuit. For cost reduction, this inductor can be easily printed on the PCB. This configuration improves the sensitivity of the receiver about 1 dB to 2 dB.

  Use the measurements of the layout of the receiver board to get an idea about the relations of printed meander shaped inductors.

– Quartz (see paragraph ‘Quartz: Frequency Pulling’)

– LNA (see paragraph ‘Input Matching’)

– CDEM (see paragraph ‘Data Encoding’)

- **Quartz: Frequency Pulling**

Quartz circuits are essential to achieve stable and accurate frequency performance. The use of a load capacitor C_L in conjunction with the quartz determines the actual frequency. Since parasitic capacitors cause differences according to the nominal local oscillator frequency in a range up to 100 ppm and more, it might be useful to apply the pulling concept (see chapter 2.2.2).

- **Input Matching**

The matching of the SAW filter/ antenna to the input impedance of the LNA causes much better noise matching results (different to power matching). **Thus, it is recommended to use the circuit & layout of the respective application suggestion.** To compensate individual layout etc., alter inductor L3 and capacitor C17. The matching parameters for SAW input towards the antenna is given by the manufacturer (see application circuits).

Notes:

– For the measurement of the input impedance, the receiver must be ON (i.e., no polling or sleep mode).

– The use of a SAW filter results in a different selectivity (see figure 8, data sheet U3741BM).

– U3742BM: The RSSI output can be used for matching purpose. The voltage is correlated to the sensitivity of the receiver.

- **Measurement of the LO Frequency**

To perform a measurement of the local oscillator frequency, the version with SAW (SAW) and without SAW (NO SAW) have to be distinguished.

NO SAW:
The LO spurious emission IS_{LORF} (see data sheet, paragraph LNA mixer) can be determined at the antenna input port. A typical value is –73 dBm.

SAW:
The saw loss backwards to the antenna reduces the signal too much, so the best way to perform the measurement is the use of an antenna and place it just above the receiver.

- **LO Frequency Shifting**

For certain reasons it might be important to shift the receiving frequency. A change of the XTO frequency causes this shift. Figure 26 shows the feed of a certain frequency into the XTO input.

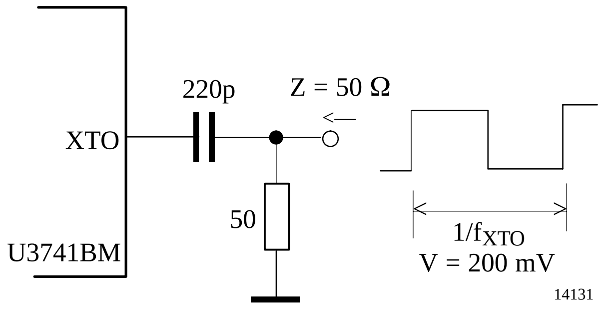
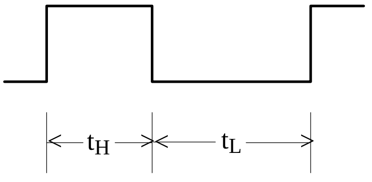


Figure 26. XTO feed circuit

- **Data Encoding**

To obtain best performance using the U3741BM, the data should be encoded using Manchester or Bi-phase coding where the duty cycle of the signal is 0.5 (= 50%). This allows to cut off the DC portion of the signal using a high-pass filter in the data filter. If the encoding is different, there are some restrictions of the signal timing and some impact on the sensitivity of the receiver.



$$DC = \frac{t_H}{t_H + t_L}$$

Figure 27. Definition of the duty cycle (DC)

Limits of LOW and HIGH Times (t_L and t_H)

The minimum duration of a high or low period (t_H, t_L) is given by the upper cut-off frequency of the data filter. If the pulse width is lower than the recommended values, the sensitivity is reduced. Furthermore, the minimum time is limited by the digital circuit (see data sheet U3741BM, Electrical Characteristics, parameter T_{DATA_min}). The mi-nimum time t_H, t_L of the encoder may not be shorter than the values shown in the tables 6 and 7 for reduced sensitivity.

Table 6 Timing conditions for ASK (see also data sheet U3741BM, Electrical Characteristics)

ASK	Recom-mended CDEM	Edge-to-Edge Time (t_H, t_L) for Full Sensitivity		Extended Edge-to-Edge Time (t_H, t_L) with Reduced Sensitivity ≈ 3 dB	
		Min. (µs)	Max. (µs)	Min. (µs)	Max. (µs)
BR_Range0	39 nF	270	1000	200	1250
BR_Range1	22 nF	156	560	100	700
BR_Range2	12 nF	89	320	60	400
BR_Range3	8.2 nF	50	180	30	250

Table 7 Timing conditions for FSK

FSK	Recom-mended CDEM	Edge-to-Edge Time (t_H, t_L) for Full Sensitivity		Extended Time
		Min. (µs)	Max. (µs)	not available
BR_Range0	27 nF	270	1000	
BR_Range1	15 nF	156	560	

The maximum time of a pulse mainly depends on the cut-off frequency of the highpass filter which is set by the CDEM capacitor. To achieve short set-up times for the polling procedure, the CDEM values are limited for each baudrate range. Using the recommended values for the CDEM capacitor, the timing should be within the ranges shown in tables 6 and 7. The extended limits are given for a sensitivity reduction of about 3 dB. The tolerance of the CDEM capacitor should be ± 5%. If the encoder signal exceeds the maximum time limit, the output of the re-ceiver becomes undefined. This could be random switching signal (see histogram, figure 29, for the dis-tribution of pulse width of that signal). The digital circuit interrupts a LOW period after the time T_{DATA_max} (see data sheet U3741BM, Electrical Characteristics). After the transmitter has been kept at one state for a time longer than the maximum given in tables 6 and 7 the following signals (1 to 2 bits) could be affected by inaccurate output timing or less noise immunity.

Duty cycle of the data signal for non-Manchester/ Bi-phase codes i.e. PWM codes

Duty cycle means the ratio between the pulse width (high level) and the whole high-low period. The full sensitivity is available at duty cycles close to 50%. Signals with different duty cycles can be received under following conditions:

Table 8 Operating conditions with different duty cycles

Duty Cycle	33% to 66%	25% to 75%	15% to 85%
ASK	≈ 2 dB less sensitivity	≈ 6 dB less sensitivity	≈ 10 dB less sensitivity
FSK	Deviation of ≥30 kHz required, no change in sensitivity	not applicable	

- **Polling**

The configurable self-polling mode with a programmable timeframe check (bitcheck) guarantees a low power con-sumption. It is also possible to control the polling directly by the µC via the Pin ENABLE.

Polling via Pin ENABLE:
The receiver remains in sleep mode as long as ENABLE is held to “L”. After switching ENABLE to “H”, the sleep time T_{Sleep} elapses. Then, the signal-processing circuits will be enabled and the incoming data stream will be ana-lyzed by the bitcheck logic.

IF the receiver is polled exclusively by a µC, T_{Sleep} can be programmed to zero to enable an instantaneous response time.

If the analyzing of the incoming data stream is also be carried out by the µC, the number of bits to be checked during the bitcheck $N_{Bitcheck}$ can be programmed to 0.

- **Lim_min and Lim_max**

During bitcheck, the incoming data stream is examined to distinguish between a valid signal from a corresponding transmitter and signals due to noise. This is done by sub-sequent time frame checks where the distance between two signal edges are continuously compared to a program-mable time window.

The limits of the time window T_{Lim_min} and T_{Lim_max} must be programmed by the µC depending on the signal baudrate. Generally we recommend for the limit T_{Lim_min} to be 0.75 × the shortest distance between two signal edges of the transmitter preburst during bitcheck and T_{Lim_max} to be 1.25 × the longest distance between two signal edges of the transmitter preburst during bitcheck.

Calculation of T_{Lim_min} and T_{Lim_max} for modulation schemes like Bi-phase and Manchester where the duty cycle is 50% and the preburst consists of a row of '1' or a row of '0':

T_{Lim_min} = 0.75 / (2 × signal baudrate)
T_{Lim_max} = 1.25 / (2 × signal baudrate)

Calculation of T_{Lim_min} and T_{Lim_max} for the modulation schemes 1/3 – 2/3 where the duty cycle is ≠ 50%.

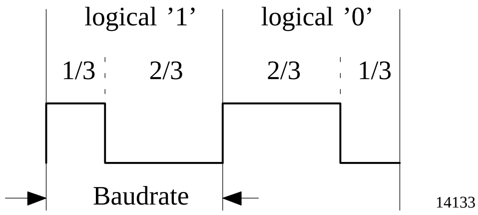


Figure 28. Modulation scheme 1/3 - 2/3

T_{Lim_min} = 0.75 / (3 × signal baudrate)
T_{Lim_max} = 1.25 / (3/2 × signal baudrate)

Additional information about the calculation of Lim_min and Lim_max: figure 29 illustrates a typical distribution of t_{ee} (edge-to-edge output) due to noise. The distribution of t_{ee} shows that the incidence of short t_{ee} is much higher than long t_{ee}. This means that the lower limit Lim_min has an essential influence regarding wake-up of the receiver due to noise.

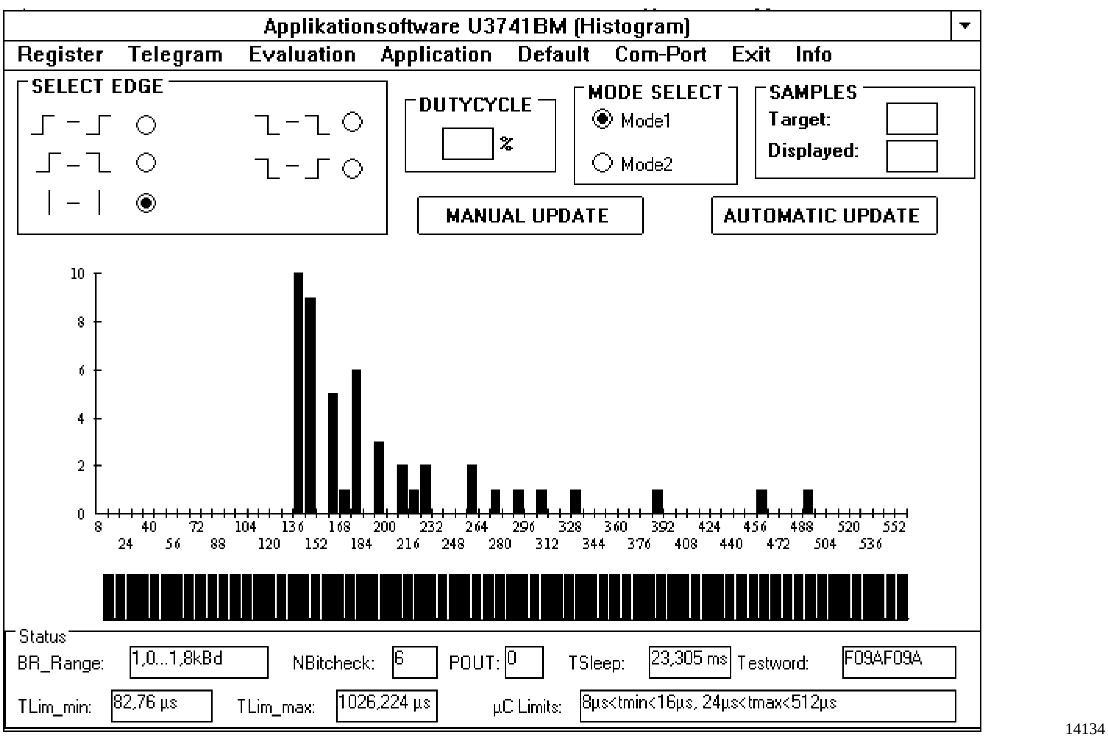


Figure 29. Typical distribution of t_{ee} (edge-to-edge output) due to noise; BR_range: B0

Table 9 illustrates the lower limit of the parameter Lim_min. To prevent wake-up of the U3741BM due to noise, the limit Lim_min must not be programmed below 'Lower Limit of Lim_min'. The limit Lim_max was set to the maximum value during the determination of the 'Lower Limit of Lim_min'. Generally, a wake-up due to noise becomes more unlikely if programming a smaller value for Lim_max. The 'Lower Limit of Lim_min' depends on the selected baudrate range (BR_range) and on the number of bits to be checked.

Table 9

BR_range	Number of Bits to be Checked	Lower Limit of Lim_min
B0 (1.0 to 1.8 kBaud)	3	16
	6	12
	9	11
B1 (1.8 to 3.2 kBaud)	3	17
	6	13
	9	11
B2 (3.2 to 5.6 kBaud)	3	19
	6	13
	9	11
B3 (5.6 to 10.0 kBaud)	3	21
	6	14
	9	12

The following method to calculate Lim_min and Lim_max is recommended:

$T_{Lim\_min} = 0.75 / (2 \times \text{signal baudrate})$
$T_{Lim\_max} = 1.25 / (2 \times \text{signal baudrate})$

$Lim\_min = T_{Lim\_min} / T_{XClk}$
$Lim\_max = (T_{Lim\_max} / T_{XClk}) + 1$

If the calculated Lim_min ≥ 'Lower Limit of Lim_min' → OK

What to do if the calculated Lim_min < 'Lower Limit of Lim_min'?

– Reduce the tolerance to calculate T_{Lim_min} and T_{Lim_max} (e.g. ± 20%)

– If possible, use a higher baudrate range. Due to the characteristic, it is more likely that the device wakes up due to noise at the upper end of the baudrate range.

- **Programming Details**

The configuration registers of the U3741BM are programmed via the bi-directional data line. The programming sequence is described in the chapter 'Programming the configuration registers' in the data sheet U3741BM. Some features of the programming sequence they will be described in more detail on the next page.

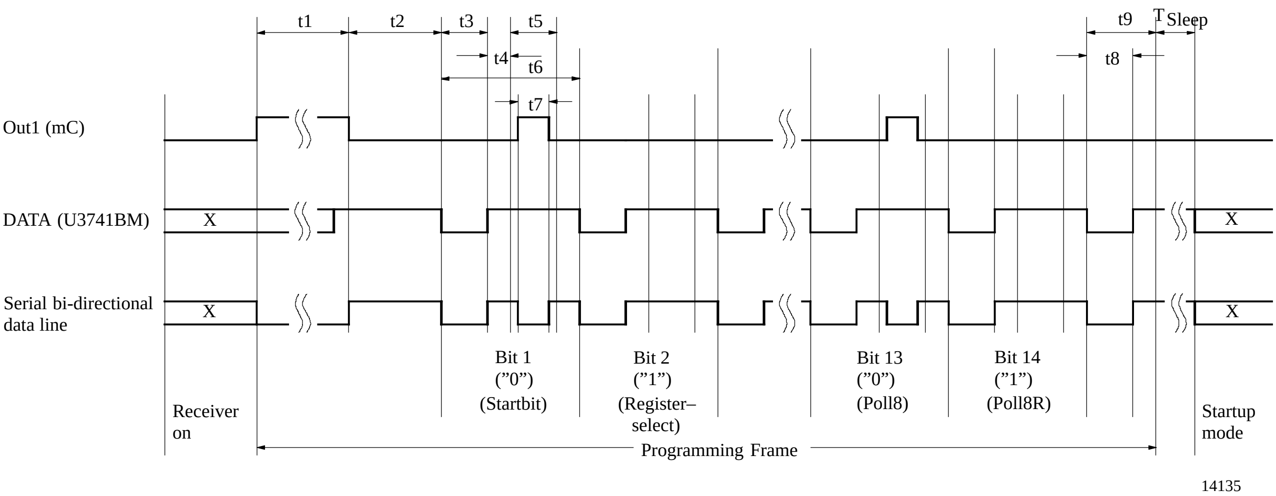


Figure 30. Programming timing

Programming start pulse t1:
The programming start pulse starts the programming sequence and is generated by a connected µC. The necessary length of the programming start pulse depends on the active baudrate range and the logic output level of Pin DATA (U3741BM) during the start pulse.

If the logic output level of Pin DATA is ‘H’ during the start pulse, the receiver is able to recognize the programming request after $t1 \geq 3 \times T_{Clk}$. A proper detection of the programming request is guaranteed after $t1 \geq 4 \times T_{Clk}$. DATA = ‘H’ can be ensured by setting Pin ENABLE to ‘L’. This feature can be used if the time to reprogram is critical. Pay attention that spikes on the serial data line ($t_{Spike} > 3 \times T_{Clk}$) could start a programming sequence.

If the logic output level of Pin DATA is unknown during the start pulse, the start pulse length must be longer as the maximum low period at the DATA output $T_{DATA\_L\_max}$.

After a power-on reset, the programming start pulse must be at least 11.7 ms due to the reset marker.

Programming pulse t7:
Within the programming window t5, the individual bits are set. If the µC pulls down the Pin DATA for the time t7 during t5, the according bit is set to ‘0’. If no programming pulse t7 is issued, this bit is set to ‘1’.

To guarantee the detection of the programming pulse, the minimum length of t7 is $64 \times T_{Clk}$. If the programming pulse becomes shorter ($32 \times T_{Clk} \leq t7 < 64 \times T_{Clk}$), the detection is not guaranteed.

Table 10

Parameter	Test Condition	Symbol	6.76438 MHz Oscillator (MODE: 1)			4.90625 MHz Oscillator (MODE: 0)			Variable Oscillator			Unit
			Min.	Typ.	Max.	Min.	Typ.	Max.	Min.	Typ.	Max.	
Basic clock cycle of the digital circuitry												
Basic clock cycle	MODE=0 (USA) MODE=1 (Europe)	T_{Clk}		2.0697			2.0383			$1/(f_{XTO}/10)$ $1/(f_{XTO}/14)$		µs
Extended basic clock cycle	BR_Range = BR_Range0 BR_Range1 BR_Range2 BR_Range3	T_{XClk}		 1.6 8.3 4.1 2.1			 16.3 8.2 4.1 2.0			 $8 \times T_{Clk}$ $4 \times T_{Clk}$ $2 \times T_{Clk}$ $1 \times T_{Clk}$		µs
Programming start pulse	DATA = ‘1’ during the start pulse. Detection of the programming request is **not** guaranteed.	t1	6.2			6.1			$3 \times T_{Clk}$			µs
	DATA = ‘1’ during the start pulse. Detection of the programming request is guaranteed.	t1	8.3			8.2			$4 \times T_{Clk}$			µs
	DATA = ‘X’ during the start pulse BR_Range = BR_Range0 BR_Range1 BR_Range2 BR_Range3 after POR	t1	 2188 1104 561 290 11656		 3176 3176 3176 3176	 2155 1087 553 286 11479		 3128 3128 3128 3128	 $1057 \times T_{Clk}$ $533 \times T_{Clk}$ $271 \times T_{Clk}$ $140 \times T_{Clk}$ $5632 \times T_{Clk}$		 $1535 \times T_{Clk}$ $1535 \times T_{Clk}$ $1535 \times T_{Clk}$ $1535 \times T_{Clk}$	µs
Programming pulse	Detection of the programming pulse **not** guaranteed.	t7	66.2			65.2			$32 \times T_{Clk}$			µs
	Detection of the programming pulse guaranteed.	t7	132.4		529.8	130.4		521	$64 \times T_{Clk}$		$256 \times T_{Clk}$	µs

- **Acknowledge Pulse**

If the mode word just programmed is equivalent to the mode word that was already stored in that register, this will be indicated by the acknowledge pulse t8. If the mode word is not equivalent, no acknowledge pulse occurs.

Example of a programming sequence:

Power on reset:	Default value for OPMODE register:	‘48B0 Hex’	
	Default value for LIMIT register:	‘0E60 Hex’	
Programming of the OPMODE register with ‘48B0 Hex’		→	Acknowledge pulse
Programming of the LIMIT register with ‘0E60 Hex’		→	Acknowledge pulse
Programming of the OPMODE register with ‘58B0 Hex’		→	no Acknowledge pulse
Programming of the LIMIT register with ‘0F60 Hex’		→	no Acknowledge pulse
Programming of the LIMIT register with ‘0F60 Hex’		→	Acknowledge pulse
Programming of the OPMODE register with ‘58B0 Hex’		→	Acknowledge pulse

- **Load Capacity of Pin DATA**

Table 11 Load capacity of Pin DATA

Parameter	Test Condition	Symbol	Min.	Typ.	Max.	Unit
Data output						
Saturation voltage Low	Iol = 1 mA	V_{Ol}		0.08	0.3	V
Internal pull-up resistor		R_{pup}		50	61	kΩ
Maximum time constant	$\tau = C_L \times (R_{pup}//R_{ext})$	τ			2.5	µs
Maximum capacitive load	Without external pull-up resistor R_{ext} = 5 kΩ	C_L C_L			41 540	pF pF

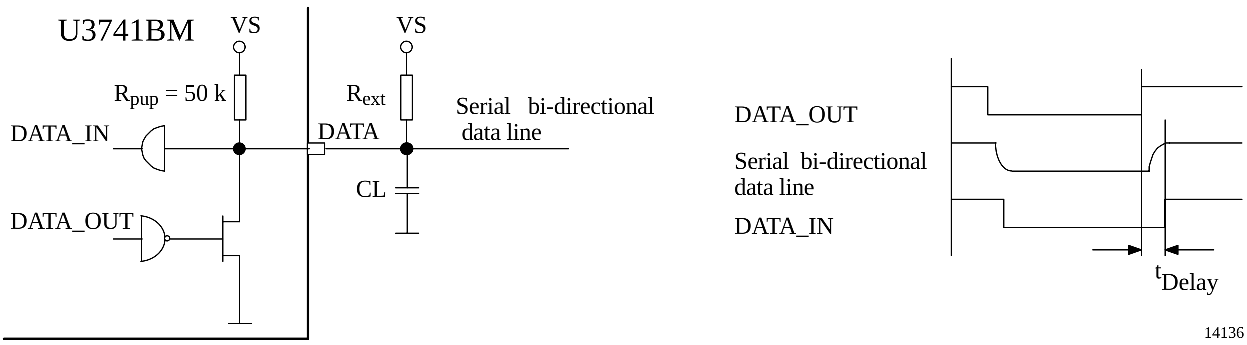


Figure 31. Load capacity of Pin DATA

The U3741BM compares the internal signals DATA_OUT and DATA_IN. If the time $t_{Delay} \geq 3 \times T_{Clk}$ (τ > 2.5 µs), this can start the programming sequence and switching the receiver back to the sleep mode.

- **Calculation Example of the Receiver Parameters**

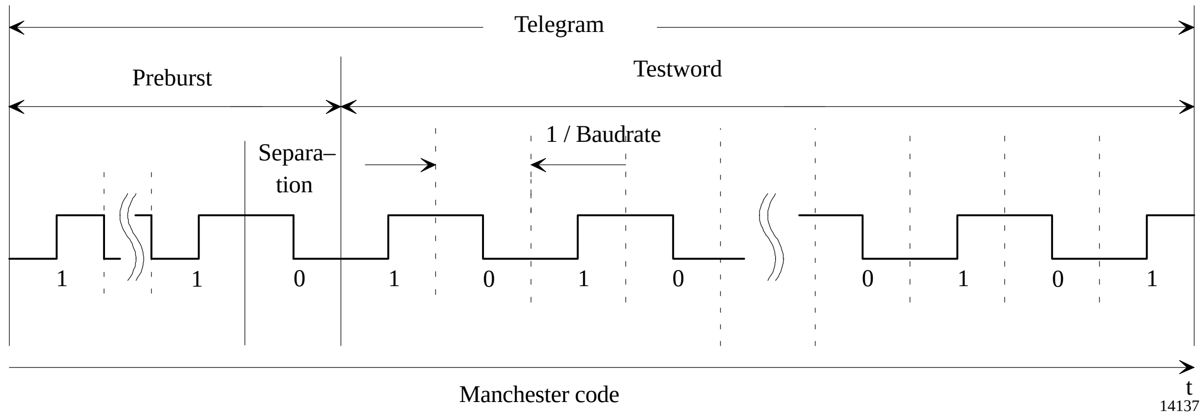


Figure 32. Transmitter signal

Table 12

Transmitter Signal	Receiver U3741BM
Signal baudrate = 2400 Baud Testword = 'A005 Hex' Preburst length = 20.83 ms (50 bits)	BR_range = B1 (1.8 to 3.2 kBaud) Number of bits to be checked = 3 *) POUT = 0 (If a resistor is connected between POUT and SENS2 this means full sensitivity) T_{Lim_min} = 156.25 µs **) T_{Lim_max} = 260.4 µs Lim_min = 19 Lim_max = 32 T_{Sleep} = 17.3 ms ***) Sleep = '01000 bin'

*) to get better immunity against disturbance and noise select 6 or 9 bits.

**) $T_{Lim\_min} = 0.75/ (2 \times 2400\ Baud) = 156.25\ \mu s$
$T_{Lim\_max} = 1.25/ (2 \times 2400\ Baud) = 260.4\ \mu s$
$Lim\_min = T_{Lim\_min}/ T_{XClk} = 156.25\ \mu s/ 8.3\ \mu s = 18.8 \rightarrow 19$
$Lim\_max = (T_{Lim\_max}/ T_{XClk}) + 1 = (260.4\ \mu s/ 8.3\ \mu s) + 1 = 32.4 \rightarrow 32$
(T_{XClk} see table 13; 6.76438 MHz oscillator)

***) $T_{Sleep} \leq T_{Preburst} - T_{Startup} - T_{Bitcheck} - T_{Start\_\mu C}$
$T_{Sleep} \leq 20.83\ ms - 1061\ \mu s - 3.5/ 2400\ Hz - 1\ ms = 17.3\ ms$ (estimated $T_{Start\_\mu C} = 1\ ms$)
$Sleep = T_{sleep}/ (X_{sleep} \times 1024 \times T_{Clk}) = 17.3\ ms/ (1 \times 1024 \times 2.0697\ \mu s) = 8.16 \rightarrow 8 \rightarrow$ '01000 bin'

Table 13

Parameter	Test Condition	Symbol	6.76438 MHz Oscillator (MODE: 1)			4.90625 MHz Oscillator (MODE: 0)			Variable Oscillator			Unit
			Min.	Typ.	Max.	Min.	Typ.	Max.	Min.	Typ.	Max.	
Basic clock cycle of the digital circuitry												
Basic clock cycle	MODE=0 (USA) MODE=1 (Europe)	T_{Clk}		2.0697			2.0383			$1/f_{XTO}/10$ $1/f_{XTO}/14$		µs
Extended basic clock cycle	BR_Range = BR_Range0 BR_Range1 BR_Range2 BR_Range3	T_{XClk}		16.6 8.3 4.1 2.1			16.3 8.2 4.1 2.0			$8 \times T_{Clk}$ $4 \times T_{Clk}$ $2 \times T_{Clk}$ $1 \times T_{Clk}$		µs
Sleep time	Sleep and XSleep are defined in the OPMODE register	T_{Sleep}		$Sleep \times X_{Sleep} \times 1024 \times 2.0697$			$Sleep \times X_{Sleep} \times 1024 \times 2.0383$			$Sleep \times X_{Sleep} \times 1024 \times T_{Clk}$		ms
Startup time	BR_Range = BR_Range0 BR_Range1 BR_Range2 BR_Range3	$T_{startup}$		1855 1061 1061 663			1827 1045 1045 653			896.5 512.5 512.5 $320.5 \times T_{Clk}$		µs
Time for bitcheck	Average bitcheck time while polling BR_Range = BR_Range0 BR_Range1 BR_Range2 BR_Range3	$T_{Bitcheck}$		2.3 1.3 1.2 0.8			2.3 1.3 1.2 0.8					ms
	Bitcheck time for a valid input signal f_{Sig} $N_{Bitcheck} = 0$ $N_{Bitcheck} = 3$ $N_{Bitcheck} = 6$ $N_{Bitcheck} = 9$	$T_{Bitcheck}$	0 $3/f_{Sig}$ $6/f_{Sig}$ $9/f_{Sig}$		0.166 $3.5/f_{Sig}$ $6.5/f_{Sig}$ $9.5/f_{Sig}$	0 $3/f_{Sig}$ $6/f_{Sig}$ $9/f_{Sig}$		0.164 $3.5/f_{Sig}$ $6.5/f_{Sig}$ $9.5/f_{Sig}$	0 $3/f_{Sig}$ $6/f_{Sig}$ $9/f_{Sig}$		$8 \times T_{Clk}$ $3.5/f_{Sig}$ $6.5/f_{Sig}$ $9.5/f_{Sig}$	ms

- **Reset marker**

To indicate a power-on reset, the receiver displays a reset marker (RM) at Pin DATA. The RM is represented by a fixed frequency f_{RM} (see data sheet U3741BM) with a 50% duty cycle.

The connected µC can distinguish between the RM and a data signal, because f_{RM} is lower than the lowest feasible frequency of a data signal.

If the RM is active, the receiver can not receive a transmitter signal.

After the µC has recognized the RM, the configuration registers must be programmed with the target values.

- **Delete the reset marker**

The first thing to do after power-on or a power-on reset is to delete the RM. To activate the receiver, delete the RM by generating a programming start pulse $t1 \geq 5632 \times T_{Clk}$.

The programming start pulse t1 must be generated with a non bouncing signal (not with a lab wire!).

If using a lab wire, the spikes on the serial data line can start a programming sequence and the register configuration is unknown.

3. Software Components

3.1 Transmitter Application Software U2741B

3.1.1 Basic Information

The transmitter application software U2741B supports the development of RKE systems with the UHF FSK/ASK remote control transmitter U2741B. The software configures the transmitter application board (RF transmitter) via PC. In this way parameters like baudrate, modulation, testword etc. can be changed in a very quick and comfortable way.

3.1.2 Installation and System Requirements

- PC 486 or higher
- Serial port Com1 or Com2
- Operating system
  – Win 3.1x
  – Win 95
  – Win NT

Installation of the transmitter– and receiver application software:

- Close all running windows applications.
- For Win 95 or Win NT installation, insert disk 1 in your floppy drive
- For Win 3.1x installation, insert disk 3 in your floppy drive
- Start setup.exe

The setup installs the transmitter application software, the receiver application software and the file PRGINST.TXT (programming instructions) on the hard disk.

To check the correct function of the whole RKE Design Kit, read the information given in the programming instructions first.

Table 14

Possible Problems During Installation	What to do
Error message: ’Setup couldn’t copy ver.dll to C:\Windows’	Remove or rename the existing ver.dll in the windows directory.
Error message: ’*.dll is in use’	Press the ignore button.
Error message: One or more Visual Basic applications are running (vbrun300.dll is in use)’	Close all windows applications.

3.1.3 Start of the Transmitter Application Software

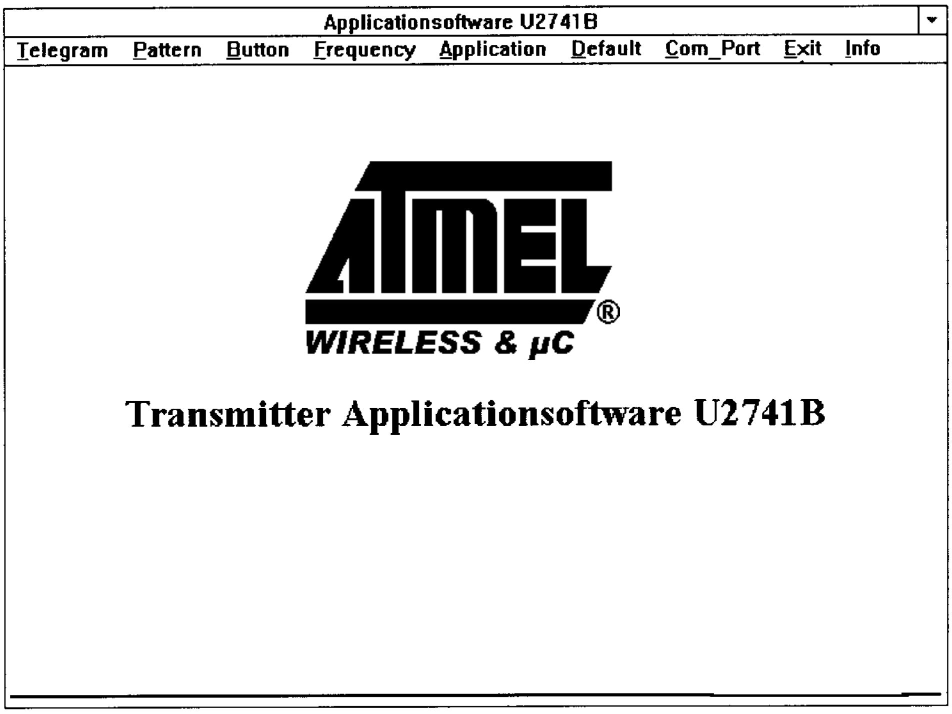


Figure 33. Start window transmitter application software

- To ensure proper operation, the following steps should be done before starting the transmitter application software:

1. Switch on the PC and start the operating system.
2. Remove or insulate the 3-V lithium battery in the transmitter.
3. Assemble the RKE Design Kit as shown in figure 1.
4. Switch on the 5-V power supply of the basic application board.
5. Connect the serial link cable (RS232) to an unused serial port (Com1, Com2).
6. Press the reset button (Key S5).

Start the transmitter application software with the command: u2741b.exe

Figure 33 shows the start window after a successful start. During loading of the program all parameters used in the latest session, stored in a non volatile memory (EEPROM) on the transmitter application board, will be read. These values will be used as the start values in the corresponding windows.

If one ore more parameters are out of the valid range, this will be reported by the error message: 'Transmitter parameter out of range'.

During loading of the program, the file com_port.cnf will be opened. This file contains the number of the Com-Port (Com1 or Com2) used in the latest session. If the file com_port.cnf does not exist, the default Com-Port is Com2.

If the selected Com-Port is not available (e.g., used by another program), this will be reported by the Com-Port Error message. In this case, the other Com-Port must be selected. The changing of the Com-Port initiates the reading of the parameters on the transmitter application board (EEPROM) and there update in the corresponding windows.

If Com1 and Com2 are not available, select 'Exit', make one Com-Port available and start the program again.

If there is no transmitter application board connected to the basic application board or any other problem with the data transmission PC <–> basic application board <–> transmitter application board, this will be reported by the error message: – 'No hardware detected!'

3.1.4 Program Description

- **'Telegram' (Telegram generator)**

By using the telegram generator, a specific telegram can be generated. The telegram consists of a testword and a precede preburst (figure 35). The encoding of the telegram is Manchester.

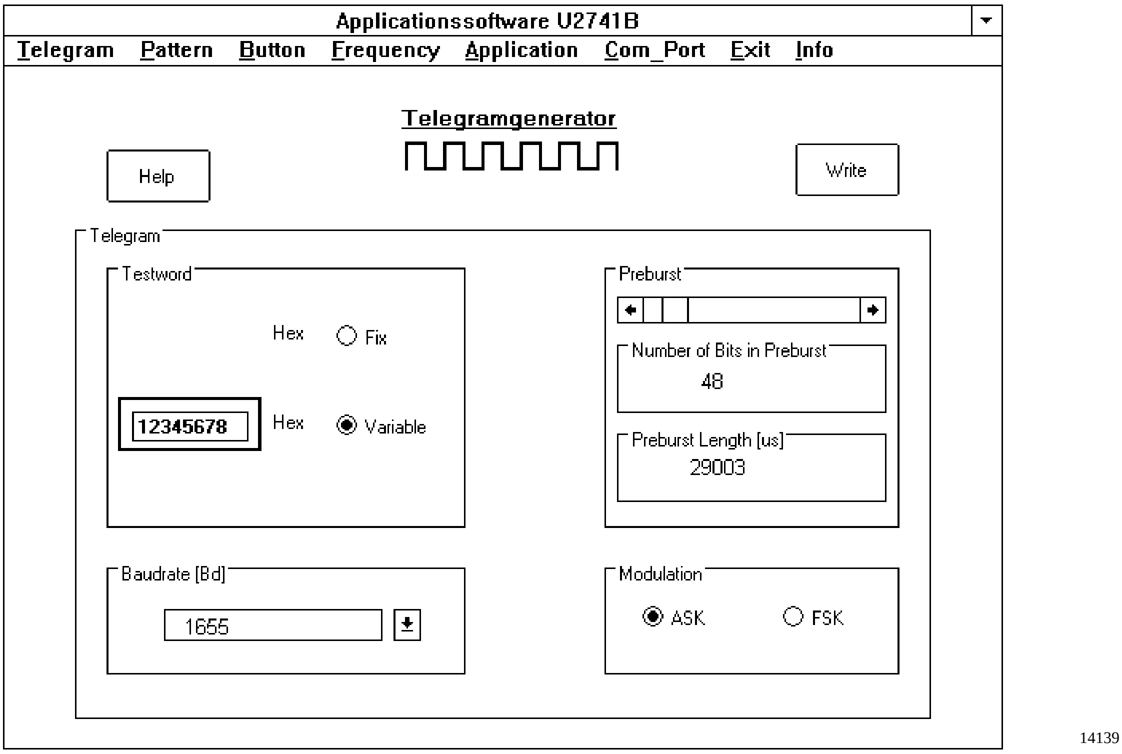


Figure 34. Telegram generator

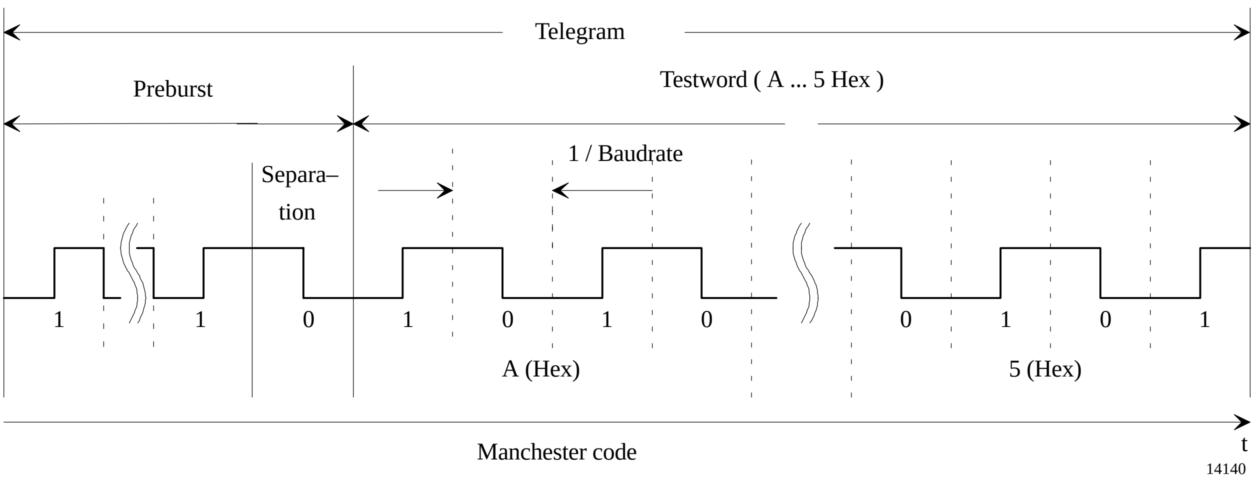


Figure 35. Telegram example

Preburst

The preburst is a number of bits (‘1’) which precede the testword and will be used by the receiver (U3741BM) and the connected µC for wake-up and synchronization.

The number of bits the preburst contains can be selected in a range of 8 to 1000 in steps of 8 by using the scrollbar ‘Preburst’. To indicate the beginning of the testword, the last bit of the preburst is a ‘0’. The length of the preburst depends on the selected baudrate and will be indicated by ‘Preburst_Length [µs]’.

The required length of the preburst is dependent on the polling parameters T_{Sleep}, $T_{Startup}$, $T_{Bitcheck}$ of the receiver U3741BM and the start-up time of a connected µC. For more information, see data sheet U3741BM.

Testword

Either a fixed (‘F09AF09A’) or a user-defined testword can be selected in a range of 4 to 32 bits in steps of 4 bits. The input of the testword must be a hexadecimal value.

The special quality of the fixed testword is that every possible value of a 4-bit word is included. This is important for proper detection of every bit – independent of the past one (data filter U3741BM).

Baudrate

The baudrate refers to the whole telegram (preburst and testword) and can be selected in a range of:

EU: → 500 to 12500 Baud
USA: → 497 to 12766 Baud

The baudrate range of the receiver application board is limited to 1.0 to 10.0 kBd.

Before selecting a baudrate, the operating frequency (433.92 MHz/ 315 MHz) must be selected in the ‘Frequency’ – window.

Modulation

Select ASK for the transmitter application board 433.92 MHz/ ASK and 315 MHz/ ASK.

Select FSK for the transmitter application board 433.92 MHz/ FSK and 315 MHz/ FSK.

Write

Press the ‘WRITE’ button to send the selected values via the serial port to the transmitter application board. If the transmission was successful, the ‘WRITE’ button will be inactive until a parameter is changed in the ‘Telegram’ window.

If there is no board selected, a transmission error occurs (see table 15) or the selected Com-Port is not available, this will be indicated by an error message and the ‘WRITE’ button remains active.

In this case, check the hardware or change the Com-Port and press the ‘WRITE’ button again.

The function of the ‘WRITE’ button in the windows ‘Pattern–Patterngen.’ and ‘Button’ is equivalent.

Help:
Press the ‘HELP’ button to get help information.

Table 15

Error	Error Messages
The selected Com–Port in not available.	Device unavailable !
Problems with the data transmission: PC <—> basic application board <—> transmitter application board.	No hardware detected ! or Serial Communication Error !
Problems with the data transmission: PC <—> basic application board <—> transmitter application board.	The parameters couldn’t be written to the application board ! (not during startup)
Verifying not correct.	Transmission error !

- **‘Pattern–Patterngen’: (Pattern Generator)**

By using the pattern generator, a specific pattern (code) can be generated. The pattern consists of a maximum of 256 segments.

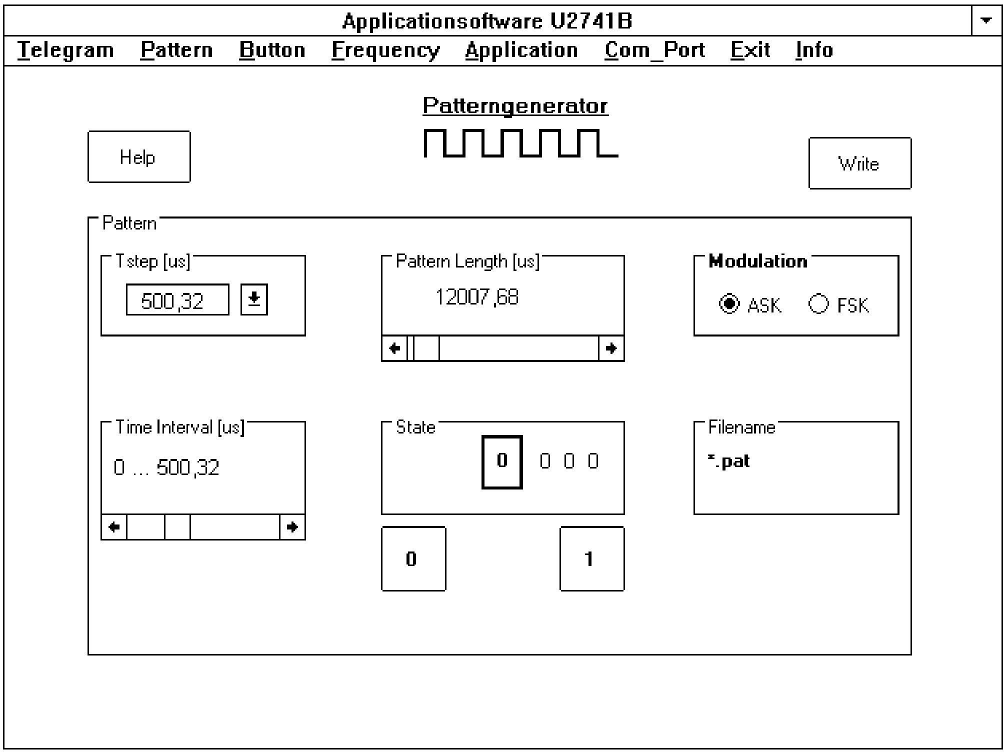


Figure 36. Pattern generator

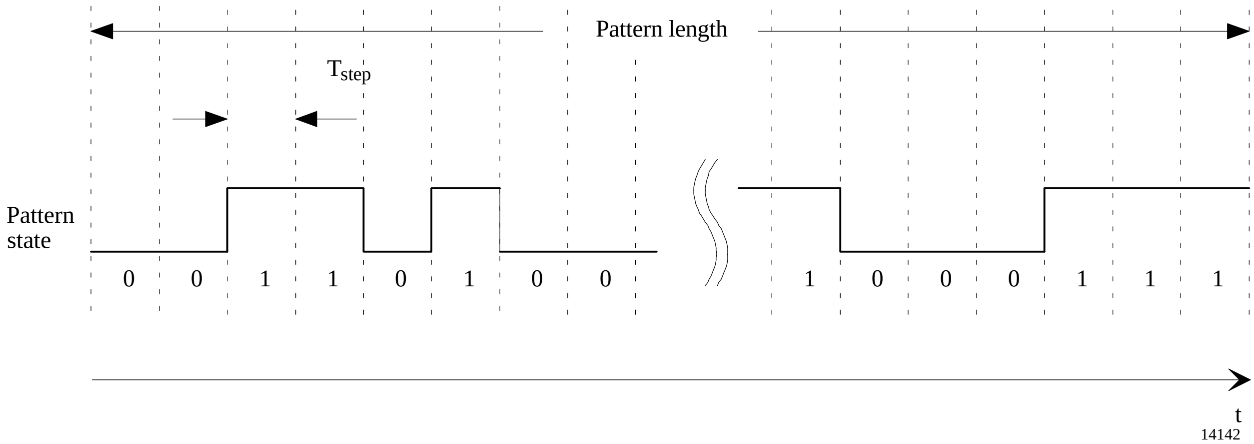


Figure 37. Example of a pattern

T_{step}

The time step T_{step} is adjustable in a range of:
EU: → 40.12 µs to 1000.64 µs
USA: → 39.168 µs to 1005.312 µs

Before selecting T_{step}, the operating frequency (433.92 MHz/ 315 MHz) must be selected in the 'Frequency' – window.

Pattern_Length

The Pattern_Length can be adjusted by using a scrollbar in a range of $n \times 8 \times T_{step}$ (n = 0 to 32).

Time Interval

By means of the scrollbar 'Time Interval', any interval (segment) of the Pattern can be selected.

State

The state of any interval (segment) can be set to '0' or '1'.

Modulation

Select ASK for the transmitter application board 433.92 MHz/ ASK and 315 MHz/ ASK.

Select FSK for the transmitter application board 433.92 MHz/ FSK and 315 MHz/ FSK.

Filename

Name of the loaded pattern file.

Write

Function identical with the 'WRITE' button in the 'Telegram' window (see paragraph 'Telegram', section 'Write').

Help

Press the help button to get help information.

Note:
The RF receiver U3741BM is designed for DC-free codes like Manchester or Bi-phase. To evaluate the pattern with the receiver application software the encoding must be Manchester and a preburst must be generated like in the Telegram generator.

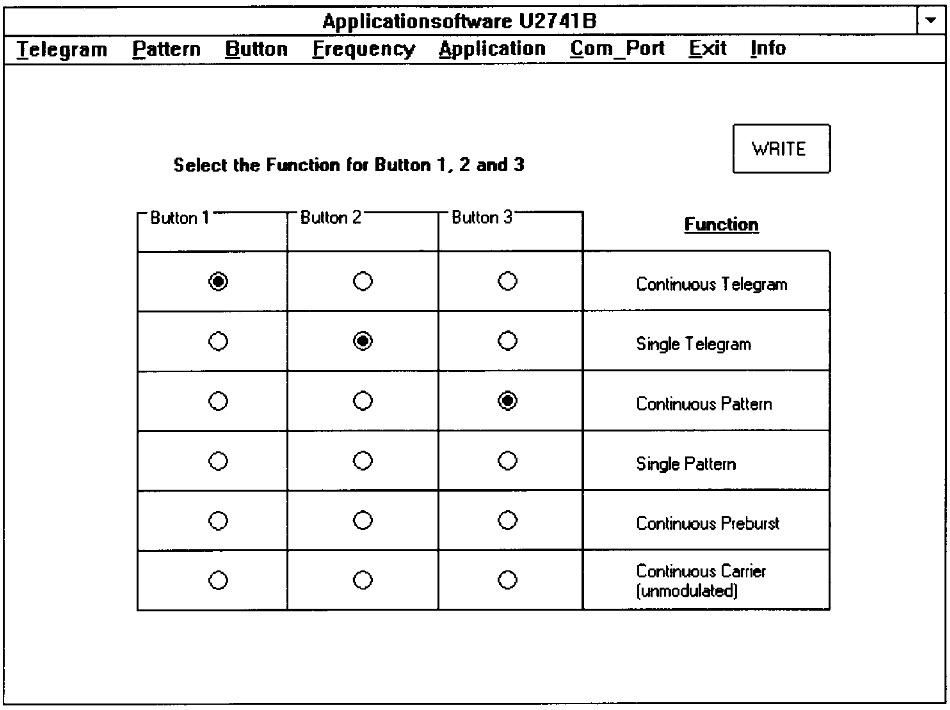
- **'Pattern–Save_Load_Pattern'**

A generated pattern can be stored or loaded in the 'Save_Load_Pattern' window.

The filename must have the extension *.pat.

Button

In the 'Button' window (see figure 38) a function can be assigned to each of the 3 buttons existing on the transmitter application board.



14143

Figure 38. Button window

Continuous Telegram

After pressing the button, the telegram (preburst + testword) generated by the telegram generator will be sent in a loop. After each telegram, the carrier will be switched off for t = 150 ms.
In order to save current, the transmission will be stopped after t = 30 s.
The start and the end of the function will be indicated by the LED D1 on the transmitter application board.

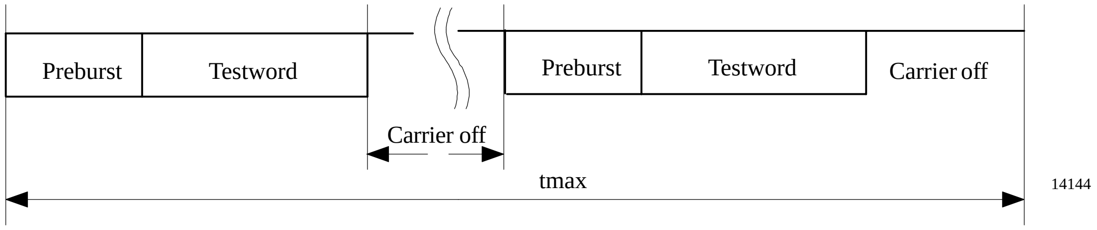


Figure 39. Timing continuous telegram

Single Telegram

After pressing the button, the telegram (preburst + testword) generated by the telegram generator will be sent once. The start of the function will be indicated by the LED D1 on the transmitter application board.

Figure 40. Timing single telegram

Continuous Pattern

After pressing the button, the pattern generated by the pattern generator will be sent in a loop. After each pattern, the carrier will be switched off for t = 150 ms. In order to save current, the transmission will be stopped after t = 30 s. The start and the end of the function will be indicated by the LED D1 on the transmitter application board.

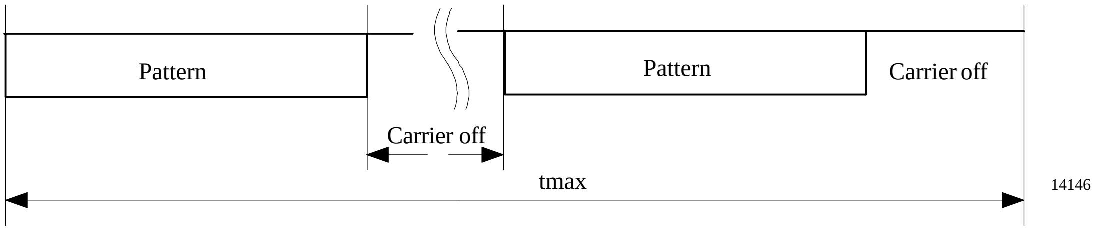


Figure 41. Timing continuous pattern

Single Pattern

After pressing the button, the pattern generated by the pattern generator will be sent once. The start of the function will be indicated by the LED D1 on the transmitter application board.

Figure 42. Single pattern

Continuous Preburst

After pressing the button, the preburst generated by the telegram generator will be sent. In order to save current, the transmission will be stopped after t = 30 s. The start and the end of the function will be indicated by the LED D1 on the transmitter application board.

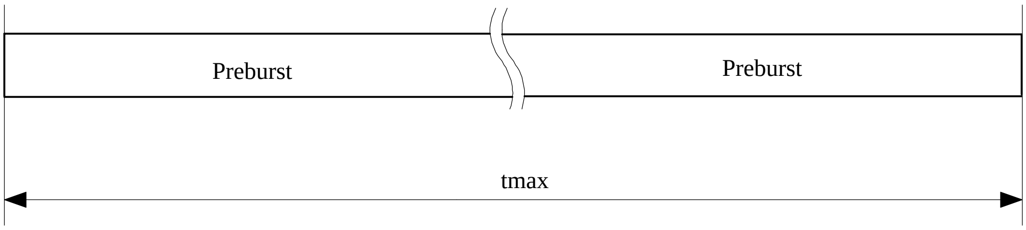


Figure 43. Timing continuous preburst

Continuous Carrier (unmodulated)

After pressing this button, the carrier (unmodulated) will be switched on. In order to save current, the carrier will be switched off after t = 30 s. The start and the end of the function will be indicated by the LED D1 on the transmitter application board.

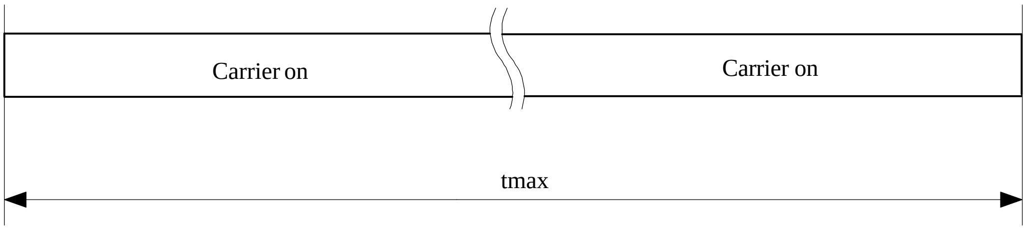


Figure 44. Timing continuous carrier

Write

Function identical with the ‘WRITE’ button in the ‘Telegram’ window (see paragraph ‘Telegram’, section ‘Write’).

- **‘Frequency’**

The divided clock of the U2741B’s crystal oscillator (f_{CLK}) is used for clocking the µC. To send the telegram or the pattern with the right baudrate, select the operating frequency f_{Send} of the used transmitter application board

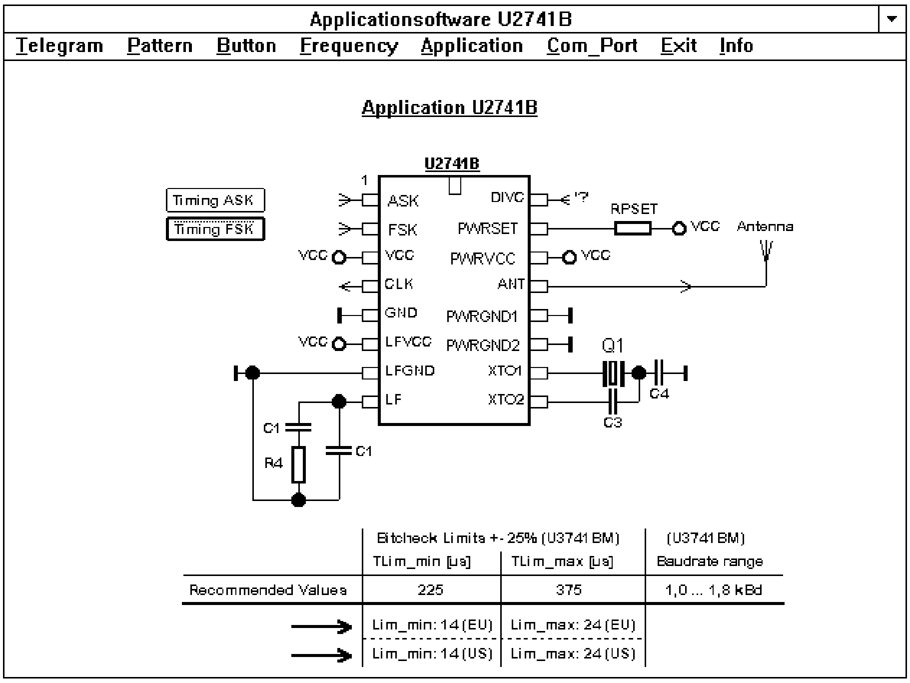
Table 16

Quartz Frequency (Q1)	f_{Send}	f_{Clk}
f_{XTO} = 13.56 MHz, DIVC = ‘0’ (EU)	433.9 MHz	3.39 MHz
*(f_{XTO} = 6.78 MHz, DIVC = ‘1’ (EU)) **	*(433.9 MHz)*	*(3.39 MHz)*
f_{XTO} = 9.84 MHz, DIVC = ‘0’ (US)	315 MHz	2.46 MHz
*(f_{XTO} = 4.92 MHz, DIVC = ‘1’ (US)) **	*(315 MHz)*	*(2.46 MHz)*

* Note: These boards are not available by Atmel Wireless & Microcontrollers

- **‘Application’**

The application window provides information about the ASK/FSK timing and the Pin DIVC. Depending on the selected baudrate, bitcheck limit values ‘Lim_min’ and ‘Lim_max’ for the receiver U3741BM are recommended.

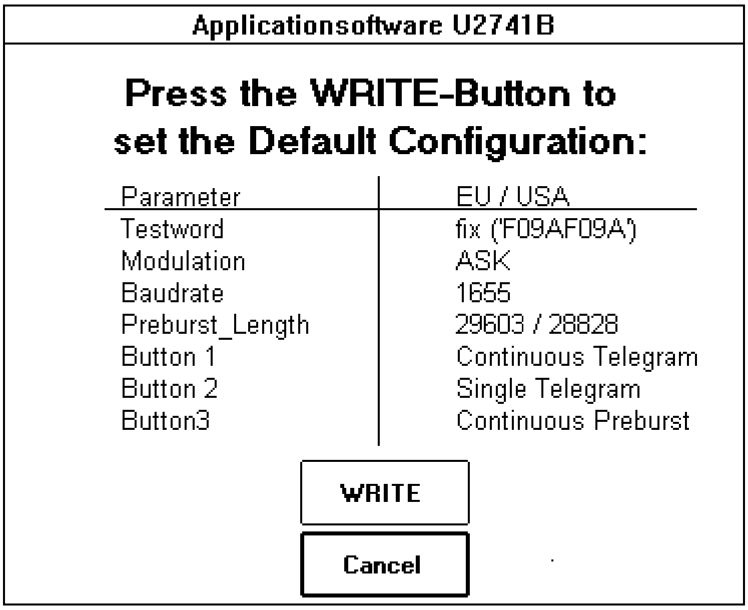


14149

Figure 45. Application window

- **‘Default’**

To operate with the transmitter in the default configuration, open the ‘Default’ window and press the ‘WRITE’ button. Examine that the operating frequency selected in the ‘Frequency’ window is identical with the used transmitter application board. To operate with the default configuration and an ASK transmitter board, change the modulation to ASK in the telegram- and pattern generator after programming the default values.



14150

Figure 46. Default configuration

- **'Com_Port'**

Selection of the serial port (Com1 or Com2). If the selected Com-Port is not available (e.g., used by another program), this will be reported by the Com-Port error message. In this case, the other Com-Port must be selected.

The change of the Com-Port will initiate the reading of the parameters on the transmitter application board and the update of the corresponding windows.

If one ore more parameters are out of the valid range, this will be reported by the error message 'Transmitter parameter out of range' and all parameters in the 'Telegram'–, 'Pattern–Patterngen.'– , 'Button'– and 'Frequency'–window will be deleted.

In this case reprogramming of the whole transmitter is necessary (frequency, telegram generator, pattern generator and the button functions).

If Com1 and Com2 are not available, press Exit, make one Com-Port available and start the program again.

3.1.5 Exit of the Transmitter Application Software

Select 'Exit' to close the program.

3.2 Receiver Application Software U3741BM

3.2.1 Basic Information

The receiver application software U3741BM supports the development of RKE systems with the UHF FSK/ASK remote control receiver U3741BM. The software configures the receiver application board (U3741BM) via the PC. In this way parameters like baudrate, modulation, testword etc. can be changed in a very quick and comfortable way. In addition, some tools to evaluate the data transmission are provided.

3.2.2 Installation and System Requirements

- PC 486 or higher
- Serial port Com1 or Com2
- Operating system
  – Win 3.1
  – Win 95
  – Win NT

Installation of the receiver- and transmitter software:

- Close all running windows applications.
- For Win 95 or Win NT installation, insert disk 1 in your floppy drive
- For Win 3.1x installation, insert disk 3 in your floppy drive
- Start setup.exe

The setup installs the receiver application software, the transmitter application software and the file PRGINST.TXT (programming instructions) on the hard disk.

To check the proper operation of the whole RKE Design Kit, read the information given in the programming instructions first.

Table 17

Possible Problems During Installation	What to Do
Error message: ‘Setup couldn’t copy ver.dll to C:\windows’	Remove or rename the existing ver.dll in the windows directory.
Error message: ‘ *.dll is in use’	Press the ignore button.
Error message: ‘One ore more Visual Basic applications are running (vbrun300.dll is in use)’	Close all windows applications.

3.2.3 Start of the Receiver Application Software

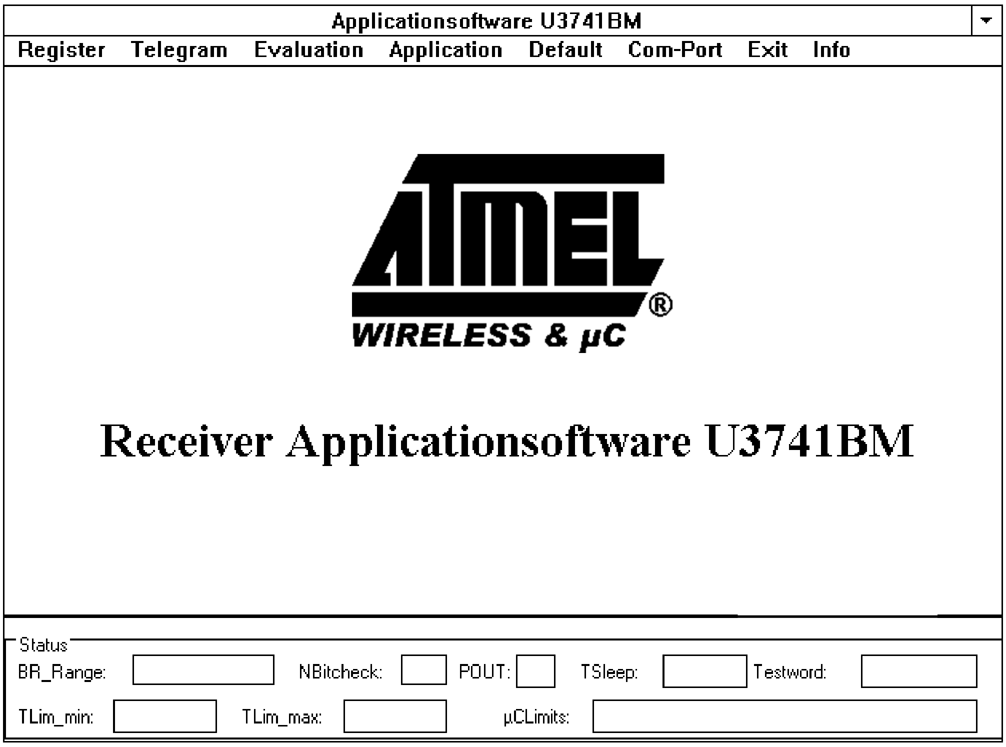


Figure 47. Start window receiver application software

- To ensure proper operation, the following steps have to be carried out before starting the receiver application software.

1. Switch on the PC and start the operating system.
2. Assemble the RKE Design Kit as shown in figure 1.
3. Switch on the 5-V power supply of the basic application board.
4. Connect the serial link cable (RS232) to an unused serial port (Com1,Com2).
5. Press the reset button (Key S5).

Start the receiver application software with the command: u3741bm.exe

The receiver application board only works in conjunction with the basic application board!

The µC on the basic application board controls the data transfer with the PC, the transmitter application board and the programming of the receiver U3741BM. The µC also evaluates the received data stream and indicates the results on the basic application board. If the 'Telegram–Testword', 'Evaluation–Histogram' or 'Evaluation–Timing_List' window is active, the results can also be transmitted to the PC.

Figure 47 shows the start window after a successful start. During loading of the program, all parameters used in the latest session, stored in a non volatile memory (EEPROM) on the basic application board, will be read. These values will be used as the start values in the corresponding windows and in the status line at the bottom of each window.

During loading of the program, the file com_port.cnf will be opened. This file contains the number of the Com-Port (Com1 or Com2) used in the latest session. If the file com_port.cnf does not exist, the default Com-Port is Com2.

If the selected Com-Port is not available (e.g. used by another program), this will be reported by the Com-Port error message. In this case, the other Com-Port must be selected. The changing of the Com-Port initiates the reading of the parameters on the basic application board (EEPROM) and their updated in the corresponding windows and the status line.

If Com1 and Com2 are not available, select ‘Exit’, make one Com-Port available and start the program again.

If there is no receiver application board connected on the basic application board or any other problem with the data transmission PC <–> basic application board <–> receiver application board, this will be reported by the error message: **– ‘No hardware detected !’**

Status Line

The actually valid parameters are indicated in the status line.

3.2.4 Program Description

- **‘Register–OPMODE’**

Programming of the receiver **op**eration **mode** register.

BR_range

Baudrate range sets the appropriate baud rate range. At the same time it defines XLim (see data sheet U3741BM).

XLim is used to define the bitcheck limits T_{Lim_min} and T_{Lim_max}.

The changing of the BR_range also changes the µC_Limits.

$N_{Bitcheck}$

Number of bits to be checked

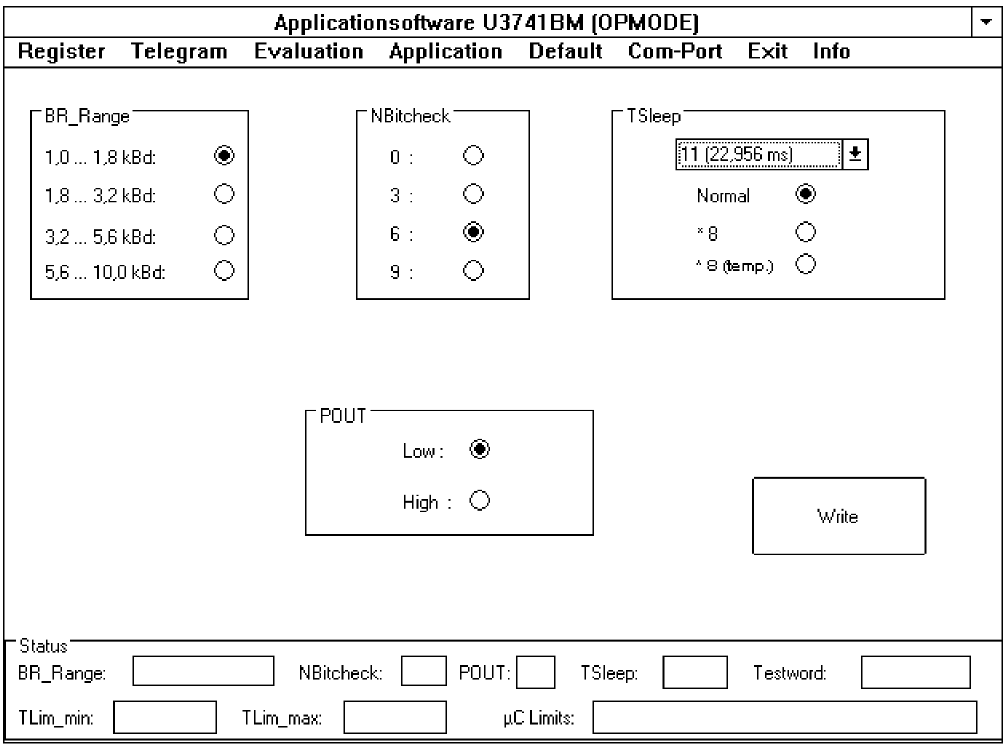
T_{Sleep}

Sleep time
Normal : sleep time
*8: extended sleep time
*8 temp: temporary extended sleep time

POUT

Multi-purpose output port. This port can be used to control the receiver’s sensitivity.

Low: normal sensitivity
High: reduced sensitivity
(R2 = 56 kΩ, see data sheet U3741BM)



14152

Figure 48. OPMODE register

Table 18.

Error	Error Messages
The selected Com–Port in not available.	Device unavailable !
Problems with the data transmission: PC <—> basic application board <—> transmitter application board.	No hardware detected ! or Serial Communication Error !
Problems with the data transmission: PC <—> basic application board <—> transmitter application board.	The parameters couldn't be written to the application board ! (not during startup)
Verifying not correct.	Transmission error !

Write

Press the 'WRITE' button to send the selected values via the serial port to the receiver application board. If the transmission was successful, the 'WRITE' button will be inactive until a parameter is changed in the 'Register–OPMODE' window.

If there is no board selected, a transmission error occurs or the selected Com-Port is not available, this will be indicated by an error message and the 'WRITE' button remains active.

In this case, check the hardware or change the Com-Port and press the 'WRITE' button again.

The function of the 'WRITE' button in the windows 'Register–Limit', 'Telegram–Testword' and 'Evaluation–µC_Limits' is equivalent.

- **'Register–LIMIT'**

Programming of the upper and lower bitcheck limits for time frame check.

Lim_min

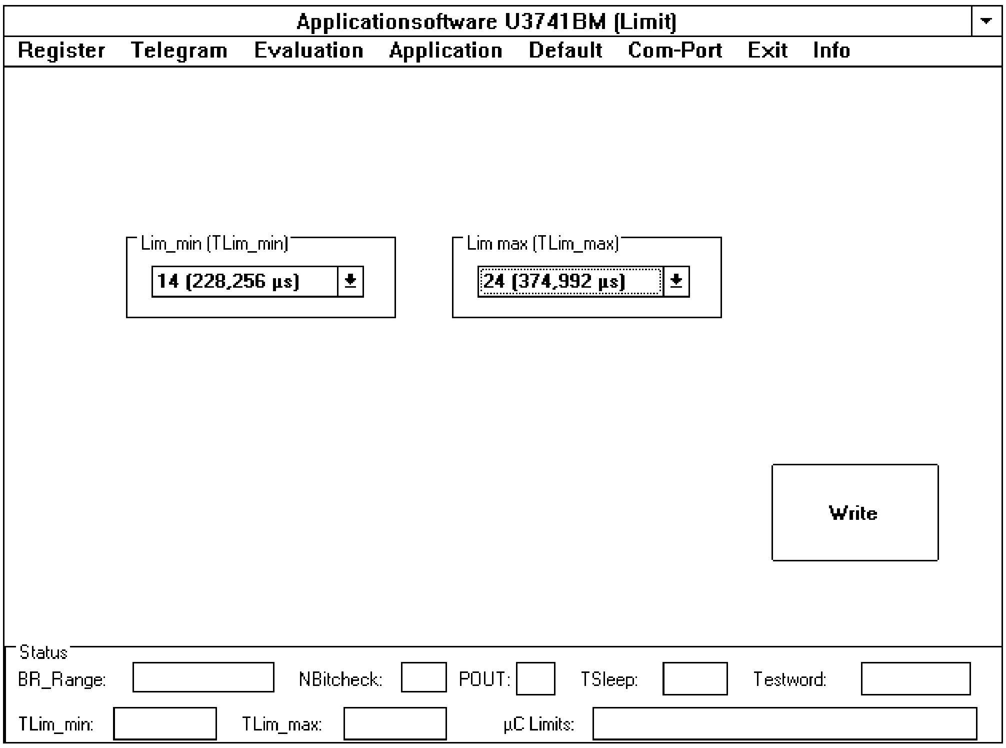
Lower bitcheck limit

Lim_max

Upper bitcheck limit

Write

Function identical with the 'WRITE' button in the 'Register–OPMODE' window



14153

Figure 49. LIMIT register

- **‘Telegram–Testword’**

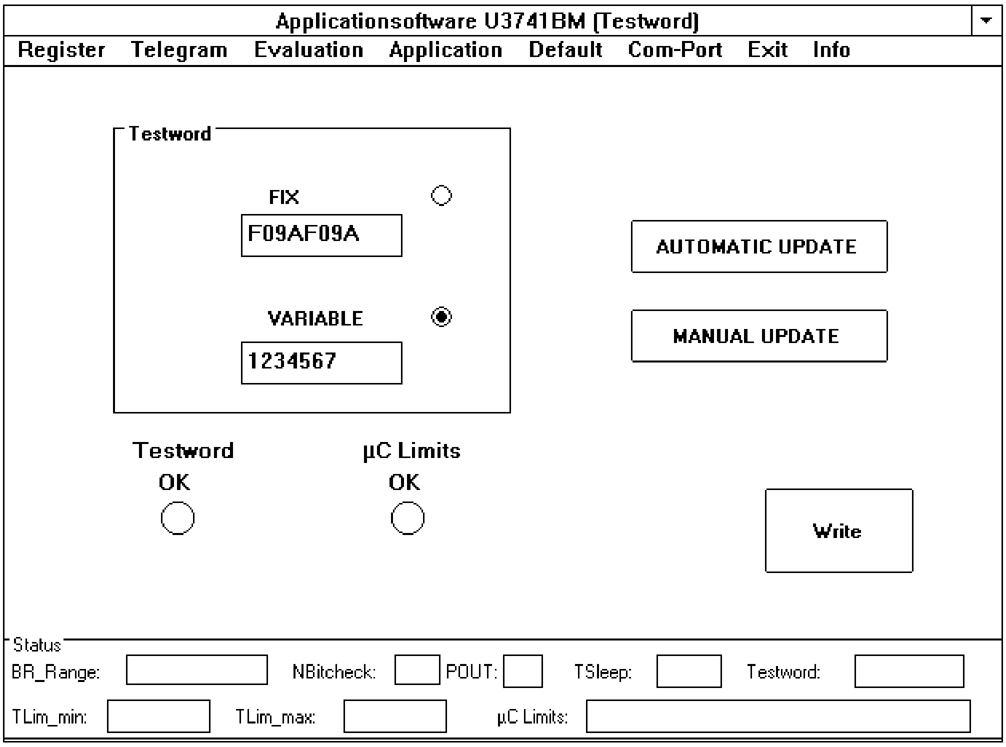


Figure 50. Testword window

A fixed (‘F09AF09A’) or a user-defined testword can be selected in a range of 4 to 32 bits in steps of 4 bits. The input of the testword must be a hexadecimal value.

The reception of the testword will be indicated by ‘Testword ok.’ and ‘µC_Limits ok.’.

In addition, 2 LEDs on the basic application board (H1, H2) indicate the receipt of the valid testword.

The encoding of the testword must be Manchester.

The special quality of the fixed testword is that every possible value of a 4-bit word is included. This is important for a proper detection of every bit – independent of the past one.

Write

Function identical with the ‘WRITE’ button in the ‘Register–OPMODE’ window.

Status

Testword ok / µC_Limits ok: (see chapter ‘Evaluation–µC_Limits’)

The µC on the basic application board compares the received data stream with the selected testword. 2 LEDs on the basic application board (H1, H2) indicate the result. If manual or automatic update is active, the result will also be transmitted to the PC.

Manual Update

If ‘MANUAL UPDATE’ is selected, the status of the next testword will be indicated.

If there is no transmitter signal, this will be indicated by the error message ‘No signal received’.

Automatic Update

If ‘AUTOMATIC UPDATE’ is selected, the status will be updated after the reception of the next testword.

This mode is active until the button ‘MANUAL UPDATE’ is selected or the testword will be changed.

If there is no transmitter signal, this will be indicated by the error message ‘No signal received’.

- **‘Evaluation–Histogram’**

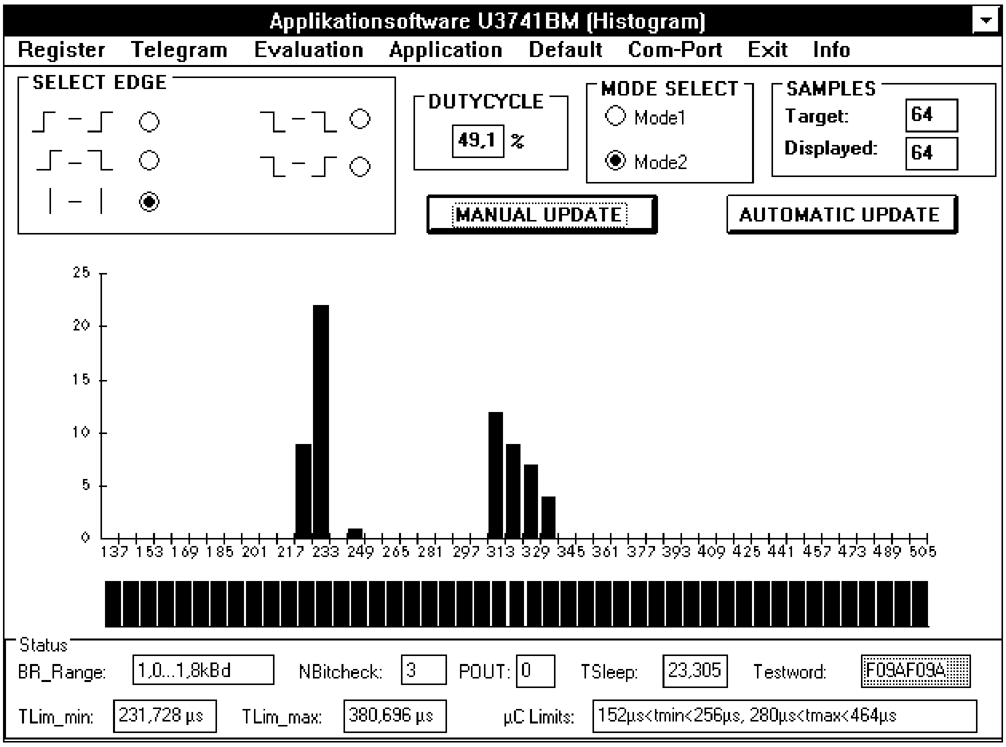


Figure 51. Histogram window

To evaluate the timing of a received data stream , the timing margins can be displayed in the ‘Evaluation–Histogram’ window. This tool is helpful to define the time µC_Limits used by the connected µC to evaluate the proper timing of the data stream.

The timing of the data stream (n samples) will be transmitted to the PC. For the testword A5 Hex , shown in figure 52, 10 samples will be transmitted. A sample is the distance between 2 signal edges. The maximum length of a displayed data stream is 64 samples.

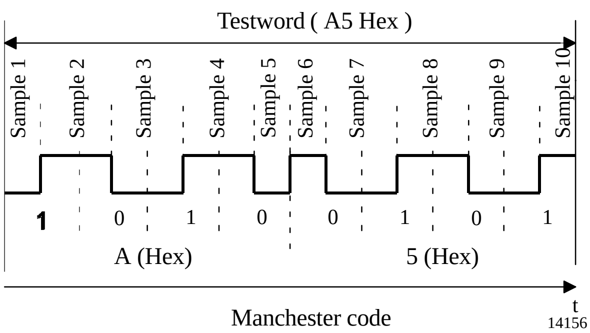


Figure 52. Example of a testword

Mode Select

– ‘Mode1’:
The number of the target samples refers to the selected testword in the ‘Telegram–Testword’ window.
e.g. Testword: A5 Hex ——> Target Samples: 10

– ‘Mode2’:
Select the max. number of the target samples in a range of 1 to 64.

Samples

– ‘Target’: Target number of the samples to be displayed.

– Displayed: Number of the actually displayed samples.

The upper timing limit Tsample_max (see table 19) of a sample depends on the selected baudrate range (BR_range).

Table 19.

BR_range [kBd]	Tsample_max [µs]
1.0 to 1.8	2032
1.8 to 3.2	1016
3.2 to 5.6	508
5.6 to 10.0	254

If a sample increases the upper timing limit Tsample_max, the following samples are invalid and will not be displayed.

Select_Edge

The histogram will be generated with the following timings:

_| _| rising edge to rising edge

|_ |_ falling edge to falling edge

_| |_ rising edge to falling edge

|_ _| falling edge to rising edge

| | edge to edge

Duty Cycle

Resulting duty cycle of the data stream. The calculation of the duty cycle is described in the chapter '3.2.6 Accuracy and Resolution of the Telegram Evaluation'.

Manual Update

If 'MANUAL UPDATE' is selected, the histogram of the next data stream will be generated.

If there is no transmitter signal, this will be indicated by the error message 'No signal received'.

Automatic Update

If 'AUTOMATIC UPDATE' is selected, the histogram will be updated after the reception of the next data stream.

This mode is active until the button 'MANUAL UPDATE' is pressed.

If there is no transmitter signal, this is indicated by the error message 'No signal received'.

Note:
The last values of the histogram will be displayed in the 'Evaluation–Timing_List' window.

- **'Evaluation–Timing_List'**

To evaluate the timing of a received data stream , the timing margins can be displayed in the 'Evaluation–Timing_List' window. This tool is helpful to define the time window µC_Limits, used by the connected µC, to evaluate the proper timing of the data stream.

The timing of the data stream (n samples) will be transmitted to the PC. A sample is the distance between 2 signal edges. The maximum length of a displayed data stream is 64 samples.

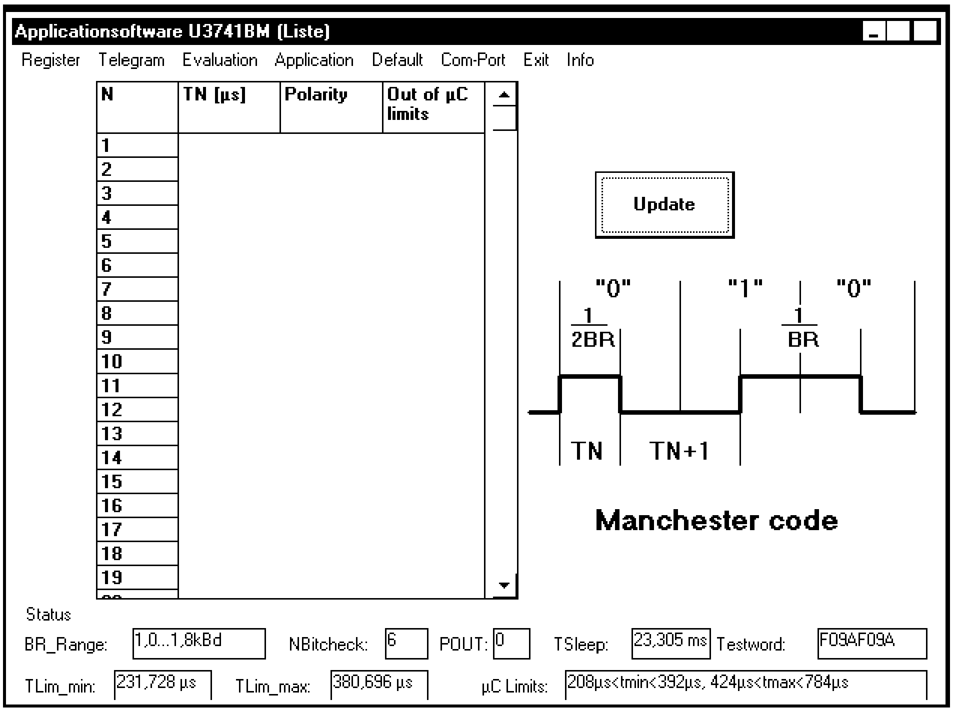
For every sample, the sample time TN, the polarity and a remark if the sample is inside of the µC_Limits are displayed. The polarity of the first sample must be 'H'. This is guaranteed if the preburst of the telegram is a row of '1' and one '0' to detect the beginning of the testword (see figure 55).If the preburst consists a row of '0' and one '1' to detect the beginning of the testword, the displayed polarity in the timing_List is inverted.

If a sample increases the upper timing limit Tsample_max (see table 17), it will not be displayed.

In this case, the displayed time TN and the polarity of the next sample are invalid.

For all following samples, the displayed time TN is valid but the displayed polarity is invalid.

If there is no transmitter signal, this will be indicated by the error message 'No signal received'.

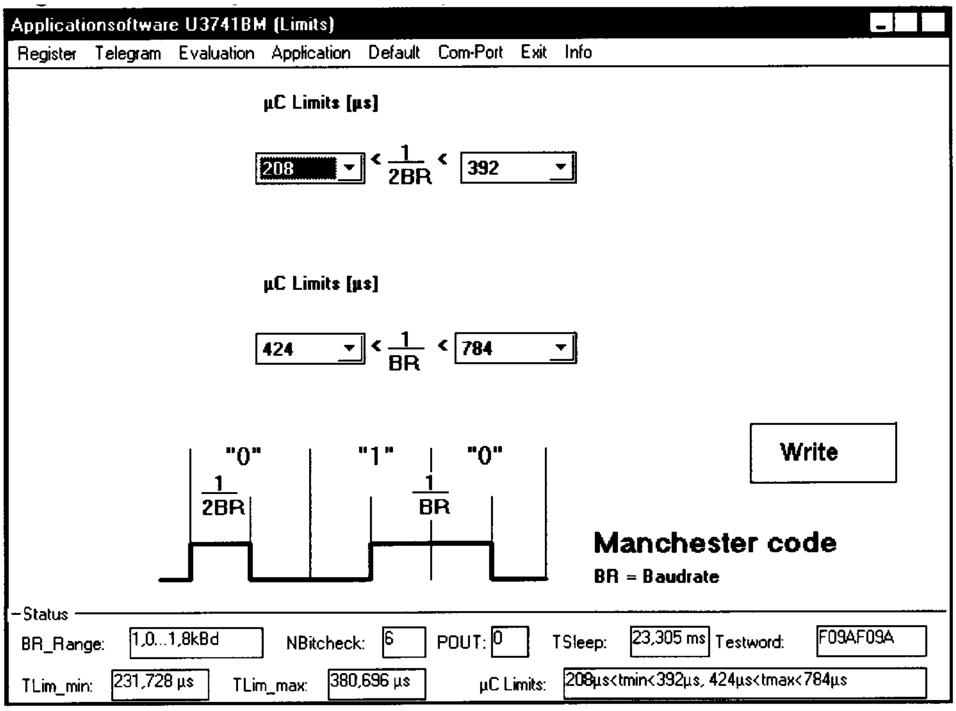


14157

Figure 53. Timing list

- **'Evaluation–µC_Limits'**

Select the timing limits, used by the connected µC, to evaluate the proper timing of the data stream.



14158

Figure 54. µC_Limits

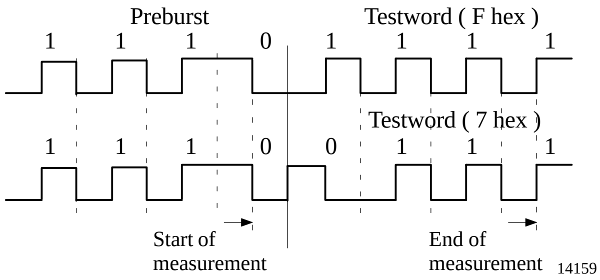


Figure 55. Example of a telegram

Note:
The measurement (sampling) of the testword begins after the falling edge of the bit ‘0’. The trigger condition is the distance between the rising edge of the last ‘1’ in the preburst and the falling edge of the ‘0’ at the end of the preburst (t_{ee}). The trigger condition is valid if t_{ee} > lower limit of 1/BR.This time is defined in the µC_Limits window.

If the preburst is inverted (‘000 to 001’), the trigger condition is the distance between the falling edge of the last ‘0’ in the preburst and the rising edge of the ‘1’ at the end of the preburst (t_{ee}).

In this case, the evaluation of the testword fails because the software measures the distance between the following 63 edges (64 samples) but does not check the logic level. This fact must be considered if a telegram is generated with the pattern generator in the transmitter application software.

Write

Function identical with the ‘WRITE’ button in the ‘Register–OPMODE’ window.

- **‘Application’**

‘POR’

Press the ‘POR’ button to generate a power-on reset on the receiver application board (see LED H4 basic application board). The register OPMODE and LIMIT will be set to the default values. The U3741BM displays the reset marker at Pin DATA (≈ 120 Hz).

‘Delete Reset Marker’

Delete the reset marker via a ‘L’ pulse (t1 ≥ 11.7 ms) at Pin DATA.

‘Sleep (Stop Command)’

Set the U3741BM back to the sleep mode via a ‘L’ pulse (t1 ≥ 3.2 ms) at Pin DATA.

‘Enable’

The level on Pin ENABLE can be switched between ‘VCC’ and ‘controlled’. If enable is connected to VCC, no evaluation of the received data stream in the ‘Telegram–Testword’, ‘Evaluation–Histogram’ and ‘Evaluation– Timing_List’ window is possible.

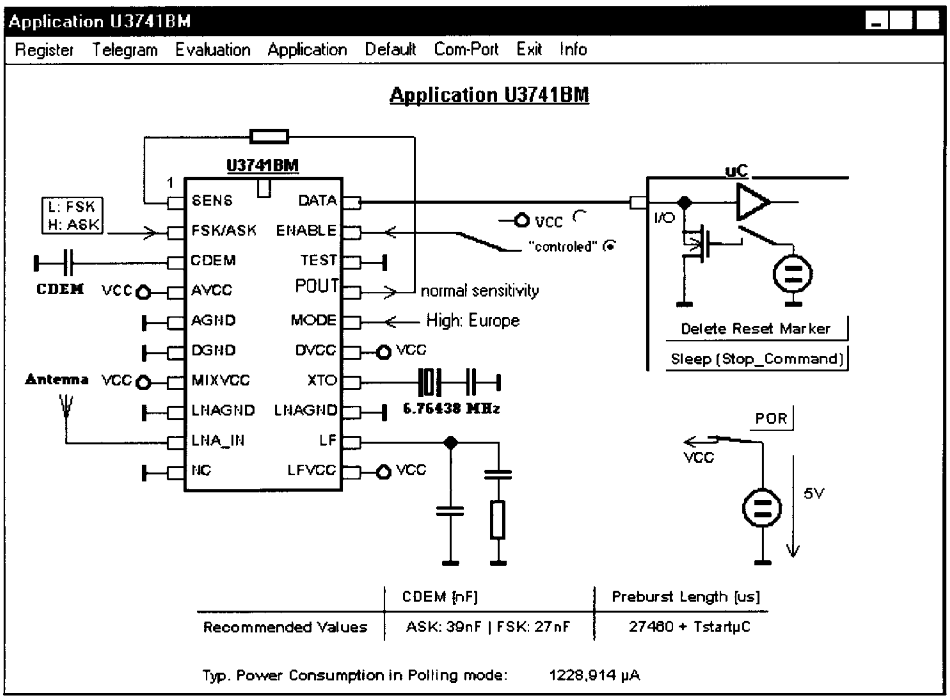
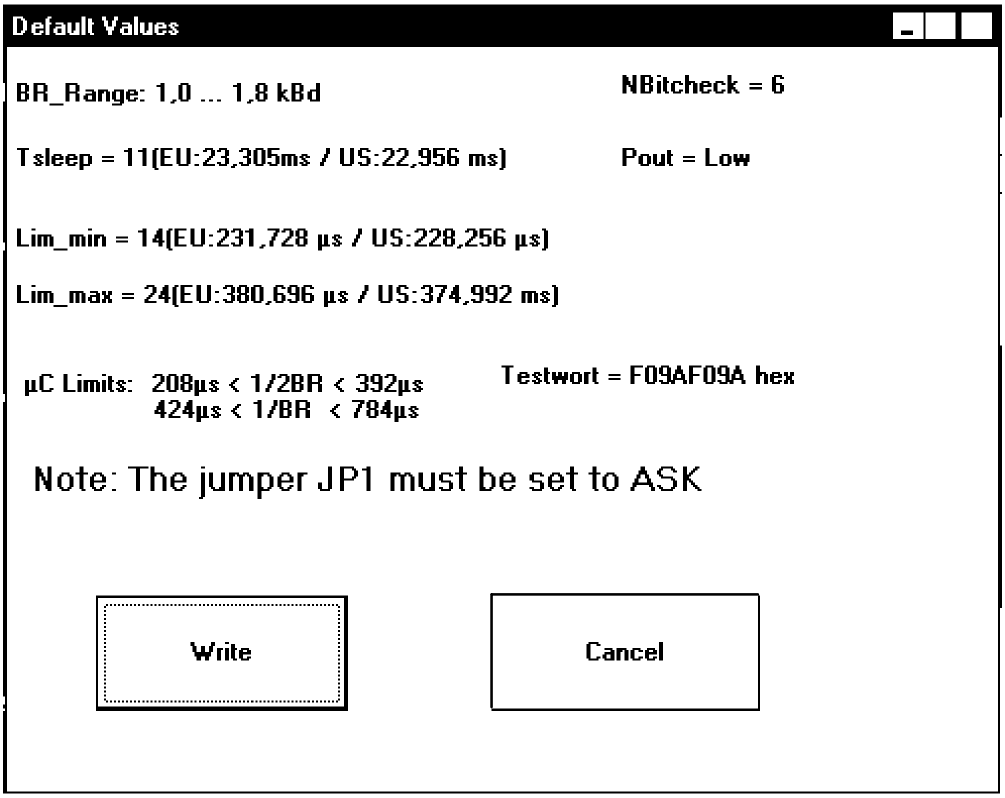


Figure 56. Application

- **‘Default’**

To operate with the receiver in the default configuration, open the ‘Default’ window and press the ‘WRITE’ button.



14161

Figure 57. Default configuration

- **‘Com_Port’**

Selection of the serial port (Com1 or Com2).

If the selected Com-Port is not available (e.g., used by another program), this will be reported by the Com-Port error message. In this case, the other Com-Port must be selected.

The change of the Com-Port will initiate the reading of the parameters on the transmitter application board and the update of the corresponding windows.

If Com1 and Com2 are not available, select ‘Exit’, make one Com-Port available and start the program again.

3.2.5 Exit of the Receiver Application Software

Select ‘Exit’ to close the program.

3.2.6 Accuracy and Resolution of the Telegram Evaluation

The evaluation of a telegram will be done by a µC on the basic application board. The results of the evaluation can be displayed in the receiver application software (Testword OK, Limits_OK, Histogram, Duty Cycle, Timing_List).

The following gives some information about the accuracy and the resolution of the telegram evaluation.

- **Resolution**

The resolution depends on the selected baudrate.

Table 20

BR_range [kBd]	Resolution (rs) [µs]
1.0 to 1.8	8
1.8 to 3.2	4
3.2 to 5.6	2
5.6 to 10.0	1

- **Accuracy**

According to the resulting resolution the worst case (accuracy) of a measured single time T is:

Measured Time T_{meas} = T ± 1 rs – 0.5 µs

- **Duty Cycle**

The calculation method of the duty cycle displayed in 'Evaluation–Histogram' is shown by the equation below.

In case of n >>1, the statistical average of the accuracy is in the range of ± 0.2% (see paragraph 'Telegram and its Timing List' on this page)

Telegram and its Timing List

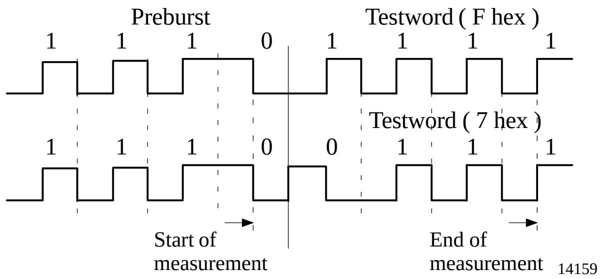


Figure 58. Example of a telegram

Figure 58 shows a possible timing of a short telegram. The possible difference between the frame of the Manchester-encoded part and the frame processed by the measuring µC can be seen.

Thus, the calculated value of the duty cycle as well as the sample numbering may be affected.

Baudrate Margins

Recommended baudrate margins: 1.0 kBd to 10.0 kBd.

Use the appropriate BR_range settings in the 'Telegram'–window' (transmitter application software).

$$\text{Duty cycle DC} = \frac{\sum_{i=1}^{n_H} T_{H\,i\,meas}}{\sum_{i=1}^{n_H} T_{H\,i\,meas} + \sum_{i=1}^{n_L} T_{L\,i\,meas}} = \frac{\sum_{i=1}^{n_H} (T_{Hi} \pm 1rs\text{–}0.5\mu s)}{\sum_{i=1}^{n_H} (T_{Hi} \pm 1rs\text{–}0.5\mu s) + \sum_{i=1}^{n_L} (T_{Li} \pm 1rs\text{–}0.5\mu s)}$$

$n_{H/L}$ = number of High/Low samples