2000

Wireless data transmission with BASIC-Tiger

Gunther Zielosko

1. Fundamentals

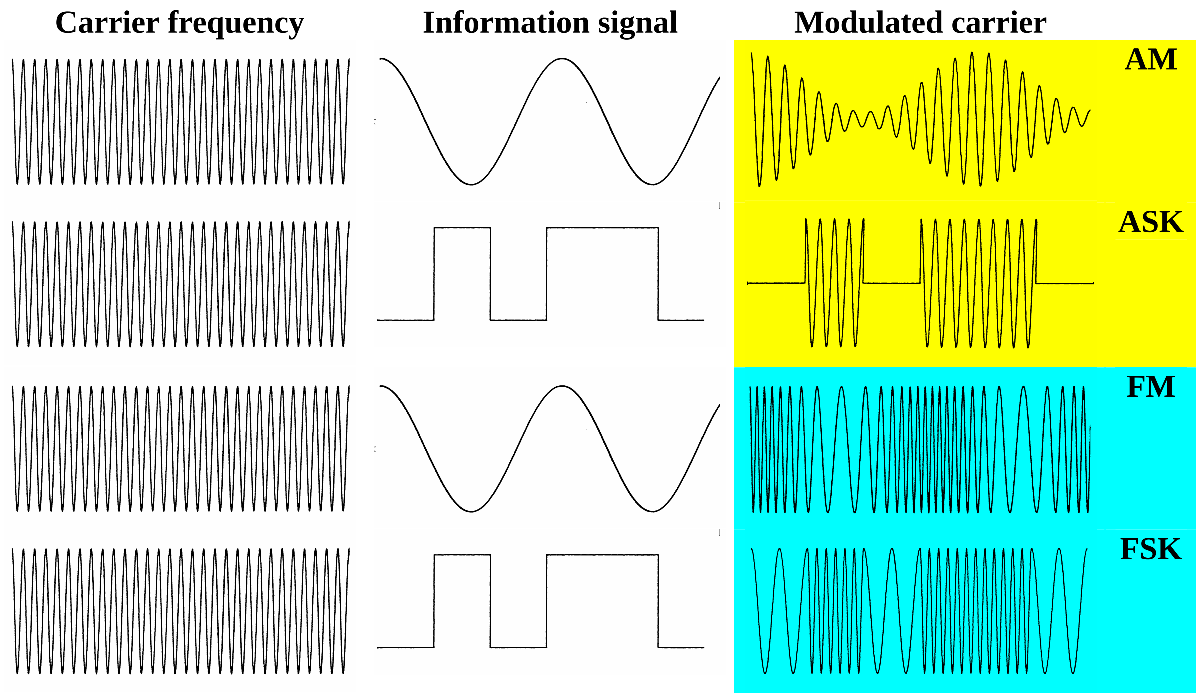
Nowadays you'll hardly find a field in electronics, for which not at least one application with radio transmission is available, just think of wireless phones, clocks, thermometers, speedometers on bicycles, garagedoor openers, your car's central locking, the wireless transmission of a jogger's pulse frequency and so on...
With this application note not just one more singular use should be added, but "recipies" for own elaborations with BASIC-Tiger will be aquired. How about a solution with which any data can be sent wireless from BASIC-Tiger to a PC?
Of course you often can get cheaper radio transmission-modules for various purposes in the electronics market, but then you are always restricted to a usage the producer intended. A general concept is more interesting, also the BASIC-Tiger user is more interested in how something works. We will find out a few things about the fundamentals of radio transmission in this application note, furthermore suggestions for own developments and of course an interesting application with BASIC-Tiger.

1.1. How does data transfer by radio transmission work? - Modulation

With a wire everything is very easy, analog values are directly transfered from transmitter to receiver as current or voltage value almost without loss (e.g. cable from radio to speaker). It is comparable easy with digital signals, information is directly understood as Low or High, 0 or 1 on the opposite side (e.g. RS232 interface). With a radio line it is a little more complicated. As transmitter and receiver of an information channel should work nearly at the same frequency, there must be other parameters with which data (no matter if analog or digital) can be transmitted by radio. With the so called modulation certain parameters of the actual radio signal (carrier frequency) are changed by the information signal. The remote station "recognizes" these changes and as a result gets back the corresponding information signal. Now there are several parameters which can be changed in a carrier frequency signal, from this different ways of modulation are deducted, the most important ones are shown in table 1. You see two groups, in one group the carrier frequency is modulated analog (AM = amplitude modulation, FM = frequency modulation) and digital in the other (ASK = amplitude shift keying, FSK = frequency shift keying). Further types of modulation like phase modulation (PM), phase shift keying (PSK) as well as modulation methods with pulse carriers should not be dealt with here. Concluding an evaluation of the 4 methods.

For AM and ASK circuits are easier to realize as well on transmitter side (modulator) as on receiver side (de-modulator). The susceptibiliy to interference is higher though, as the amplitude varies not only wanted, but often also unwanted. An example for this is the rather bad receiving quality of medium-wave and short-wave radio stations, which mostly operate with AM.

FM and FSK even out receiving problems much easier, like you know from VHF broadcasting. Interferences can here too affect the amplitude, but hardly the frequency, which contains the actual information. This advantage requires additional effort for the circuits.



Tab. 1 The for us most important modulaton types

As you can see, the two modulation types ASK and FSK are an exception of the appropriate methods AM und FM. For radio data transmission with BASIC-Tiger usually only digital signals will be used, so it doesn't matter here if the radio line works with AM resp. ASK or FM resp. FSK. You just have to choose between amplitude modulation and frequency modulation, where frequency modulation has decisive advantages regarding interference immunity.
Besides the modulation type of a radio line there are further criteria which have to be taken into account for selecting a suitable solution:

- The frequency band and the position of the there chosen frequency,
- the range,
- the maximum data transmission rate,
- the voltage and current requirements (Standby circuit if necessary),
- and of course the cost.

1.2. Legal and technical questions – Carrier frequencies

Only a few years ago there were considerable restrictions for construction and operation of radio-engineered installations. In the meantime some limits have been removed, many devices

are longer subject to charges and licenses, even the self construction of a radio plant is possible without problems in compliance with the regulations. It is still important to exactly follow the regulations for such applications. So the carrier frequencies have to be exactly right, transmission power and perturbing radiation must not exceed a certain level to prevent disturbance of other radio services. At this time one regulation has been added, which concerns the on-time of the transmitter. It is logical that you only send if you really have something to say, the new direction regulates the active transmission time in percent, what is called ”Duty Cycle“.
Over the years the frequencies “for general needs” were expanded, momentary the following bands are available, the exact frequency ranges and other details for different uses are laid down in special regulations. Here you’ve got to be aware that on all bands different channels can be used, whose choice has influence on the transmission quality. If you e.g. choose the middle frequency, you are in “good company“, because nearly all manufacturers do so and thus there are many possible sources of interference.

- 27 MHz (general use, remote control)
- 40 MHz (general use, remote control)
- 433 MHz (general use, from 433.05 to 434.79 MHz in many European countries)
- 868 MHz (general use, from 868.00 to 870.00 MHz in whole Europe)

Experience shows that you can expect especially few interferences on the newest frequencies, because the number of radio installations is still very small there. So today you can hardly expect a safe operation at 27 MHz or 40 MHz, and on the today also overloaded 433 MHz band it doesn’t look much better. Whereas the 868 MHz band is still so “new“, that you’ll get the best results there. Unfortunately for that reason there is no great choice of radio modules, which are optimized in HF technic and checked from the manufacturer as well as mail- and communication administrations if the regulations are kept.
In Germany the devices should carry a so called FTZ sign. Is such a transmission module triggered by logical levels, you don’t have to expect any HF problems and penalties.
You have to make a little expenditure concerning the safe data transmission. As on the chosen radio band numerous “users“ may be simultaneously, it may happen that the receiver gets mutilated messages. An interference of the high frequency transmission can hardly be excluded, but with the right methods you can at least do something against faultive messages.

2. Finished radio modules for data transmission

There is a great number of complete solutions in the electronic market which mostly consist of a transmission and a receiver module, unfortunately almost nothing for the new 868 MHz area. From the experience of the author amplitude modulated modules are hardly usable for the chosen application.
An extensive and varied assortment offers the chip manufacturer Melexis GmbH (Erfurt, Germany), which covers the frequency ranges and modulation types of interest with a number of high integrated ICs. Besides the ICs Melexis also offers so called evaluation boards, which

carry all components on a small printed circuit, though are ready for transmission and receipt. Table 2 shows an overview of the available ICs with their specifications:

Transmitter IC	TH7107	TH71071	TH71072	TH7108	TH71081	TH71082
Frequency Range	310 – 480 MHz	310 – 480 MHz	310 – 480 MHz	800 – 950 MHz	800 – 950 MHz	800 – 950 MHz
Supply Range	2.0 – 5.5 V	2.0 – 5.5 V	2.3 – 5.5 V	2.0 – 5.5 V	2.0 – 5.5 V	2.3 – 5.5 V
Supply Current	5 – 12 mA	5 – 11.5 mA	5 – 12 mA	6 – 13 mA	6 – 12.5 mA	6 – 13 mA
Standby Current	< 50 nA	< 50 nA	< 50 nA	< 50 nA	< 50 nA	< 50 nA
Modulation	FSK, FM, ASK	ASK	ASK	FSK, FM, ASK	ASK	ASK
RF Output	Differential -12 to 3 dBm	Differential -12 to 3 dBm	single-ended -14 to 0 dBm	Differential -16 to 1 dBm	differential -16 to 1 dBm	Single-ended -18 to –3 dBm
Clock Output	Yes	No	yes	Yes	no	Yes
Package	SSOP16	SOP8	SOP8	SSOP16	SOP8	SOP8

Receiver IC	TH7110	TH71101	TH71102	TH7111	TH71111	TH71112
Frequency Range	310 – 480 MHz	310 – 480 MHz	310 – 480 MHz	800 – 950 MHz	800 – 950 MHz	800 – 950 MHz
Supply Range	2.5–5.5V, FSK 2.3-5.5V, ASK	2.5–5.5V, FSK 2.3-5.5V, ASK	2.5–5.5V, FSK 2.3-5.5V, ASK	2.5–5.5V, FSK 2.3-5.5V, ASK	2.5–5.5V, FSK 2.3-5.5V, ASK	2.5–5.5V, FSK 2.3-5.5V, ASK
Supply Current	6.5 – 7.8 mA	6.5 – 7.8 mA	6.5 – 7.8 mA	7.6 – 9.2 mA	7.6 – 9.2 mA	7.6 – 9.2 mA
Standby Current	< 50 nA	< 50 nA	< 50 nA	< 50 nA	< 50 nA	< 50 nA
Demodulation	FSK, FM, ASK	FSK, FM, ASK	FSK, FM, ASK	FSK, FM, ASK	FSK, FM, ASK	FSK, FM, ASK
Frequency Conversion	Double superhet	Single Superhet	double superhet	double superhet	single superhet	Double superhet
Input Sensitivity (incl. RF front-end filter loss)	-111 dBm @ 40kHz BW @ FSK	-110 dBm @ 40kHz BW @ FSK	-111 dBm @ 40kHz BW @ FSK	-109 dBm @ 40kHz BW @ FSK	-108 dBm @ 40kHz BW @ FSK	-109 dBm @ 40kHz BW @ FSK
Max. Input Signal	0 dBm, FSK -10 dBm, ASK	0 dBm, FSK -10 dBm, ASK	0 dBm, FSK -10 dBm, ASK	0 dBm, FSK -10 dBm, ASK	0 dBm, FSK -10 dBm, ASK	0 dBm, FSK -10 dBm, ASK
Image Rejection (incl. RF front-end filter)	> 65 dB	> 50 dB	> 65 dB	> 65 dB	> 50 dB	> 65 dB
Spurious Emission	< -70 dBm	< -70 dBm	< -70 dBm	< -70 dBm	< -70 dBm	< -70 dBm
Multi-channel Option	Yes	No	no	Yes	no	No
PLL Demodulator Option	Yes	No	no	Yes	no	No
Package	LQFP44	LQFP32	LQFP32	LQFP44	LQFP32	LQFP32

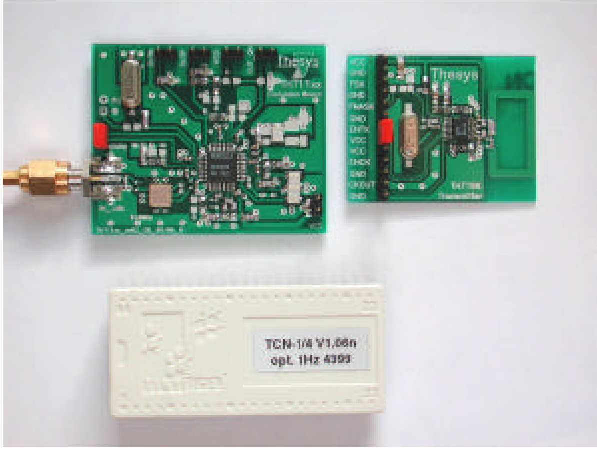
Tab. 2 Various transmitter and receiver ICs from Melexis (Erfurt, Germany)

Extensive data sheets of these switching circuits and the available evaluation boards can be found at:

http://www.melexis.com/home_products.htm

The author has decided for transmitter TH7108 and receiver TH71112, both for 868MHz and FSK. Besides the ICs and evaluation boards (EVB7108 momentary ca. 50 € and EVB71112 ca. 100 €) Melexis also offers bare boards and, for professional integrated solutions, Gerber files for free (complete construction and production documentation of the boards).

Picture 1 shows both modules compared in size to a Tiny Tiger, really “portable“ solutions, which can even get significantly smaller when you develop your own board, leaving out unused features of the evaluation boards.



Pic. 1 Receiving module EVB71112 (left) and transmission module EVB7108 (right)

3. The concept of transmission

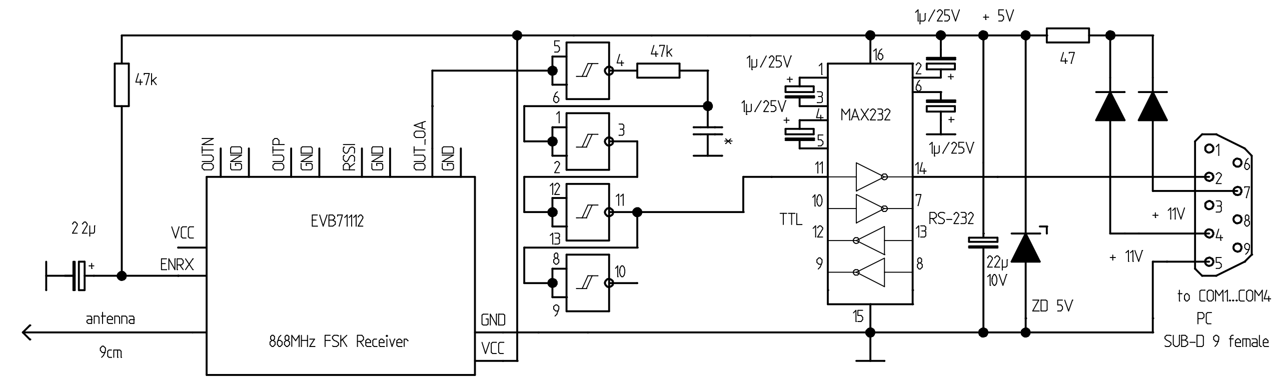
Besides the questions about high frequency just discussed we also have to resolve what kind of data we want to transmit. In general all data pins of the BASIC-Tiger could be used for a HF transmission. In this application note we once again take a look at the serial interface, because this opens wider oppertunities. However, with acceptable effort only a one-directional communication can be realized, either from BASIC-Tiger to PC or vice versa. So we have similar conditions as in the project “data transmission with laser pointer“. The transmitter should be controlled by BASIC-Tiger through RS232 and the receiver should hand over its data to the RS232 interface of the PC, the recipient should get its operating voltage from the serial interface. This avoids the need of a power supply or batteries and would expand the operational field. Our concept:

- The BASIC-Tiger should send (autonome maesuring instrument sends data...),
- both “ends“ should work with RS232 levels (Plug & Play Lab and PC),
- the receiver should get its operating voltage from the PC’s serial interface.

4. Receiver circuit

The HF part is already finished, only the small receiving module EVB71112 has to be connected to the MAX232 and a 9-pin socket terminal strip. With the given circuit the operating voltage for the complete circuit can be won from the serial interface of the PC. For this it is required that it can deliver enough current over the diodes at pins 4 and 7 that the voltage for the ICs and the transmitter is still about 5V. On some PCs, laptops and unfortunately the Plug & Play Lab this doesn’t work well, here the available voltage is too low to supply more parts of the circuit. Because of that the circuit’s operating voltage should

be checked when it is ready. To do so the receiver side (the PC) also has to be set to receiving mode, so e.g. the terminal program has to be started! If the measured voltage is too low, an external +5V voltage has to be supplied (Battery, power supply, Plug & Play Lab). For this nothing has to be changed at the circuit, the diodes take care of separating both power supplies. The RC section at input ENRX (control input standby / operation) of the receiver is used to start it delayed. On start of the terminal program and with it supplying the operating voltage for the receiver the MAX232, the transmitter itself and the blocking capacitors need a rather high current at make. In this already critical situation that can lead to stagnation of the operation voltage at less than 3V and so nothing goes anymore. The later connection of the receiver EVB71112 defuses this behavior a bit.
So summarized about operating voltage supply:
In principle the a bit on the low side “self supply“ of the receiver works reliable on many serial PC interfaces. If it doesn’t work in single cases (voltage less 3.5V), an external power supply of +5V is required.
The rest of the circuit in general consists of a 4-fold NAND-CMOS-IC CD4093 with Schmitt-trigger behavior. Actually not all 4 gates are needed, but a series connection enables you to chose the right logic level at the different gates for other applications. This is necessary e.g. when using BASIC-Tigers without internal RS232 interface as transmitter. Compared with the circuit in picture 2 the level then has to be negated, the transmitter circuit can be adopted without any change. To extract short interfering impulses a interconnected RC section is used.
That’s how it works:
A RC section at the output of the first Schmitt-trigger gate makes the flanks less steep. If a short (unwanted) noise peak appears, the time is too short to charge the capacitor over the resistor and to reach the switching level of the second trigger input. So the peak doesn’t lead to switching of this gate. With a longer (real) impulse the level reaches the switching level and the gate turns over. Because it is the same with the contrasting flank, the impulse length is virtually not changed. The C in the noise supressor circuit is depending from the baud rate and the length of typical noise peaks, a reference value is <1nF.
Picture 2 shows the complete receiver circuit:



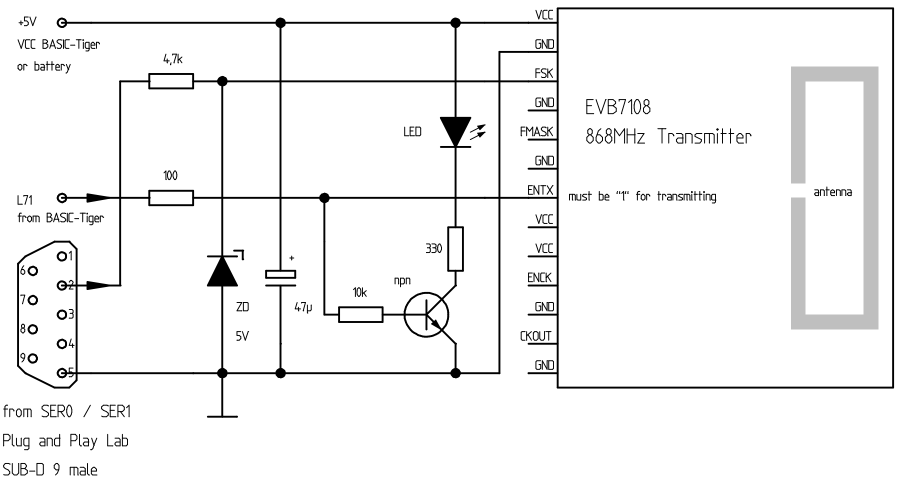
Pic. 2 Receiver circuit with EVB71112, RS232 level converter, noise extraction and power supply from ther RS232 interface

5. Transmitter circuit

Like the receiver circuit also the transmitter board TH108 is supplied with a 5V operating voltage. In contrast to modules which need e.g. 12V, that is a big advantage for our project. Besides the operating voltage (VCC) and ground (GND) there is the actual data input (FSK) which is normally switched by CMOS levels (0V / +5V). On the RS232 interface there are e.g. only –11V and +11V, again a task for the MAX232? Not necessarily, it can be done easier. The 5V Zener diode at the FSK input against ground shorts out negative levels at the RS232 interface. Levels higher than +5V are also “wiped out”, so there can be no damages at the transmitter module. Else there is only one special feature. With the both mode inputs ENCK and ENTX different operation modes for the TH7108 can be set. These two connections also have CMOS levels (with pull-down resistors) and simply can be controlled by a BASIC-Tiger output. All variations most likely are not interesting for us, only the input level of pin ENTX is important:

- ENTX = 0 or open: With ENCK input = 0 (or open, too) standby operation (transmitter completely off)
- ENTX = 1: Transmitter operates normal (ENCK state doesn’t matter).

With this we can (and we have to!!) turn off the transmitter in operation breaks). Here be once more reminded that permanent operation is not allowed. The duty cycle ot the 868.3 MHz band is 1%! At FSK the transmitter in full operation with 0 as well with 1 at data input, only the frequency varies (see chapter 1.1). The regular sequence of data transmission has to be like this: First the transmitter has to be turned on with an OUT instruction (1 at ENTX) e.g. through pin L71 of the BASIC-Tiger, after that data is sent over the serial interface and at last the transmitter is turned off again with 0 at ENTX. For experiments the transmitter can be permanently activated with a jumper (ENTX at VCC). The circuit with transistor and LED is for indicating transmitter activity.



Pic. 3 Transmitter circuit with EVB7108, “mute circuit“ over ENTX and CMOS level limitation

6. Operation

If both circuits are ready, we can start the test operation. Here everything is valid what we have learned in the application note about data transmission with laser pointers. You can build a data transmission from BASIC-Tiger to PC, therefore we again need the program TERMINAL.EXE (or any other suitable terminal program). The program FUNK_01.TIG coming with this application note sends out a text at SER1 with 1200 baud every 10 seconds, which is read by the PC or serial interface SER0 of the Plug & Play Lab with the corresponding settings. If necessary the baudrate can be increased or decreased at both programs (BASIC-Tiger and PC!). For this you select baudrates which are available in both programs.

If all this works, you can test the range of the arrangement. From manufacturer specifications of the radio modules this should be up to 100m in a free space and without interferences. In reality there will be a range loss because of buildings (especially armoured concrete) and electrical interferences (e.g. the BASIC-Tiger or the PC itself, other radio lines etc.).

Concluding a few words about safety of transmission. We don’t think about data privacy protection here, but about possible “mutilation“ of our data by interferences. Such interferences will always appear despite the above mentioned methods for noise peak extraction, just thinking about “foreign“ transmitters, which of course reach our receiver, too. Because we only have a one-directional connection and only a single “line“, all ordinary possibilities for transfer control of a serial connection have to be left out. We must think of something new. A simply possibility would be to send all data three times and for the receiver to check if the received data is identical all three times. Only then it is accepted. Not absolutely safe, but somewhat better anyway. Also the for serial data transmission according to RS232 available parity check gives additional safety (has of course to be established at receiver and transmitter!). As well possible is the calculation of a checksum at sending and receiving of data.

Just try everything...