BASIC-Tiger® – Remote Controlled

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1. Objectives

It is fascinating to watch models of planes, boats or cars in action. As onlookers we are impressed by these events, by the model technology, but also by the remote control systems. Anybody who owns a remote control system and also deals with our BASIC-Tiger® can use them for totally new purposes. Always keeping in mind legal regulations it is easily possible to remote control a BASIC-Tiger® instead of a model car. This won't make the BASIC-Tiger® fly, but you will be able to wirelessly transmit to it up to 8 analog values from some distance. Besides this application there is a target worthwhile pursuing for model aircraft pilots...

Remote controlled airplanes have a higher risk of crashing than their life-sized models. This is due to errors caused by model airplane pilots with inadequate training and experience. Although crashing a model airplane cannot be compared to a real life plane crash model aircraft pilots are interested in finding an explanation for the error, since those toys are very expensive. Usually the model is far away when crashing so it is hard to comprehend what went wrong. This is where our data telecommunication can help. Just imagine BASIC-Tiger® would not only receive all data sent via a second receiver, but also save them. This could turn out to be a kind of flight data recorder (so-called black box) for airplane model pilots. This device allows reconstructing all movements of the control stick and other remote control elements. It could also be interesting to repeat certain flight maneuvers in reality – saved data are transmitted to the model as remote control signals. We will create the basis for such a solution in this application note. It is our objective to simultaneously transmit one (or even 8) analog records via radio to BASIC-Tiger® using a standard remote control.

2. Analog multi channel remote control basics

Looking at a standard remote control system for models we usually only recognize a portable remote control transmitter (figure 1). Other parts, such as receiver, servos, starter, motor regulator, receiver batteries etc. are usually tiny and hidden within the model. Figure 2 shows a typical selection of such model airplane components. How does the electronic part of this device work?

- The **transmitter** contains all mechanical control elements, a circuit part which converts the position of those elements to impulses with corresponding length and a HF element which transmits these modulated as pulse repetition via a transmitter stage with antenna.
- At the other end of the HF connection, usually inside the model, there is a suitable **receiver** which receives HF signals with its antenna and decodes them. Decoding means it

creates single impulses from the HF modulated impulse repetition for every control respectively drive element. There are up to 8 separate outputs.

- **Servos** are connected to the receiver's outputs. They are used for steering respectively drive control. Those servos have their own electronics which creates the actuator position out of the delivered impulse length. For instance a short impulse becomes a turn to the right, a long impulse becomes a turn to the left and a medium impulse makes the steering element go back to the centre position.

Fig. 1 Robbe remote control transmitter

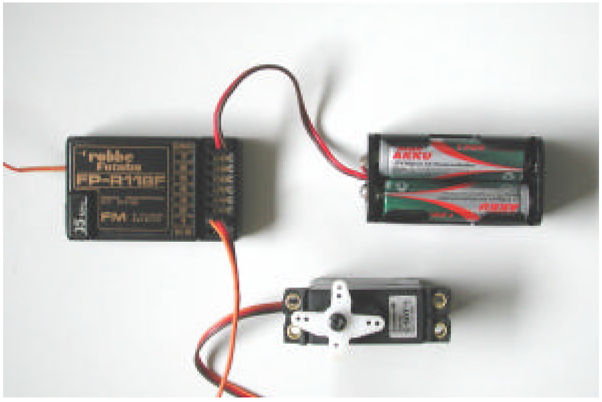

Fig. 2 Receiver, servo, battery pack

2.1. Control elements at the remote control transmitter

In the case of airplane models mostly only two control sticks are visible. They can control four analogue channels in total. Such a control stick is free moving in two directions which can be set in combination, i.e. not only forward/back and right/left, but also to the back right etc. Every axle adjusts a potentiometer, i.e. the position of both axles is available analogue as two resistance values. Besides the control sticks there are further control elements depending on the model, such as switches, controller knobs etc. which, being additional channels, electronically are treated similar as the control sticks.

2.2. Electronically processing the analogue channel values

Usually there are up to 8 channels with standard model remote controls. Those channels have to be transmitted to the model virtually at the same time. Since we only have one radio channel, the analogue control channel signals have to be transmitted successively. At present there are two standardized procedures for model remote controls, the rather old **PPM (Pulse Phase Modulation)** and the rather new **PCM (Pulse Code Modulation)**. Modern remote control transmitters based on microprocessor technology (see figure 1) usually are able to carry out both procedures. Here only the universal PPM procedure is important to us, this is why the following sections will only deal with this kind of procedure.

Eventually both procedures recreate single impulses at the receiver's servo outputs, the impulse length being a measure for the servo movement. In order to transmit a single value for every channel the system can take up to 20 ms. Within these 20 ms there are 8 impulses, one for every channel. The impulse length represents the analogue value for the respective channel and lies between 1 and 2 ms. The impulse length is created by a monostable multivibrator inside the transmitter. The actuator for the first impulse is potentiometer 1. In combination with an integrated capacitor the impulse time t1 proportionally arises from the product of C and R1. After impulse 1 is finished impulse 2 starts, the length of which depends on the position of potentiometer 2 etc. After sending 8 channels a synchronization phase (pause) takes place and then the procedure reconvenes. Figure 5 shows the impulse scheme of an 8-channel proportional remote control. By the way this procedure is standardized all over the world and it is independent from the system's producer.
The rest of the system is used for HF modulation as well as for data transmission, which we will not present in this application note.

2.3. Receiver

In this context we are not interested in the HF part either. Only the outputs to which usually the servos' plugs are connected to are of importance to us. Figure 3 shows a Robbe standard receiver with several pin connectors at the output. Usually every channel has three pins (ground, positive supply voltage, control output). The plug's order is mostly standardized, but you cannot go wrong if you take a look at the manual! The 8 incoming impulses already code the control output so that only an impulse of a variable length within 20 ms is outputted on the respective channel. From that impulse length the standard servo independently creates a position proportional to the control stick on the transmitter's side. Ground and operating voltage from the transmitter supply are used for feeding the servos and other actuators at the same time.

Fig. 3 Robbe remote control receiver with 8 servo outputs

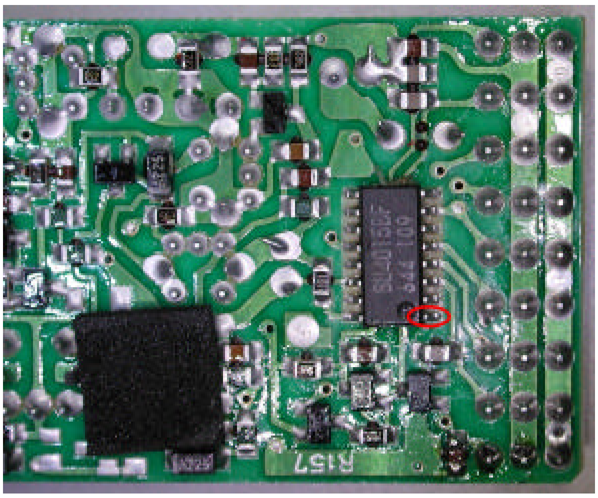

Fig. 4 Receiver's conductor side with BU4015 – pin 1 sends 8 impulses

When watching such a single channel with an oscilloscope there is, as mentioned above, a positive impulse (between 1 ms and 2 ms long) every 20 ms. The next channel's impulse comes right after the first one. For evaluating using BASIC-Tiger®, all 8 outputs would have to be connected to the Tiger, which takes a lot of wiring effort and it would require a complex logic to measure the 8 single impulses.
The signaling before channel separation inside the receiver is more interesting. The latter is carried out by shift registers. In the case of the receiver shown in figure 3 it is a BU4015BF. At its input (pin 1) all single impulses still can be tapped one after the other. Figure 5 shows schematically how the single impulses are stringed together temporarily at the outputs (green) and how the original signal looks like at pin 1 of the BU4015 (black).

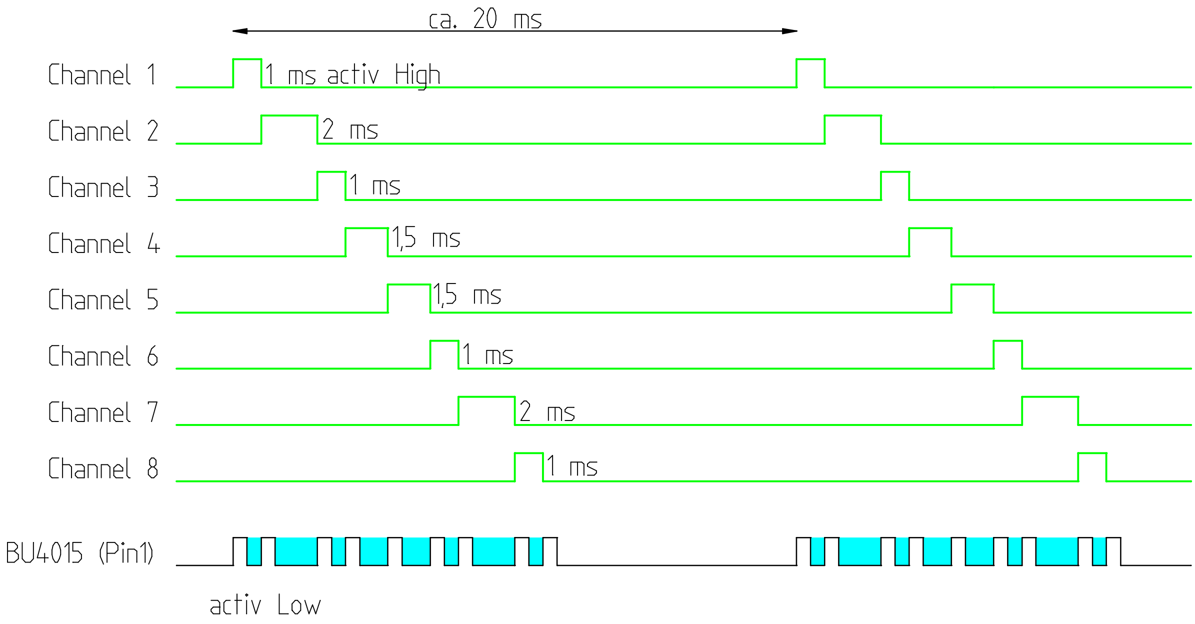

Fig. 5 8 output signals and their state before the BU4015

Figures 6 to 9 show the same at the oscilloscope. Control channel 1 (green) is used for triggering, the signal sequence at the shift register's input is depicted in black. The timing information lies within

- The length of a single high impulse at the single outputs (1ms ... 2ms).
- The length of the 8 low impulses at the input of the BU4015 which are separated by 9 (!) high impulses with constant length (about 500 µs). Please note that the low impulses appear shortened by the amount of this constant high impulse compared to the single channel impulses at the outputs. This effect is not of importance for our application, since we will measure only relatively.

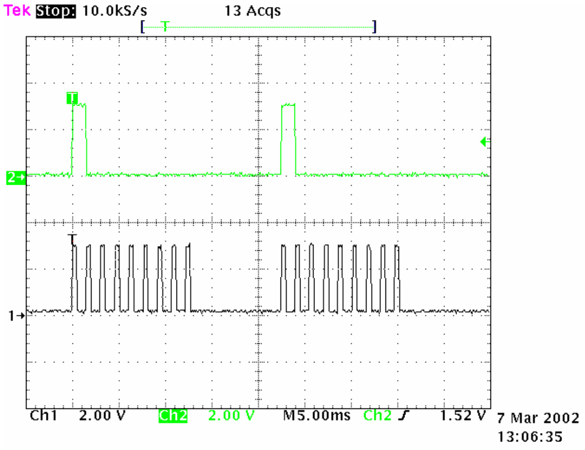

Fig. 6 Two passes of about 20 ms with the 8 impulses for the 8 channels

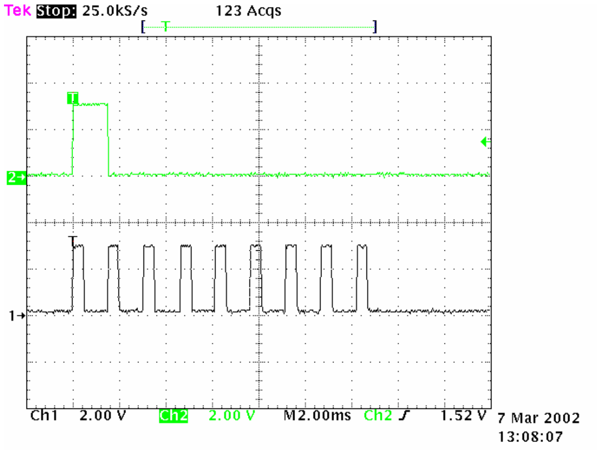

Fig. 7 the same slightly stretched

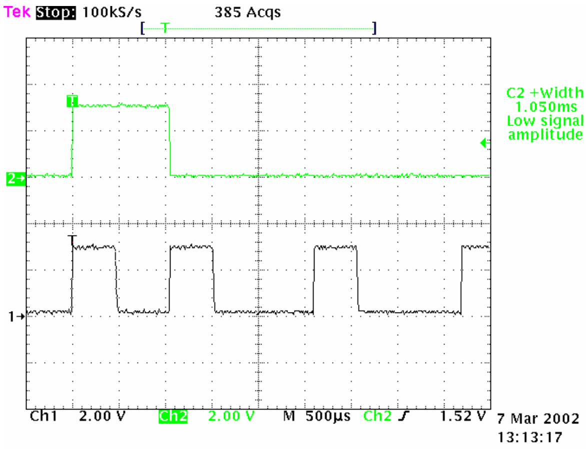

Fig. 8 here the channel 1 impulse at its minimum length (ca. 1 ms)

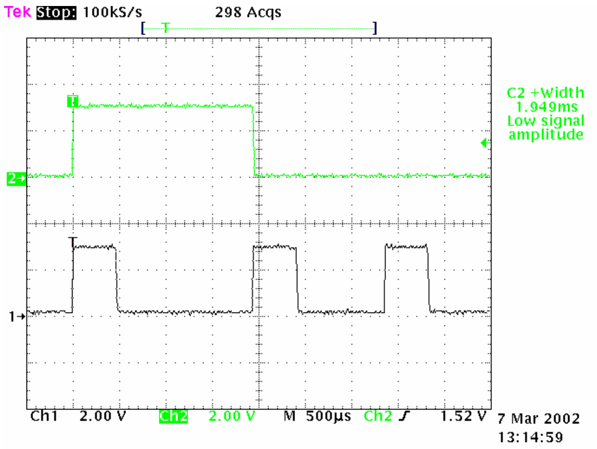

Fig. 9 and at its maximum length of about 2 ms

So cycle total length of the 8 impulses is variable and depends on the single impulse length's sum. Only the interval between the impulse packages remains constant at 20 ms and is independent from the single impulses. Two conclusions concerning our project arise from this discovery:
If we want to examine only one channel and e.g. transmit only one analogue information via radio control to the BASIC-Tiger®, simply measuring the impulse length (high period) from the chosen channel on the lead out receiver's output pin using the device driver PLSIN1.TDD is convenient.
If we need more than one channel (up to 8 are possible!) there are two options. We either dare manipulating the receiver by looking for shift register BU4015BF and connecting its pin 1 negated to the BASIC-Tiger® or "reunite" the output impulses from the 8 single channels using a rather complex logic.

In the first case (measuring in front of the shift register) the variable impulse length is not displayed as a high period but as a low period at the shift register's input (as shown in figures 5 – 9). One advantage of this method is that between the impulses to be evaluated there are long enough high impulses for triggering the impulse length measurement. The long low period between impulse packages is also convenient for synchronizing the channel allocation. There is only the disadvantage of having to negate the impulses for using the device driver PLSIN1.TDD, since PLSIN1.TDD is only able to measure the high period of impulses.

In the case of connecting logic externally we need 8 lines, which pool the single impulses from the 8 outputs by using an OR circuit. In between artificial gaps have to be created, since the single impulses are chronological stringed together immediately which very much complicates measuring the 8 impulse lengths. On balance this is a complex solution which, however, does without manipulating the receiver.

Both example programs PPM_01.TIG and PPM_02.TIG show both the single channel transmission (this works without manipulating the receiver and without any additional logic) and the simultaneous transmission of 8 channels. In the latter case the author opened the receiver and connected the shift register input signal to the BASIC-Tiger® pin L84 after negating it.

3. Measuring the impulse length by using BASIC-Tiger®

3.1. Circuitries

Connecting the version for one channel using program PPM_01.TIG is quite easy (figure 10). Simply tap operating voltage and ground from the BASIC-Tiger® with the receiver and connect pin L84 to the receiver's output – finished!

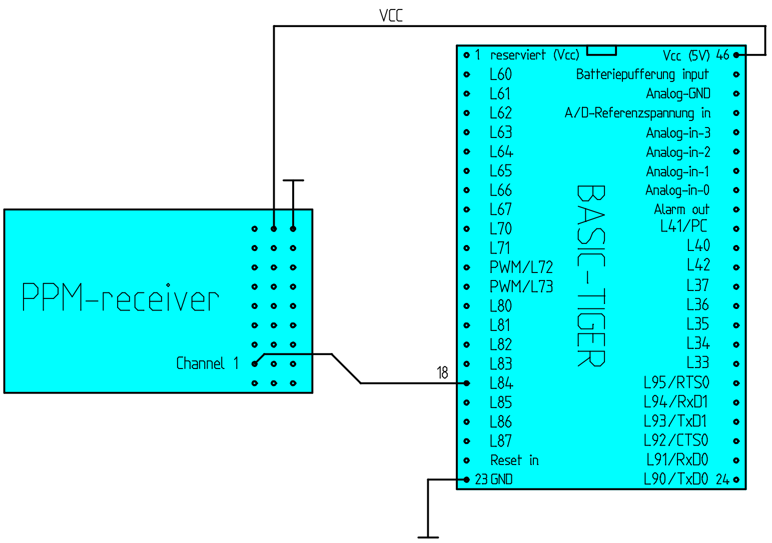

Fig. 10 Remote control with one analogue channel (for program PPM_01.TIG)

The 8 channel version is a little more sophisticated (figure 11). Provided that you tapped and lead through the whole signal in the receiver this is how the rest of the circuitry looks like:

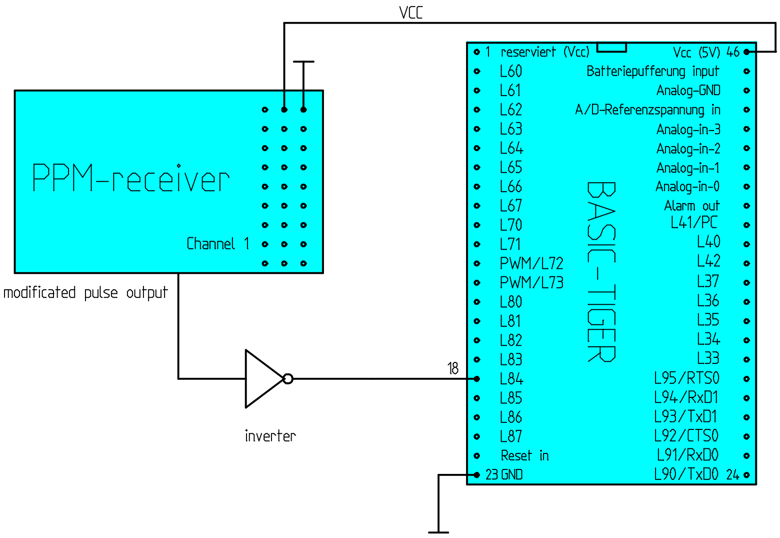

Fig. 11 Version for 8 channels (program PPM_02.TIG)

It is almost irrelevant how you invert the mutual impulse package. Virtually all logic families such as TTL, Low Power Schottky, CMOS, HCT as well as a simple transistor stage are suitable for preparing the signal for the BASIC-Tiger®.

3.2. Programs

We offer two simple programs which demonstrate the link-up of a remote control system and a BASIC-Tiger®.

PPM_01.TIG

An arbitrary remote control receiver channel is connected directly to the BASIC-Tiger® pin L84 according to figure 10. The remote control transmitter can be operated directly by the Tiger's VCC. If this is not desired, an additional connection between receiver ground and BASIC-Tiger® ground has to be created; otherwise it is already connected via the voltage supply. The impulse length of the respective channel is displayed in ms.

PPM_02.TIG

Measuring 8 channels at the same time happens similarly. Figure 11 shows the wiring with the **modified** receiver. The impulse package is read at pin 1 of the shift register CD4015 which is mostly used for separating single impulses. Program PPM_02 displays all channel impulse lengths.

4. Outlooks

Simply displaying remote control data is just the beginning. Just think of all the opportunities to use and evaluate it in your own applications. Many procedures in home, garden, industries, hobbies etc. can gain totally new features by using a remote control system and BASIC-Tiger®. New ideas are implemented easily, e.g. replacing the control sticks of the transmitter by suitable sensors. This allows data telecommunication in a simple way. Please keep in mind legal regulations for radio remote control in general and in special cases when experimenting:

- Manipulating the transmitter's and receiver's HF range is taboo.
- Not all frequency bands are allowed for common remote control tasks. E.g. the 35 MHz range is allocated for model aircraft only. The 40 MHz range, however, can be used for all surface model applications (cars, ships etc.). The 27 MHz range can be used for both surface and aircraft. These regulations may vary from country to country, please check which frequency band can be used for what purpose in your country.
- There are also restrictions concerning the operation times as well as usage in certain areas. You cannot prosecute "data telecommunication" everywhere and always.

Still have fun experimenting!