# Functional description TSU6000

## *1) General description of device*

The TSU6000 is a color LCD touch screen universal remote control.
It is intended to operated a large variety of TV's, VCR's, hi-fi combinations,…
To minimize the number of hard buttons, an LCD is used to display the buttons and a touch screen will sense whether a button is pressed. It also offers an intuitive user interface. In order to accommodate a wide range of brands, a database is include to pick the right code set for a particular device. To be future proof, the user has the possibility to update the database and/or software in the device by connecting the TSU6000 via a cable to the serial com port of a PC. With the included software (Pronto Edit), the user can customize his device.
Next to having a database, the device is also capable of learning IR (infrared) codes via an infrared receiver. The received code is stored aboard the flash memory.
While the larger part of the controlled devices by the TSU6000 are controlled by infrared, the TSU6000 is also capable of sending out codes via RF. This operates in combination with a remote control extender, which is sold separately.
The power source for this device is a rechargable battery pack (4 x AAA NiMH pack with temperature sensor and poly fuse). The TSU6000 is combined with the DS6000, which is the battery charger for this device.

## *2) Main use*

This device is a standalone remote control device, for indoor use only. When upgrading the software or user interface, it has to be linked via the included cable to the com port of a PC. When the battery is empty, it must be recharged with the included docking device.

## *3) Circuit description*

The function of the device is build around the Motorola Dragonball uP (IC 7001). Via its build in memory controller, it uses 512KB SRAM (IC 7006) and 8 MB of flash memory (IC 7059). The Flash is used as storage for the database, programs and learned IR codes. The SRAM is used to run the programs from and to hold copies of the flash blocks. An additional footprint to add memory is provided, but not used in this device (IC7005). IC 7067 is the glue logic between uP and memory.

In stead of using the on board LCD controller, there is chosen to use an external LCD controller: this is IC 7060. It is attached on the memory and data bus of the uP. An image is build in a particular address space of the uP and translated by the LCD controller in order to display a bitmap on the color LCD.

The color LCD is attached to the pwb via connector 1002.

The clock needed to operate the LCD controller comes from the uP and is 8MHz.
The clock frequency to operate the uP is derived from a low frequency crystal: 32.768 kHz.
Via the internal PLL from the uP, this is multiplied to 16.6 MHz. This clock does NOT leaves the uP.
The hardware round components 7066 and 3125 are to power down the LCD when the device is in the sleep mode and also regulate the contrast of the LCD.

IC 7004 is a touch screen controller: it has 4 connections to the LCD via connector 1002. It provides x and y coordinates to the uP via the SPI port of the uP. Via the auxiliary input of ic 7004, the battery voltage is measured to estimate the remained capacity of the battery. ESD protection of the touch screen is provides via diodes 6001…6004.
The generation of IR signals is proved by combining the PWM output of the uP with some glue logic (ic's 7011, 7012, 7007, 7009): for an example of what the wave form looks likes: see next page.

The carrier frequency is generated by the PWM of the uP. This is a square wave with a frequency between 36kHz and 455 kHz, dependent on the format of the IR code. Different brands use different carrier frequencies. Because the generated square wave can also be an audible signal, which goes to the piezo driver, a demultiplexer is used (IC 7007-A and –C). The output of the PWM goes via the multiplexer (IC 7009) to IRQ7 and TIN1. Each carrier pulse is counted and when the amount of carrier pulses equals the value of the compare register of the counter (which is in the uP), IC 7012 ( is commanded via TOUT of the uP) will stop the carrier from being transferred past IC 7007-B. Now the compare value in the counter register is set to the amount of pulses that are not allowed to be send out. Those pulses are count and when this value is reached, IC 7012 will command IC 7007B to let the pulses true again.
In this way, any pulse train can be obtained which forms a command.

The IC's 7012 and 7071 forms a switch that direct the pulse train to the IR driver (transistors 7064 and 7013), or to the RF transmitter.

There are two infrared receivers: 6010 and 6028. The 6010 is used to learn IR codes that are send out by other remotes on a short distance (typical 1 – 10 cm), while the 6028 is intended in two way infrared communication up to 10 meter.

In order to attach the device to a communication port of a PC, it is necessary to convert the signal of the UART (in uP) that has a level between 0 and +3.3V, to an RS232 compatible level. The RS232 spec requires for a logic "1" a level between –15 and –3.3V, for a logic "0" a level between +3.3 and +15V. The transistors 7016, 7017 and 7018 will provide an output level between Vbat ( minimum + 4.2 V) and the voltage supplied by the TX of the PC. Additional components are used to guaranty ESD protection and to detect if the device is hooked up to a PC.

A key matrix provides the device with some frequently used buttons such as volume up & down, channel up & down, page up & down,.. Some of the buttons are backlighted by LED's (6042 to 6046).

## Example of IR protocol:

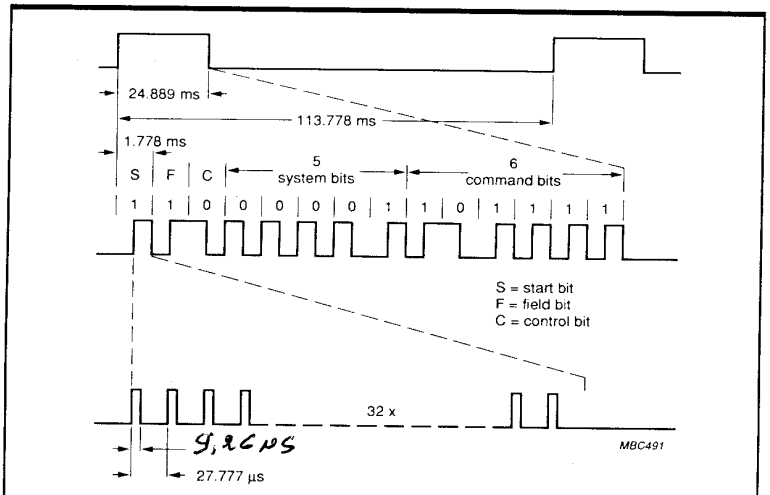


*Fig.2 Transmission details for RC-5 command 47 in system 1*

### RC-5 REMOTE CONTROL TRANSMISSION PROTOCOL

Each 14-bit RC-5 code word generated within the transmitter as shown in Fig.2 is preceded by a 20 ms de-bounce time followed by a keyboard scanning time. Since a bit period is 1.778 ms, transmission of a 14-bit code word takes 24.889 ms. Each code word is repeated every 113.78 ms as long as a key remains pressed. Once a transmission has been initiated, a complete code word is sent, even if the key is released. The code word format is:

- 2 start bits, the first of which is always logic 1, and the second of which is a field bit denoting command codes 0 to 63 (logic 1) or command codes 64 to 127 (logic 0)
- 1 control bit which toggles after each key release and initiates a new transmission.
- 5 system address bits for selecting one of the 32 possible systems
- 6 command bits representing one of the 128 possible RC-5 commands

To ensure high immunity to interference from other infrared sources such as the sun, lamps and infrared sound transmissions to headphones, biphase encoding (also called Manchester code) is used for the code words. As shown in Fig.3, for biphase encoding, each bit of a code word is represented by a symbol comprising two logic levels with a transition in the middle of the bit period. A HIGH to LOW transition represents logic 0; a LOW to HIGH transition represents logic 0.

Before transmission via the IR LED, the HIGH period of each 1.778 ms symbol is modulated at 36 kHz with a duty factor of 25%. Each half-symbol period which is HIGH therefore contains 32 pulses with an on-time of 7,00 µs and a repetition period of 27.777 µs.

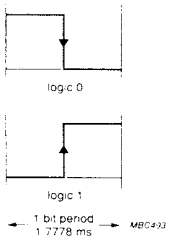


*Fig.3 Bi-phase transmission technique*

The circuit around 7035 is the reset circuit for the uP. The tilt switches 1020 and 1026 will wake up the device if tilted under an angle of 40 º.

The power management block has 3 main blocks: the voltage monitor IC 7028, The 3.3V LDO and the enable switch (7047 or 7024, 7029 and 7030). When the battery voltage is lower than 4.2V, IC 7028 will shut down the LDO (IC 7023) by opening the switch 7047. An alternative switch is build around transistors 7024, 7029 and 7030 but are not mounted in this device.

Connector 1018 is the link to the battery pack, connector 1019 is the link to the charger (docking station).

The last block is the CCFL converter: this provides the power to the fluorescent tube of the LCD.
This requires a voltage of approx. 280V RMS and a current of 0.5 – 2 mA to operate.
The converter is build around transistors 7062 and 7063, transformer1023 and coil 5012.
These form a basic current fed Royer converter. In order to stabilize the light output with respect to varying battery voltage, IC 7061 act as a switching voltage regulator. The tube current is measured via resistor 3129.

Dimming function is provided via diodes 6038 and 6039.

## *4) RF transmitter Part.*

This transmitter is based on a SAW stabilised Colpitts oscillator topology.

**Circuit description.**

Supply voltage, stabilised 3.3V
Base drive voltage, stabilised 3.3V
Working frequency, 418MHz ±200KHz (SAW stabilised)
Type of antenna, integrated helical (no posibilitys to connect an external antenna)
Type of modulation, real on/off keying (OOK)
Nominal modulation frequency, 36KHz - duty cycle 50%
Type of transmission, remote control command codes

**Circuit components**

The components 7073,2107,2114,5021,2103,1028,3209,5020,2104,5025 and base biasing 3207,3208,5027 form a common collector SAW stabilised Colpitts oscillator.

The components 5020,2104 form together with 5019,2115 a low pass-filter.

The components 2108,2110 and 1027(PCB loop track) form a matching arrangement for the antenna.

The components 2112,2113,3210,3214,5023,2119 form a power supply decoupling network.

Note:
The components 7074,7072 and peripheral components are meant for European versions and are not assembled.