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Severity: Information

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Calibrating Real-Time Clock

Background: Making computer's internal clocks running accurately without specific tools is uneasy and time consuming task. One of the manual ways is to preset trimming capacitor in some position, preset the time, wait for an hour and see the difference. However you may guess following such algorithm will take a lot of hours to figure out in which direction capacitor to rotate, and what is its optimal position.

Solution: we designed a program which helps to calibrate the RTC (real-time clock). In addition, it identifies and displays estimated speed of the CPU, and screen vertical refresh rate.

Limitation: please note that if your computer uses variable wait-state cycles, or variable CPU operating frequency, program will not display proper CPU speed estimation results.

Description: Program is called CHKSPD, which stands for "check speed" – of the computer and of the RTC. You can run it on GR8BIT platform, or any other MSX PC.

Take a look at fig. 1. First parameter, VDP XTAL, is an input parameter for the CPU T-cycle calculation. If you put wrong VDP frequency, program will calculate wrong CPU speed and wrong RTC deviation. First step is calculation of VR – vertical refresh rate. The following formula is used:

$$VR = \frac{VDPXTAL}{6 * TRow * Rows},$$

where VDPXTAL is a frequency of the VDP, TRow is VDP cycles per screen row displayed, and Rows is number of rows displayed for the specific mode. In "60Hz" mode VDP displays 262 lines, in "50Hz" mode it displays 313 lines (see VDP V9938 LSI datasheet, pp.146-147).

```
B>chkspd
GR8BIT CPU speed estimation
and RTC calibration program
Usage:
CHKSPD[M*][V*][R*][H][X@][F#]

VDP XTAL: 21.480000 MHz
VR rate: 50.165349 Hz

T-Cycles/s      Z80 CPU speed
00369EBE       3.579582 MHz

T  T-cycle delta
16 +00000036/0.0 ahead
```

Figure 1. Typical output of the CHKSPD program – ideal shot in BlueMSX

Basing on calculation of the VR rate, program calculates number of CPU T-cycles. In order to perform it properly, you should ensure that correct wait-state parameters are set – these include number of $\overline{M1}$ CPU cycle wait-states, VDP access cycle wait-states, and RTC access cycle wait-states.

To the right of the T-cycles/s' hexadecimal value you see more readable value in Mhz. As it is calculated on-the-fly and is not hard-coded into the program, please allow some deviation from your ideal estimation of the CPU speed. Or, if you totally disagree with the speed calculation, please (a) ensure that you have set proper wait-states in the command line and XTAL frequency, and if it does not help, report issue to us.

Next step after calculation of the CPU speed is tracking 1 (one) full RTC second interval and calculating a number of CPU T-cycles occurred during this period. The difference in T-cycles is displayed in the "T-cycle delta" column along with estimation of deviation in seconds per hour. Positive deviation value means that RTC is faster than real time, and negative means RTC is slower than real time. As explained earlier, "reality" depends on previous calculation of the CPU speed, thus to have proper estimation of the RTC deviation it is required to have CPU speed identified properly.

CHKSPD download is available in source and executable forms from the GR8BIT web site, "Downloads" section.

Special thanks to **Raymond van der Meulen** (NL) for testing and **Daniel Vik** (US) for provision of the CPU and VDP timing information.

Preparation for adjustment: Before your GR8BIT's real time clock stuff works correctly, you need to perform two minor modifications to the design.



the picture to the left).

First modification is improvement in design; if you will not implement it your RTC may be prone to EMI from the components nearby and may work improperly or halt if you touch RTC circuits with your finger. Your task is to connect body of the RTC crystal XTAL1 (on the main board) to the ground. As there was no special soldering pad designed for it, please use air-wire to the nearest ground power rail (e.g. as on

Second modification is a fix of the mistake in the design. If you will look into the RP5C01 datasheet and compare crystal oscillation part to the GR8BIT, you will see that 100KOhm resistor is missing between RTC's pin 17 and XTAL1/C65 connection. To fix it, please cut a conductor as shown on the fig. 2a, and solder 100KOhm resistor as shown on the fig 2b.

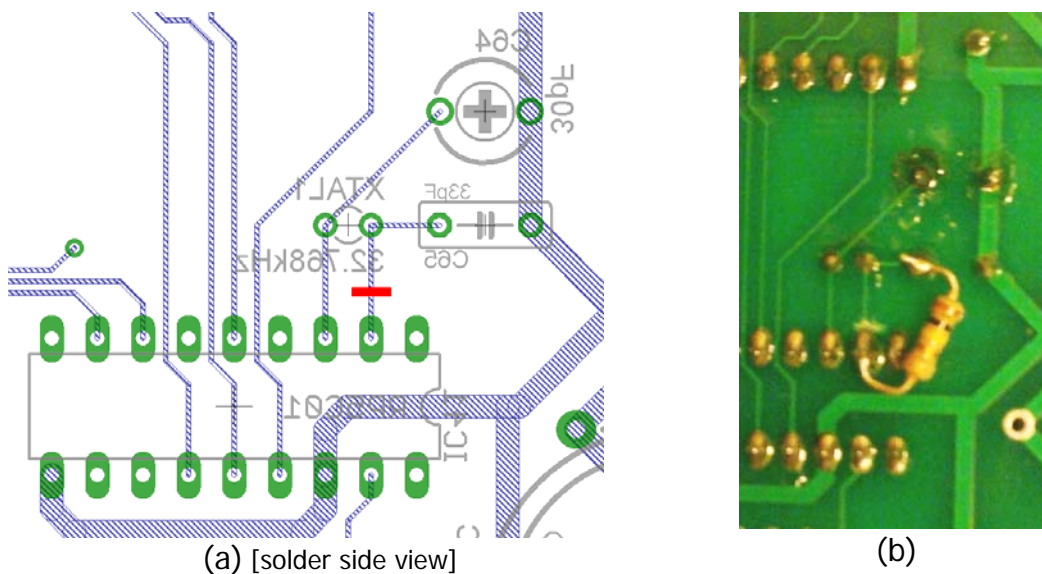


Figure 2. Soldering resistor in

After you implement these changes, you need to find a small flat screwdriver to rotate trimming capacitor. Suitable tool can be made from the nail (fig 3). Find a nail of the diameter a little less than the hole in the trimming capacitor, and use small file to make double-sided bevel (like a screw-driver,

shown by red lines on the picture). No need to make its tip sharp – just ensure tip fits into the capacitor's screw and you can rotate it.



Figure 3. Nail converted to the small screwdriver (at the top)

Adjusting RTC speed: turn on GR8BIT, start MSX-DOS. Run CHKSPD with proper command line keys, and ensure it displays CPU speed correctly. Use screwdriver to rotate trimming capacitor in either directions, and watch T-cycle delta. Your task is to make the delta as close to 0.0 as possible. When finished, you can interrupt program execution by pressing CTRL-C or CTRL-STOP.

CHKSPD command line: please use command line modifiers (keys) to set initial values for the program. You type CHKSPD, then space character, and they keys, without "-", "\", "/" or any other characters. You can put space characters between keys, but not between key identifier and its value. Those keys include:

- **M*** – number of the $\overline{M1}$ cycle wait-states, "*" is a hexadecimal representation of the value, 0-F. Default value is 1;
- **V*** – number of the VDP access cycle wait-states, "*" is a hexadecimal representation of the value, 0-F. Default value is 0;
- **R*** – number of RTC access cycle wait-states, "*" is a hexadecimal representation of the value, 0-F. Default value is 0;
- **X@** – VDP XTAL frequency, "@" is 8-digit value in Hertz, minimal value is 20260000Hz and maximal value is 22550000Hz (per V9938/58 datasheet). Default value is 21480000;
- **F#** – use specified VDP VR mode, "#" is either 5 for "50Hz" mode, and 6 for "60Hz" mode. By default current VR mode is used;
- **H** – display help message.

The following examples of MSX-DOS prompt strings are valid ones:

CHKSPD M1V5R5X21477270F6

CHKSPD M1 R0 X21328100

Identifying VDP XTAL value: there're several ways how to identify the exact speed of the VDP in your machine: (a) using service/technical manuals, but you should ensure that your machine was not modified; and (b) opening the machine, locating the crystal and reading its value, converting it to Hertz. Standard XTAL for GR8BIT supplied within GR8BOX is 21480000Hz.

Search for manuals over the internet. Here're some links with a collection of manuals to download:

- MSXBlue, http://www.msxblue.com/?page_id=6157&lang=en (Philips hardware);
- MSXArchive, <http://www.msxarchive.nl/pub/msx/mirrors/hanso/> (mirror of Hans Otten's scans of manuals).

Identifying wait states: Almost every MSX machine is running with 1 (one) $\overline{M1}$ cycle wait-state, 0 or 1 VDP access cycle wait-states and 0 (zero) RTC access wait-states. GR8BIT can be preset to use other wait-state values using SW1 switch located on the main board.

In case you use default slowdown circuit

- If SW1 position 5 is **off**, one $\overline{M1}$ wait-state is inserted, otherwise 0;
- SW1's positions 1...4 identify binary representation of the wait-states inserted when $\overline{SLDN}\%$ line is activated, with position 0 identifying least significant bit (LSB);
- If SW1 position 6 is **on**, RTC and PPI access period is supplemented by the insertion of the number of wait-states indicated by SW1's positions 1...4;
- If Video board's SMD jumper SJ2 "Slowdown" is **closed**, any VPD access cycle will be supplemented by insertion of the number of wait-states indicated by SW1's positions 1...4;
- If I/O board's jumper JP2 "I/O Slowdown" is **closed**, any access cycle to GR8BIT storage subsystem will be supplemented by insertion of the number of wait-states indicated by SW1's positions 1...4.

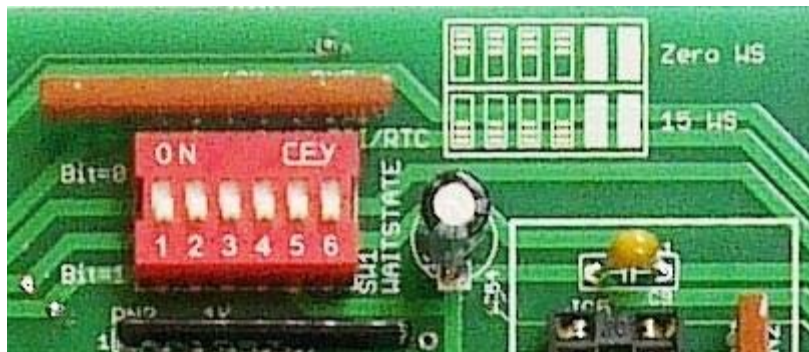


Figure 4. SW1 wait-state preset switch of the GR8BIT main board

In case you use modified slowdown circuit (see *GR8BOOK part VII*), there's a difference in the behavior of $\overline{M1}$ wait-state application:

- If SW1 position 5 is **on**, $\overline{M1}$ CPU cycle is supplemented by the insertion of the number of wait-states indicated by SW1's positions 1...4.

Running CHKSPD on the Turbo-R machine in Turbo mode: in this mode program will not display correct estimation of the RTC accuracy. However you can see (fig. 5) the estimation of the speed at which equivalent Z80 CPU is running – and it appears that running Turbo-R MSX machine in the Turbo mode is equivalent to running Z80 MSX machine at about 41MHz!

In Z80 mode Turbo-R machine displays correct results, and you can use CHKSPD to adjust its RTC.



```
Volume in drive E: is AM
Directory of E:\CHKSPD

.           <dir> 12-09-17 19:04
..          <dir> 12-09-17 19:04
CHKSPD.COM 2304 12-09-26 17:00
2K in 3 files 1480864K free
E:\CHKSPD>time
Current time is 18:29:43
Enter new time:
E:\CHKSPD>CHKSPD.COM
GR8BIT CPU speed estimation
and RTC calibration program
Usage:
CHKSPD[M*][V*][R*][H][X*][F#]

VDP XTAL: 21480000Hz
VR rate: 59.93036Hz

T-Cycles/s   CPU speed
026E0DAB    40.766MHz

T T-cycle delta
21 +0109FC1F/-.-ahead
```

Figure 5. Running on Turbo-R machine in Turbo mode
(photo by Raymond van der Meulen)

Sources and information for further reading:

- Ricoh Company Ltd. (1995) *Real-time clock with internal RAM*, datasheet, available online at <http://amiga.serveftp.net/Datasheets/RP5C01A-RealTimeClock.pdf> (accessed 02-Oct-2012, hosted by Anthony Hoffman from NZ)
- ASCII Corporation, Nippon Gakki Co. (1985) *V9938 MSX-Video Technical data book: Part 2 "LSI data sheet"*, available online at <http://www.msxarchive.nl/pub/msx/docs/datasheets/v9938.pdf> (accessed on 02-Oct-2012, hosted on MSX Assembly Page)

End of KB0008 "Calibrating Real-Time Clock".