# ***Technical Description***

Mains Voltage Analysis Board

7515

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# *1 General Information*

The board 7515 contains a measuring and monitoring system for mains frequencies between 45 and 65 Hz. It is equipped with a bus connection for the ***hopf*** radio clock system 7001.

The board contains the following functional groups:

- board identification
- calculation of the mains frequency
- time from the mains frequency
- difference time between system time and mains time
- analogue output of the frequency deviation from the set value (optional)
- serial data output

## *1.1 Starting*

As the board runs in the GPS system 7001 or in the DCF77 system 7001, no initializing or reset function is required to operate the board. It is only necessary to connect the mains frequency which is to be analyzed to the system. The voltage must be between 90 - 260 V AC.

## *1.2 Board Identification*

Up to four boards type 7515 can be used in the system to obtain data from different voltage mains supplies. The identification of each board is carried out by means of the DIP switch DS3.

| S5 | S4 | board |
|---|---|---|
| on | on | board 1 |
| on | off | board 2 |
| off | on | board 3 |
| off | off | board 4 |

The board identification is pre-set by our company. The customer is only asked to regard the correct switch position when the board is exchanged.

## *1.3 Precautions*

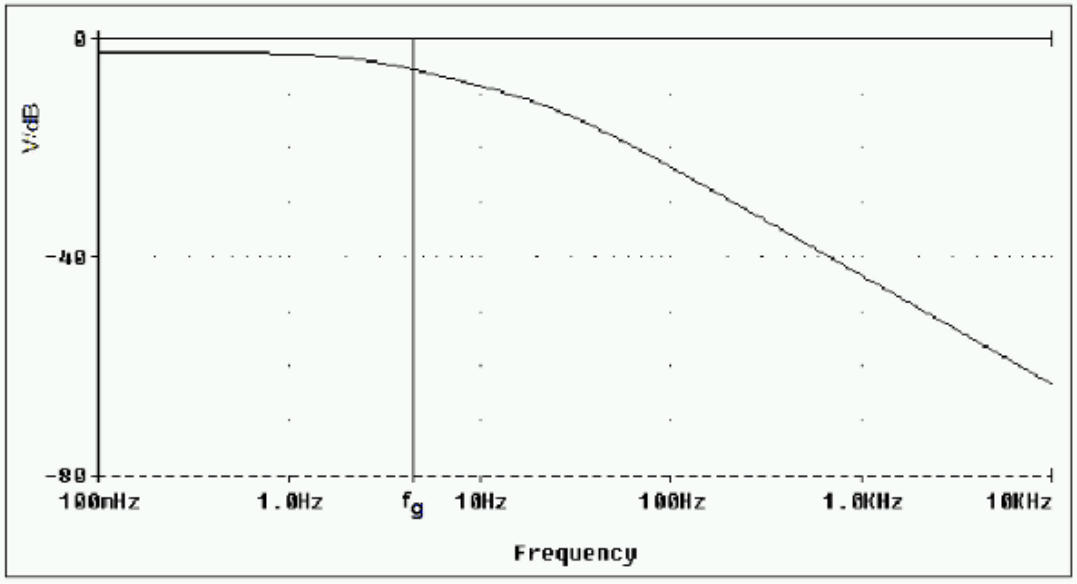
The power supply must not be connected by anybody except specialists or authorized persons. The mains fuse protection should be 260 V / 1 A.

# 2 Mains Frequency

## 2.1 Calculation of the Mains Frequency

The mains voltage is transformed to max. 8.5 V AC by means of a safety transformer in the input circuit of the board and it is changed into square pulses by a Schmitt-trigger circuit.

To suppress interferences caused by high frequency glitches a low pass filter with the following curve is placed before the Schmitt-trigger.




The pulse width of the square pulses is used to calculate the mains frequency. On the board a frequency of 512 kHz is created from the highly accurate system time base of 1 kHz.

The accuracy of the 512 kHz signal depends on the system and is, when using a board in a

- DCF-system ± 2,0 ppm
- GPS-system ± 0,2 ppm

This frequency is used to create a measuring value from the sum of 8 mains periods. A new measuring value (cycle duration) is available after about 160 msec in case of 50 Hz mains frequency and after about 133 msec in case of 60 Hz mains frequency. After a measuring value is made the frequency is calculated to ± 1 mHz from the last 8 values by division of the cycle duration. The last 64 mains periods are used for each frequency calculation.

## *2.2 Time from the Mains Frequency*

The time is created from the mains frequency by counting the mains periods in the micro processor. As the time is generated in second steps it is necessary to tell the board the base frequency so that the processor can use the according dividing factor for one second.

The frequency is selected by means of the DIP-switch 3 (see table DS3).

- S3 off 50 Hz base frequency
- S3 on 60 Hz base frequency

### *2.2.1 Mains time / System time - Synchronization*

There are the following possibilities to synchronize the mains time with the system time:

- after a system reset caused by program error or voltage loss a synchronization is carried out automatically.
- by addressing the board via key-pad. The following input mode is required.

Choice the "Time Synchronized by Mains Time Monitoring" via the menu item **S.-CLK** (see Key-Entry / System Control and Choice of Special Functions).

### *2.2.2 Time Synchronized by Mains Time Monitoring*

After the selection of the mains time (time synchronized by mains supply) function the following picture is displayed:

selection picture

**SELECT NET-CLOCK 1 - 4 > <**
**RESET NET-TIME TO MATCH SYSTEM TIME**

By selecting the board number (1 - 4) one out of 4 boards 7515 can be addressed in the system.

The second line of the selection picture shows the commands which can be used to control this board.

If the first board 7515 in the system is to be selected press key **"1"**.

The display shows (example):

**1. NT: 12:34:56 dT: +0:00:00,032**
**SY.-T: 12:34:56 F: 50,001 Hz INPUT ->_**

Entering **"R"** and **"ENT"** synchronizes the mains time with the system time and the difference time will be set back to 0.

The mains time synchronization can also be done by superior computers or controls via a potential free voltage pulse of at least 0.5 sec duration. This pulse is fed to the board via the 9-pole SUB-D female connector 3. The pulse height can be on 3 different voltage levels.

| | | |
|---|---|---|
| connector 3 | connection 1 | TTL-level |
| connector 3 | connection 2 | + 12 – 24 V DC |
| connector 3 | connection 3 | + 18 – 36 V DC |
| connector 3 | connection 6 | GND |

### *2.2.3 Difference Time System / Mains time*

The precise adjustment of the frequency requires the difference time between system time and the mains time, because the system time has a long term accuracy of $1*10^{-13}$. This is the same as the accuracy of the DCF77-transmitter or of the GPS satellites.

The difference time is calculated on every mains time second change in millisecond steps.

The maximum difference time is ± 00:59:59,999 sec.

## *2.3 Analogue Frequency Output / FG751510 (option)*

Optionally there are 2 analogue frequency outputs available for the long term recording of the mains frequency. Every output can be set ex works by voltage to ± 2.5 V or by current to ± 1 mA or ± 20 mA limit range based on the ground potential (see ***chapter 5 Position Overview***).

| Channel | Jumper | Pin | Output Current |
|---|---|---|---|
| 1 | J1 | 1-2 | ± 1 mA (standard setting) |
| 1 | J1 | 2-3 | ± 20 mA |
| 2 | J2 | 1-2 | ± 1 mA (standard setting) |
| 2 | J2 | 2-3 | ± 20 mA |

Channel 1 is an output of ± 5 Hz for the limit range, whereas channel 2 has an output of ± 0.5 Hz for the limit range. The ranges refer to the set standard frequency of 50 or 60 Hz (see pt. 2.2). The analogue outputs are realized via a DAC with 4000 parts resolution.

The analogue output goes via the 9-pole SUB-D female connector 4.

| Channel | Pin | |
|---|---|---|
| channel 1 voltage output | 1 | + 5 Hz = + 2,5 V or - 5 Hz = - 2,5 V |
| ground | 3 | |
| resolution | | 2 mHz / mV |
| channel 1 power output | 2 | + 5 Hz = + 1 mA or - 5 Hz = - 1mA |
| ground | 3 | |
| resolution | | 5 mHz / µA |
| channel 2 voltage output | 6 | + 0,5 Hz = + 2,5 V or - 0,5 Hz = - 2,5 V |
| ground | 8 | |
| resolution | | 0,2 mHz / mV |
| channel 2 power output | 7 | + 0,5 Hz = + 1 mA or - 0,5 Hz = - 1 mA |
| ground | 8 | |
| resolution | | 0,5 mHz / µA |

# *3 Set-up*

## *3.1 Serial Interface*

The measuring values like frequency, time etc. can be displayed on ***hopf*** large displays. The selection is carried out via a serial interface in RS232 or RS422 mode.

The following data strings are available for the individual measurements:

| Identifier | String | Construction | Max. resolution |
|---|---|---|---|
| F0 | System time | Sy 12:34:56 | Seconds |
| F1 | Mains time | N1 12:34:56 | Seconds |
| F2 | Difference time (positive) | t + 00:00:00,056 | msec |
| F3 | Frequency (50Hz / 60Hz) | f1 50,001 | mHz |
| F7 | Synchronization via F7-Master/Slave-String | hr min sec dow Da Mo Yr | Seconds |

The exact string structure is described in ***Chapter 4 Data Strings***.

The strings are output every second, with the exception of the F7-Master/Slave-String, which is transmitted on the 59th second of every minute.

## *3.2 Setting the Transmission Parameter with DS1 and DS2*

- DS1 for interface S1 on connector S1 in the front panel.
- DS2 for interface S2 on connector S2 in the front panel (not activated at present)

***baud rate***

| DS1 and DS2 | | | | |
|---|---|---|---|---|
| **S8** | **S7** | **S6** | **S5** | **baud rate/Bd** |
| on | on | on | on | 19.200 |
| off | on | on | on | 9.600 |
| on | off | on | on | 7.200 |
| off | off | on | on | 4.800 |
| on | on | off | on | 3.600 |
| off | on | off | on | 2.400 |
| on | off | off | on | 1.800 |
| off | off | off | on | 1.200 |
| on | on | on | off | 600 |
| off | on | on | off | 300 |
| on | off | on | off | 150 |
| off | off | on | off | 135 |
| on | on | off | off | 110 |
| off | on | off | off | 75 |
| on | off | off | off | 50 |

***Please note :*** A correct data transmission cannot be garuanteed in case of baud rates below 2400 baud.

***Parity-Mode and Wordlength***

| DS1 and DS2 | on | off |
|---|---|---|
| S1 | 7 data bits | 8 data bits |
| S2 | parity odd | parity even |
| S3 | parity on | parity off |
| S4 | 2 stopbits | 1 stopbit |

***Handshake Signals (not activated at present)***

| DS3 | on | off |
|---|---|---|
| S1 | RTS/CTS-simulation UART A | RTS/CTS active UART A |
| S8 | RTS/CTS-simulation UART B | RTS/CTS active UART B |

## 3.3 Pin Function Serial Interface

***Connector S1 and S2 in the Front Panel***

| Pin | Signal | |
|---|---|---|
| 1 | GND | |
| 2 | RS232 TxD | |
| 3 | RS232 RxD | |
| 4 | RS232 RTS | |
| 5 | RS232 CTS | |
| 6 | RS422 TxD + | high active |
| 7 | RS422 TxD – | low active |
| 8 | RS422 RxD – | low active |
| 9 | RS422 RxD + | high active |

## 3.4 Setting of the Board 7515 with DS3

| DS3 | On | Off |
|---|---|---|
| S2 | autoreset suppressed | autoreset active |
| S3 | mains frequency 60 Hz | mains frequency 50 Hz |
| S4 | board identification | board identification |
| S5 | board identification | board identification |
| S6 | not used | not used |
| S7 | bussystem 7001 | bussystem 7000 |

# *4 Data Strings*

## *4.1 System Time (Identifier F0)*

| Character No. | Meaning | Hex-Value |
|---|---|---|
| 1 | STX (start of text) | $02 |
| 2 | "F" ASCII F | $46 |
| 3 | "0" ASCII 0 | $30 |
| 4 | "S" ASCII S | $53 |
| 5 | "y" ASCII y | $79 |
| 6 | Space | $20 |
| 7 | Tens hour | $30-32 |
| 8 | Unit hour | $30-39 |
| 9 | ":" Colon | $3A |
| 10 | Tens minute | $30-35 |
| 11 | Unit minute | $30-39 |
| 12 | ":" Colon | $3A |
| 13 | Tens second | $30-36 |
| 14 | Unit second | $30-39 |
| 15 | CR (carriage return) | $0D |
| 16 | ETX (end of text) | $03 |

## *4.2 Mains Time (Identifier F1)*

| Character No. | Meaning | Hex-Value |
|---|---|---|
| 1 | STX (start of text) | $02 |
| 2 | "F" ASCII F | $46 |
| 3 | "1" ASCII 1 | $31 |
| 4 | "N" ASCII N | $4E |
| 5 | "1" ASCII 1 | $31 |
| 6 | Space | $20 |
| 7 | Tens hour | $30-32 |
| 8 | Unit hour | $30-39 |
| 9 | ":" Colon | $3A |
| 10 | Tens minute | $30-35 |
| 11 | Unit minute | $30-39 |
| 12 | ":" Colon | $3A |
| 13 | Tens second | $30-36 |
| 14 | Unit second | $30-39 |
| 15 | ETB (end of block) | $17 |
| 16 | ETX (end of text) | $03 |

## *4.3 Difference Time (Identifier F2)*

| Character No. | Meaning | Hex-Value |
|---|---|---|
| 1 | STX (start of text) | $02 |
| 2 | "F" ASCII F | $46 |
| 3 | "2" ASCII 2 | $30 |
| 4 | "t" ASCII t | $53 |
| 5 | DEL (Delete) | $7F |
| 6 | DEL (Delete) | $7F |
| 7 | Operational sign (+/-) | $2B-2D |
| 8 | DEL (Delete) | $7F |
| 9 | DEL (Delete) | $7F |
| 10 | Tens hour | $30-32 |
| 11 | Unit hour | $30-39 |
| 12 | ":" Colon | $3A |
| 13 | Tens minute | $30-35 |
| 14 | Unit minute | $30-39 |
| 15 | ":" Column | $3A |
| 16 | Tens second | $30-36 |
| 17 | Unit second | $30-39 |
| 18 | CR (carriage return) | $0D |
| 19-23 | 5 * Space | $20 |
| 24 | Hundreds millisecond | $30-39 |
| 25 | Tens millisecond | $30-39 |
| 26 | Unit millisecond | $30-39 |
| 27 | ETB (end of block) | $17 |
| 28 | ETX (end of text) | $03 |

## *4.4 Mains Frequency (Identifier F3)*

| Character No. | Meaning | Hex-Value |
|---|---|---|
| 1 | STX (start of text) | $02 |
| 2 | "F" ASCII F | $46 |
| 3 | "3" ASCII 3 | $33 |
| 4 | "f" ASCII f | $66 |
| 5 | "1" ASCII 1 | $31 |
| 6 | Space | $20 |
| 7 | Frequency tens | $30-39 |
| 8 | Frequency unit | $30-39 |
| 9 | "," Comma | $2C |
| 10 | Frequency 1/10 | $30-39 |
| 11 | Frequency 1/100 | $30-39 |
| 12 | Frequency 1/1000 | $30-39 |
| 13 | Space | $20 |
| 14 | "H" ASCII H | $48 |
| 15 | "z" ASCII z | $7A |
| 16 | ETB (end of block) | $17 |
| 17 | ETX (end of text) | $03 |

## *4.5 F7-Master/Slave-String (Identifier F7)*

E.g. the large scale display 4985 can be synchronized to the Master System time data with the F7-Master/Slave-String. The difference time of the base system is also transferred in the data string, so that the UTC time can also be displayed with the correct difference to local time.

The string is transmitted in the 59th second together with the data of the next full minute. The end character "**ETX**" takes place on the exact second change and updates the data on the large display.

The F7-Master/Slave-String transmits:

- Local time (hour, minute, second)
- Date (day, month, year [2-digit])
- Difference time - Local time to UTC time (hour, minute)
- Day of the week
- Status information (announcement of a ST/WT-changeover, announcement of a leap second, reception status of the F7-Master/Slave-String source)

### *4.5.1 Structure*

| Character No. | Meaning | Hex-Value |
|---|---|---|
| 1 | STX (start of text) | $02 |
| 2 | "F" ASCII F | $46 |
| 3 | "7" ASCII 7 | $37 |
| 4 | status | $30-39, $41-46 |
| 5 | day-of-week | $31-37 |
| 6 | tens hour | $30-32 |
| 7 | unit hour | $30-39 |
| 8 | tens minute | $30-35 |
| 9 | unit minute | $30-39 |
| 10 | tens second | $30-36 |
| 11 | unit second | $30-39 |
| 12 | tens day | $30-33 |
| 13 | unit day | $30-39 |
| 14 | tens month | $30-31 |
| 15 | unit month | $30-39 |
| 16 | tens year | $30-39 |
| 17 | unit year | $30-39 |
| 18 | difference time tens hour / operational sign | $30-31, $38-39 |
| 19 | difference time unit hour | $30-39 |
| 20 | difference time tens minute | $30-35 |
| 21 | difference time unit minute | $30-39 |
| 22 | CR (carriage return) | $0D |
| 23 | LF (line feed) | $0A |
| 22 | ETX (end of text) | $03 |

The difference time in hours and minutes is transmitted after the year. The transfer takes place in BCD. The difference time can be max. ± 11.59 hours.

The operational sign is shown as the highest bit in the Tens Hours:

Logic **1** = Local time is behind UTC
Logic **0** = Local time is ahead of UTC

**Example:**

| Data String | Tens Diff.-Time | Difference Time |
|---|---|---|
| (STX)F7831234560301960300(LF)(CR)(ETX) | **0000** | - 03:00h |
| (STX)F7831234560301961100(LF)(CR)(ETX) | **0001** | - 11:00h |
| (STX)F7831234560301968230(LF)(CR)(ETX) | **1000** | + 02:30h |
| (STX)F7831234560301969100(LF)(CR)(ETX) | **1001** | + 11:00h |

### *4.5.2 Status*

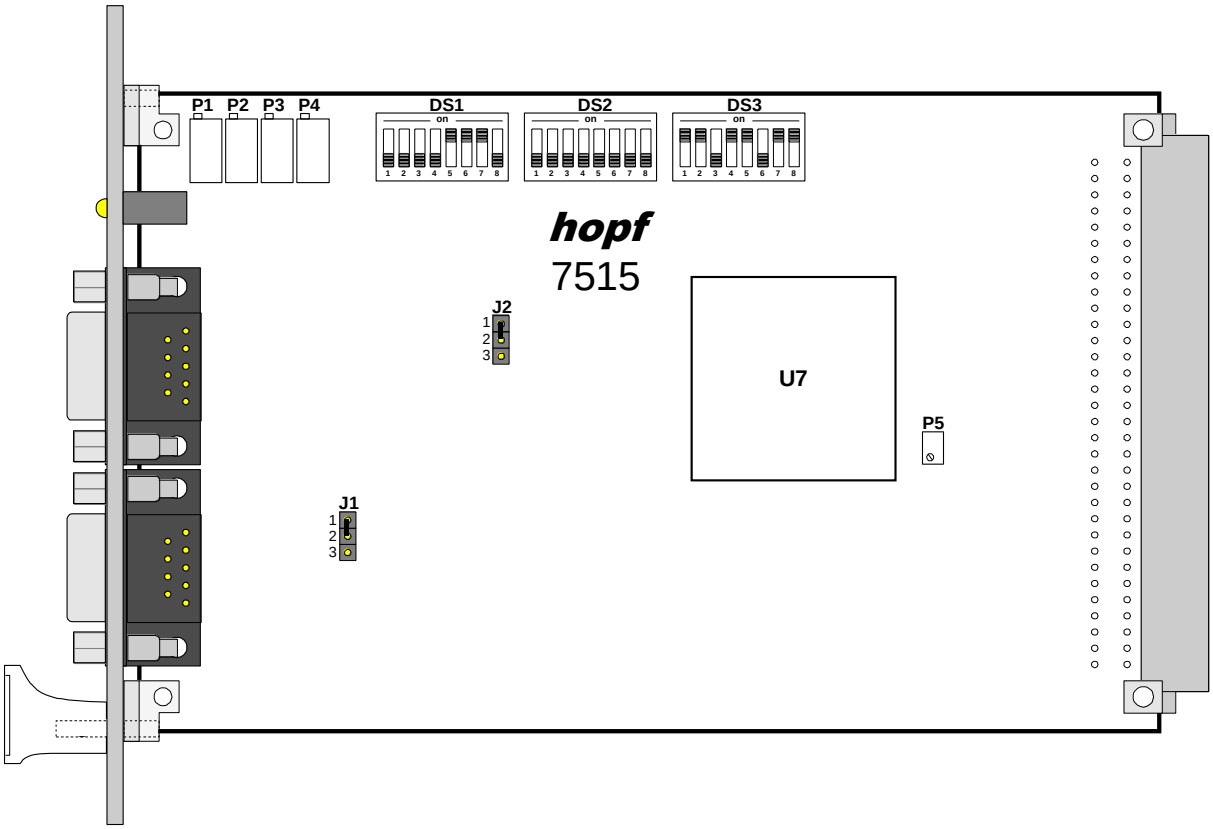
| Nibble | b3 | b2 | b1 | b0 | Meaning |
|---|---|---|---|---|---|
| **Status** | x | x | x | 0 | No ST/WT-changeover announcement |
| | x | x | x | 1 | ST/WT-changeover announcement |
| | x | x | 0 | x | Wintertime (WT) |
| | x | x | 1 | x | Summertime (ST) |
| | x | 0 | x | x | No leap second announcement |
| | x | 1 | x | x | Leap second announcement |
| | 0 | x | x | x | Quartz operation |
| | 1 | x | x | x | Radio operation |
| **Nibble** | **b3** | **b2** | **b1** | **b0** | **Meaning** |
| **Day of the Week** | 0 | 0 | 0 | 1 | Monday |
| | 0 | 0 | 1 | 0 | Tuesday |
| | 0 | 0 | 1 | 1 | Wednesday |
| | 0 | 1 | 0 | 0 | Thursday |
| | 0 | 1 | 0 | 1 | Friday |
| | 0 | 1 | 1 | 0 | Saturday |
| | 0 | 1 | 1 | 1 | Sunday |

### *4.5.3 Example*

**(STX)F7831234560301968230(LF)(CR)(ETX)**

- Radio operation
- No announcement
- Wintertime
- It is Wednesday 03.01.96 - 12:34:56 o'clock
- The difference time to UTC is + 2.30 hours

## 5 Position Overview



# *6 Technical Data*

| | |
|---|---|
| voltage supply: | 5 V DC via bussystem |
| power consumption: | 260 mA |
| mains supervision voltage input: | 90 - 260 V AC |
| frequency range: | 45 - 55 Hz |
| or | 55 - 65 Hz |

***measuring accuracy mains frequency***

| | |
|---|---|
| DCF77-system: | ± 2 ppm ± 1 mHz |
| GPS-system: | ± 0.2 ppm ± 1 mHz |
| difference time: | ± 1 msec |
| Current consumption measuring input (50Hz) | 0.9mA (110V AC)<br>3.2mA (230V AC) |

***analogue outputs***

*output 1*

| | |
|---|---|
| voltage output: | ± 2.5 V resolution 2 mHz / mV |
| power output: | ± 1 mA resolution 5 mHz / µA |

*output 2*

| | |
|---|---|
| voltage output: | ± 2.5 V resolution 0.2 mHz / mV |
| power output: | ± 1 mA resolution 0.5 mHz / µA |

***special versions***

Soft and hardware alterations accroding to customer specifications are possible

***Please note :*** The ***hopf*** company withhold the right to technical alterations at any time.