Industriefunkuhren

hopf Elektronik GmbH

Technical Manual

System 7001RC

Multi-Source Function

ENGLISH

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hopf Elektronik GmbH
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Version number (Firmware / Description)

REGARDING VALIDITY OF THIS MANUAL PLEASE SEE TECHNICAL MANUAL OF SYSTEM 7001RC (SEE CHAPTER MULTI-SOURCE SYSTEMS).

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Functionality

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Information

Notes and Information.

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Safety regulations

The safety regulations and technical data serve to ensure trouble-free operation of the devices and protection of persons and equipment. It is therefore of utmost importance to observe and comply with these regulations. If these are not complied with, then no claims may be made under the terms of the warranty and no liability will be assumed for any ensuing damage.

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This device has been manufactured in accordance with the latest technological standards and approved safety regulations

The device should only be put into operation by trained and qualified staff. Care must be taken that all cable connections are laid and fixed in position correctly. The device should only be operated with the voltage supply indicated on the identification label.

The device should only be operated by qualified staff or employees who have received specific instruction.

If a device must be opened for repair, this should only be carried out by employees with appropriate qualifications or by ***hopf*** Elektronik GmbH.

Before a device is opened or a fuse is changed all power supplies must be disconnected.

If there are reasons to believe that the operational safety can no longer be guaranteed the device must be taken out of service and labelled accordingly. The safety may be impaired when the device does not operate properly or if it is obviously damaged. Contact your local ***hopf*** Elektronik GmbH representative for required action.

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This device fulfils the requirements of the EU directive 89/336/EWG "Electromagnetic compatibility" and 73/23/EWG "Low voltage equipment".

Therefore the device bears the CE identification marking (CE=Communauté Européenne)

CE = Communautes Europeénnes = European communities

The CE indicates to the controlling bodies that the product complies with the requirements of the EU directive - especially with regard to protection of health and safety for the operator and the user - and may be released for sale within the common markets.

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Contents Page

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1 Multi-Source System - General

A multi-source system makes it possible to create a clock system that can select between various synchronisation sources (sync. sources), independent of their respective status. For this purpose, all available sync. sources are evaluated and monitored.

Different priorities are assigned by the user to the various sync. sources (primary, secondary etc.). These priorities define the synchronisation source that will be preferred when sources have the same status.

The system will be synchronised and controlled by the primary source for as long as this source has the status "Sync". In the event that the primary source reverts to "Quartz" or "Invalid" status, the system automatically switches for synchronisation to the secondary source – provided that this source has the synchronisation status "Sync".

The systems that are connected to the clock system are not able to recognise which source is being used for synchronisation. These systems are only able to recognise, from the type of signal emitted by the clock system, whether the clock system is synchronised or is running in internal quartz mode.

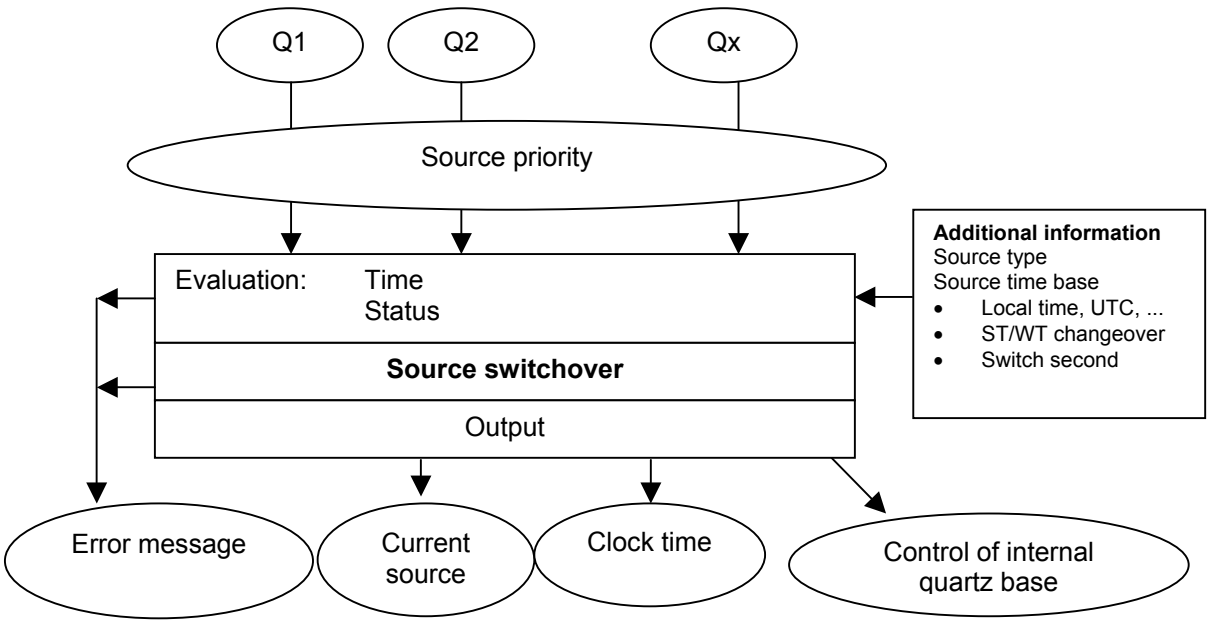
The internal quartz mode of the clock system is only used as the time base when there is no synchronisation source (sync. source) with "Sync" status available. In this case the clock system status is output as "Quartz".

Switching between the various sync. sources generally takes place automatically but can also be done manually.

1.1 Functional Schematic of a Multi-Source System

Different priorities are assigned to the sources Q1 ... Qx (primary, secondary etc.). The system time and date are defined from the time and status information of the primary source. In addition, the time and status information of the other sources is evaluated and monitored; however this data is not used to synchronise the system. The synchronisation status of the respective source is reported via the system such that, in the event of the failure of the primary source, the user or the system can switch over to the next synchronous source.

Diagram: Schematic of a multi-source system



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1.2 Fundamental Problems of Multi-Source Systems

Multi-source systems have more than one sync. source. Each of these sources is evaluated and monitored in its own right. In this situation it is necessary to be aware of the problem that the various time transfer formats may contain different information about the signal status, time difference to UTC etc.

Due to the differences in time transfer formats several points should be noted when feeding information into a multi-source system:

1.2.1 Status Information as a Component of Time Transfer

There are transfer formats where, for purposes of differentiation of signal quality, the only difference is whether the signal can be evaluated or not.

An example of this is the GPS signal – this is either received and evaluated correctly, thereby representing a valid sync. source, or the signal cannot be evaluated and the source is classified as invalid.

1.2.2 Time Zone / Time Difference to UTC

A time zone is a section of the earth's surface across which a common time applies. This runs ideally from the poles along the lines of longitude. The time zone is defined by the time difference between local time and UTC (Coordinated Universal Time).

The time base is defined from:

- The time zone: time difference from local time to UTC
- and the hour offset due to Summer/Wintertime changeover

1.2.3 Summertime/Wintertime Changeover (ST/WT changeover)

In the summer months many countries change to another time zone. In this way, Central European Time (CET) applies in most middle European countries in winter (UTC+1h); however in the summer months Central European Summer Time (CEST) applies (UTC+2h).

There are time transfer formats that carry out a ST/WT changeover with or without an announcement.

In the case of a ST/WT changeover without an announcement the time leaps by one hour, without the receiver being able to prepare for this. Since the time output is always prepared in advance, other sub-systems that are synchronised by the receiver cannot accept the ST/WT changeover and therefore continue to operate with an incorrect time until the next time transfer.

For this reason these times must be known to the receiver when there are time transfer formats that transmit the ST/WT changeover times without an announcement or do not carry out any ST/WT changeover at all. Only in this way is it possible for the clock system to output the correct local time.

Basically there are three possible signal combinations for handling ST/WT:

1. The signal sends an announcement prior to changeover (e.g. DCF77)
2. The signal changes over without an announcement (e.g. IRIG-B)
3. The signal ignores the changeover and continues without a leap (e.g. GPS)

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1.2.4 Leap Second

There are time transfer formats that carry out a leap second changeover with or without an announcement.

In the case of a leap second changeover without an announcement the time leaps by one second, without the receiver being able to prepare for this. Since the time output is always prepared in advance, other sub-systems that are synchronised by the receiver cannot accept the leap second changeover and therefore continue to operate with an incorrect time until the next time transfer.

1.2.5 Automatic / Manual Changeover between the Sync. Sources

- Multi-source with **automatic** changeover between the sync. sources:
  The system automatically selects the sync. source, depending on the synchronisation status of the sync. source and the system status.
- Multi-source with **manual** changeover between the sync. sources:
  The user can decide which sync. source should be selected to synchronise the system. In the event of failure of this sync. source there is no automatic switchover to the second sync. source.

1.2.6 Time Leaps when switching between two Sync. Sources

Sync. sources may have leaps in time due to, for example

- different signal runtimes,
- different time base accuracies
- configuration errors
- time differences or
- different time offsets to UTC etc.

Since each sync. source is evaluated in its own right and its time is accepted as valid, provided that the time signal meets the formal conditions for synchronisation of the respective channel, there may result a time leap in the multi-source system when switching between sync. sources.

1.2.7 Unification of the different Time Information

There are various time transfer formats that must be known to the receiver system in order for it to be able to calculate the correct time base.

For example:

- GPS always transmits in UTC
- IRIG-B transmits local time as standard but can also transmit in UTC

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1.3 Difference from a Safety System

At least two independent synchronisation sources (sync. sources) are required for synchronisation in a safety system. The time information of the available sources is compared and is only used to synchronise the system if a defined time difference between the time data is not exceeded.

If the permissible difference is exceeded then the time is not accepted into the clock system and an error message is output.

In a multi-source system, only one sync. source is used to synchronise the clock system. The selection of the time source that is used for this purpose depends on the priority of the respective source and its status.

The received time information in the multi-source system is not checked for consistency.

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2 Multi-Source System based on System 7001RC

The sync. sources are selected via the **"SYNCHRONISATION SETTINGS BYTE"** in the **"INITIAL-SETUP"** of the 7001RC system.

2.1 Principle of the *hopf* 7001RC Multi-Source System

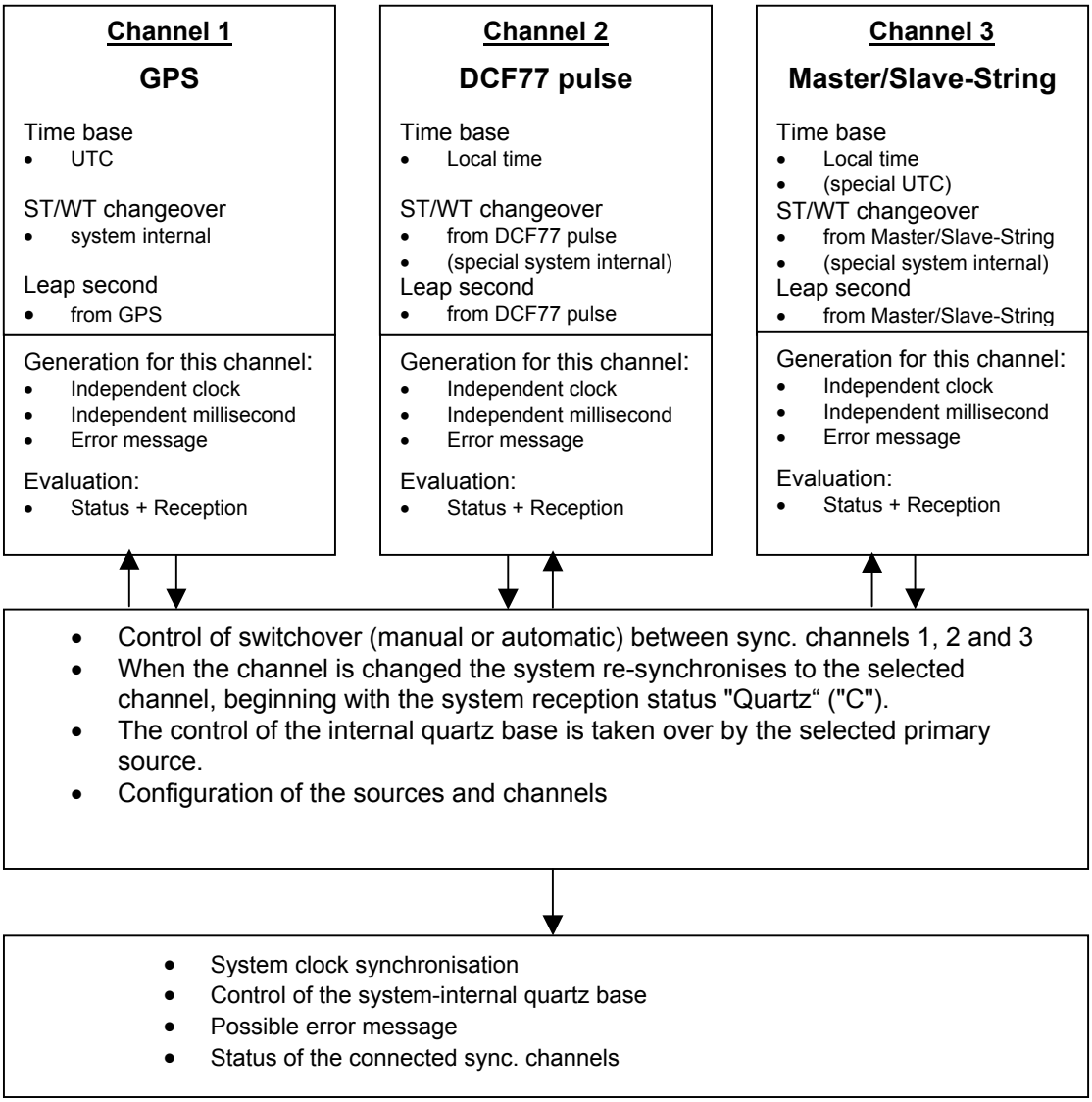
The 7020RC control board of the 7001RC system has three synchronisation inputs (channels) for connecting the sync. sources.

Each of these channels can evaluate a specific type of time information.

The 3 channels can be combined in 2 modes as a multiple source with 2 sync. sources:

GPS (Channel 1)	and	**Master/Slave-String (Channel 3)**
DCF77 pulse (Channel 2)	and	**Master/Slave-String (Channel 3)**

The following schematic presents an overview of all the synchronisation channel formats available on the 7020RC control board and the associated information flow:



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hopf Elektronik GmbH has various modules in the range for converting time information in order to produce the signals for channel 2 (DCF77 pulse) and channel 3 (serial Master/Slave-String). For example, to convert an IRIG-B signal into a serial Master/Slave-String that can be evaluated by the system 7001RC. This makes it possible for customers also to be able to use other time signals to synchronise the multi-source system.

2.1.1 Differentiation between Sync. Source Status and System Status

There is a fundamental difference between the system status and the respective status of the sync. sources:

Sync. source status

- refers to the synchronisation status of the connected time sources, (**not** to the synchronisation status of the multi-source system)
- is displayed alternately on the upper line of the 7001RC system display for each sync. source
- can accept the conditions **"-"** (invalid) and **"R"** (radio synchronous **with** control of the internal quartz base)
- independently for each source

System status

- represents the synchronisation status of the clock system
- is displayed on the lower line of the 7001RC system display, followed by the indication of accuracy
- can accept the conditions **"-"** (invalid), **"C"** (quartz), **"r"** (radio synchronous **without** control of the internal quartz base) and **"R"** (radio synchronous **with** control of the internal quartz base)
- depends on the synchronisation status of the selected primary source and the set delay time (sync. time OFF) for a change of status

2.1.2 Differentiation between Primary and Secondary Source

The primary source is the source with which the clock system synchronises by preference and which controls the system's internal quartz base provided that this has the status "**Sync**".

In the event that the signal to the primary source fails and the secondary source has the status "**Sync**" at this time, synchronisation and control of the internal quartz base switches to the secondary source.

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2.1.3 System Behaviour on Automatic Source Changeover

Primary Source Status	Secondary Source Status	System Condition
synchronous	synchronous	System is synchronised by the **primary source**.
synchronous	not synchronous	System is synchronised by the **primary source**.
not synchronous	synchronous	System is synchronised by the **secondary source**.
not synchronous	not synchronous	System is not synchronised and runs in **internal quartz base** mode The sync. source leaps to the primary source

2.1.4 Example of System Behaviour on Changing Status of the Sync. Sources

No.	Actions on the system	Status			System		Comments
		Prim. source	Sec. source	System Status	Selected sync. source	Time base of system time	
1	Switch on	**-**	**-**	**-**	Primary source	Internal quartz base	System was without power for 3 days; System operates with system quartz time; All time and date information begin with zeros in all positions
2	Manual setting of a valid time / date	**-**	**-**	**C**	Primary source	Internal quartz base	System operates with valid time The set time is continued with the internal quartz base
3	Primary source connection with valid time information (synchronous)	**R**	**-**	**C**	Primary source	Internal quartz base	Primary source is synchronised (duration: approx. 3-5 min.)
4		**R**	**-**	**r**	Primary source	Primary source	System starts with synchronisation to the primary source (duration: approx. 2-3 min.) **Time leap possible on synchronisation**
5		**R**	**-**	**R**	Primary source	Primary source	After one minute system status goes to synchronisation with control of the internal quartz base
6	Secondary source connection with valid time information (primary source continues synchronous)	**R**	**R**	**R**	Primary source	Primary source	Secondary source is synchronised (duration: approx. 3-5 min.)
7	Primary source failure (secondary source continues synchronous)	**-**	**R**	**R**	Primary source	Internal quartz base	Primary source failure detection; System status is maintained in "sync." by means of "sync. status change after sync fail" timer. System operates with internal quartz base

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8		–	**R**	**r**	Primary source	Internal quartz base	"Sync. status change after sync. fail" timer expired Loss of synchronisation via small "r" system status System operates with internal quartz base
9		–	**R**	**C**	Secondary source	Internal quartz base	Change to secondary source System operates with internal quartz base
10		–	**R**	**r**	Secondary source	Secondary source	System synchronises to secondary source **Time leap possible - in the event of a difference in the sync. source times.**
11		–	**R**	**R**	Secondary source	Secondary source	After one minute system status goes to synchronisation with control of the internal quartz base
12	Secondary source failure	–	–	**R**	Secondary source	Internal quartz base	Detection of a fault in reception from the secondary source System status is maintained as radio synchronous by means of "sync. status change after sync. fail" timer.
13		–	–	**r**	Secondary source	Internal quartz base	"Sync. status change after sync. fail" timer expired Loss of synchronisation via small "r" system status System operates with internal quartz base
14		–	–	**C**	Primary source	Internal quartz base	No synchronisation, change to primary source System operates with internal quartz base
15	Secondary source refreshed with valid information	–	**R**	**C**	Secondary source	Internal quartz base	Secondary source is synchronised (duration: approx. 3-5 min.) System operates with internal quartz base
16		–	**R**	**r**	Secondary source	Secondary source	System synchronises to secondary source **Time leap possible (only on long operation with the internal quartz base)**
17		–	**R**	**R**	Secondary source	Secondary source	After one minute system status goes to synchronisation with control of the internal quartz base
18	Primary source refreshed with valid time information (secondary source continues synchronous)	**R**	**R**	**C**	Primary source	Internal quartz base	Primary source is synchronised (duration: approx. 3-5 min.) System status leaps to Quartz "C" System operates with internal quartz base
19		**R**	**R**	**r**	Primary source	Primary source	System synchronises to primary source; **Time leap possible - in the event of a difference in the sync. source times.**
20		**R**	**R**	**R**	Primary source	Primary source	After one minute system status goes to synchronisation with control of the internal quartz base

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2.2 Display of the Synchronisation Status in the 7001RC System Display

The following information about the system status can be taken from the system display:

- Display of the selected primary and secondary sources
- Synchronisation status of the primary and secondary sources
- Synchronisation status of the 7001RC system
- Error messages

The possible displays for the sync. sources and their synchronisation status are made up of 6 characters:

`>GPS_R` `>GPS_-` ⇨ **Channel 1, GPS**

`>DCF_R` `>DCF_-` ⇨ **Channel; 2, DCF77 pulse**

`>SER_R` `>SER_-` ⇨ **Channel 3, Master/Slave-String**

The position of these characters in the display is highlighted in white in the following picture:

The display switches every 5 seconds between the displays of the two sync. sources.

The meaning of the individual characters is as follows:

Character No.	Description	Character	Meaning
Character 1	Sync. source (channel)	**">"**	System-synchronising source
		" "	Second sync. source
Characters 2-4	Sources (channel)	**"GPS"**	GPS source (channel 1)
		"DCF"	DCF77 pulse source (channel 2)
		"SER"	Serial string source (channel 3)
Character 5	Variable	**"_"**	Variable, no further function
Character 6	Source status	**"-"**	The source (channel) is not connected at present or cannot be evaluated and is not available for synchronisation
		"R"	Source successfully evaluated and can be used to synchronise the system

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2.3 Configuration of the Multi-Source System

The system must be configured correctly in order to ensure the uniformity of the different time information from the sync. sources and to make the special multi-source settings.

2.3.1 Automatic / Manual Source Changeover

The source changeover takes place automatically as standard (factory setting). If not required, this automatic changeover can be prevented, using Bit 3 of the 'Control Bytes' function. This may be necessary if, for example, it is known to the user that the time information supplied by the secondary source is erroneous and cannot therefore be used.

Function Control Byte Bit 3	System Behaviour
0	**Automatic changeover** between primary and secondary source
1	**Manual changeover** between primary and secondary source by inputting the synchronisation setting byte

The clock system status is always set to "**C**" (quartz) after every source changeover - **automatic or manual** – so that it then synchronises to the new source.

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2.3.1.1 Status Table for Automatic Source Changeover

The following table shows the sync. source that is automatically selected for changeover, together with its respective status.

Changeover takes place dependent on:

- The primary and secondary sources selected
- The reception status of the respective sync. source
- The timer for loss of synchronisation of the system status

Primary Source Status	Secondary Source Status	System status	"Sync. Status change after sync. fail" Timer	System switches or remains on
-	**-**	C / -	--	Primary source
-	**-**	R / r	**running**	Remains on **last sync. source with system quartz time** until **timer** expires
R	**-**	- / C / r / R	--	Synchronised with **primary source**
R	R	- / C / r / R	--	**always synchronised with primary source**
-	R	R / r	**running**	Remains on primary source until **timer** expires
-	**R**	- / C / r / R	**--**	Synchronised with **secondary source**

Source Status	
-	The source (channel) is not currently connected or cannot be evaluated and is not available for synchronisation.
R	Source is successfully evaluated and can be used to synchronise the system.

System Status	
-	System does not have a valid time
C	• System has a valid time. • System runs with quartz time.
r	• System synchronised at this moment or • System loses synchronisation at this moment
R	• System is synchronised and the internal quartz base is controlled. or • "Sync. Status change after sync. fail" timer is active after synchronisation.

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2.3.2 Adjustable Multi-Source Modes

The sync. sources are connected to the synchronisation channels of the 7020RC control board. The selection and connection of the various synchronisation channels is described below. Only the described combinations of synchronisation channels are available.

A re-configuration of these modes automatically triggers a RESET after configuration in the system.

2.3.2.1 Multi-Source with GPS (Channel 1) and Master/Slave-String (Channel 3)

The combination of GPS and Master/Slave-String can be selected via the following two bit combinations in the **"Synchronisation Settings Byte"**. The primary and secondary sources can also be assigned. After the initial setting of one of the two bit combinations a System Reset is carried out automatically. When there is a changeover within this multi-source mode no System Reset is carried out and the system then continues with quartz system status.

B3	B2	B1	B0	Abbreviation in Time Display	Synchronisation Source
1	**0**	**0**	**1**	alternately **>GPS_** and **SER_**	**Primary source**: GPS **Secondary source**: Master/Slave-String
1	**0**	**1**	**0**	alternately **>SER_** and **GPS_**	**Primary source**: Master/Slave-String **Secondary source**: GPS

2.3.2.2 Multi-Source with DCF77 Pulse (Channel 2) and Master/Slave-String (Channel 3)

The combination of DCF77 pulse and Master/Slave-String can be selected via the following two bit combinations in the **"Synchronisation Settings Byte"**. The primary and secondary sources can also be assigned. After the initial setting of one of the two bit combinations a System Reset is carried out automatically. When there is a changeover within this multi-source mode no System Reset is carried out and the system then continues with quartz system status.

B3	B2	B1	B0	Abbreviation in Time Display	Synchronisation Source
1	**0**	**1**	**1**	alternately **>DCF_** and **SER_**	**Primary source**: DCF77 pulse **Secondary source**: Master/Slave-String
1	**1**	**0**	**0**	alternately **>SER_** and **DCF_**	**Primary source**: Master/Slave-String **Secondary source**: DCF77 pulse

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2.3.3 Delayed Changeover between Primary and Secondary Source

The automatic changeover from the selected primary source to the secondary source depends on two factors:

- Validity or availability of the synchronisation signal
- Expiry of the "Sync. Status Change after Sync. Fail" timer

The timer bridges failures of the primary sync. source and maintains the status of the clock system on radio status "**R**" for the time set by the user (possible settings: 2 - 255 minutes). The setting to be made depends on the difference in accuracy between the primary and secondary sources.

If the primary source is significantly more accurate than the secondary source then the internal quartz base of the system is also controlled correspondingly more accurately.

In the event that the primary source fails for a few minutes, the system then continues to run demonstrably more accurately using this control value than if it were to be re-synchronised via the secondary source. For this reason it is sensible to prevent a premature changeover by means of the timer, in order to maintain system accuracy.

2.3.4 System Behaviour on Summertime/Wintertime Changeover

Bits 5 and 6 are used to define the changeover times for summertime / 'wintertime via the **"Synchronisation Settings Byte"**.

Bit 6	Bit 5	System Behaviour
0	0	ST/WT changeover is only carried out by the external source. The system 7001RC internal changeover times are ignored. (GPS always requires the internal ST/WT changeover)
1	0	ST/WT changeover is carried out, dependent on the status of the external source system, either via the external source **or** via the internal changeover times: • Changeover times are carried out by the external source provided that this is delivering valid time information (GPS always requires internal ST/WT changeover) • Changeover times are carried out by the system 7001RC internal changeover times if the external source is not available.
x	1	ST/WT changeover is only carried out via the system 7001RC internal changeover times. Changeover times transmitted via the sync. sources are ignored.

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2.3.5 Configuration of the Master/Slave-String Time Base

Different time bases can be set for the Master/Slave-String.

2.3.5.1 Local Time as the Time Base in the Master/Slave-String (Standard)

As standard the 7001RC system is synchronised with the local time information via the Master/Slave-String. For this purpose **Bit 2** is set to **"0"** in the **"Function Control Byte"**.

The system UTC time is calculated via the local time, the system-internal values for the time difference between UTC and local time and the summertime/wintertime status information.

Synchronisation via the Master/Slave-String

"Function Control Byte", Bit 2 set to "0":

- The received time is local time
- The system UTC time is calculated

In the event that UTC time is received when in this setting, this is interpreted as local time and accordingly all times in the system are incorrectly displayed.

2.3.5.2 UTC as the Time Base in the Master/Slave-String

When UTC time is transmitted via the Master/Slave-String then this is to be set up in the **"Function Control Byte"**, by setting **Bit 2** to **"1"**.

The system UTC time is calculated via the UTC time, the system-internal values for the time difference between UTC and local time and the summertime/wintertime status information.

Synchronisation via the Master/Slave-String

"Function Control Byte", Bit 2 set to "0":

- The received time is UTC time
- The system local time is calculated

In the event that local time is received when in this setting, this is interpreted as UTC time and accordingly all times in the system are incorrectly displayed.

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2.4 Synchronisation Signal Requirements

The following signals can currently be used to synchronise a multi-source system:

- **GPS signal** – to receive with a ***hopf*** GPS antenna device
- **DCF77** pulse with:
  - DCF77 L pulse length: 100ms
  - DCF77 H pulse length: 200ms
  - DCF77 pulse can be low or high active
  - TTL level
- **Serial *hopf* Master/Slave-String** – with the following transmission levels:
  - TTL
  - RS422

Feeding other signal levels and time transfer formats

In order to make the connection of various signal sources available to the user, additional components are available for **signal conversion**:

- To convert **signal levels** such as e.g. RS232, TTY or LWL to the level required by the internal system
- To transform **time transfer formats** such as e.g. IRIG-B to the formats required by the internal system

When planning a multi-source system any necessary signal adaptation should be borne in mind at the outset.
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2.5 Sync. Source Requirements

The sync. sources must have the following characteristics:

- Transmission of local time (synchronisation channels 2 and 3) or UTC time (synchronisation channels 1 and 3)
- Preservation of the synchronisation channel format
- Continuous, strictly increasing time information
- Plausibility of time information (e.g. no 31 February)

If the received time is recognised as plausible then this is accepted by the system without any further verification.
This means that any information incorrectly transmitted by the source is accepted as being correct. For this reason the user should verify the correctness of the time information transmitted by the source.

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2.6 Special Features in the System Behaviour

The following points should be observed when operating the multi-source system:

2.6.1 System Behaviour on Sync. Source Changeover

When switching between primary and secondary sources the system status is **always** switched to quartz "**C**".

There then follows a re-synchronisation with the new sync. source. The system status changes from "**C**" -> "**r**" -> "**R**" with a continuous increase in accuracy.

On a channel change within a multi-source:

- no reset is triggered in the system
- the system runs with system reception status "quartz"
- the new active sync. source synchronises the clock system and controls the internal quartz base

Multi-source modes with channels 1 / 3

- Channel 1 ⇨ Channel 3 **or** Channel 3 ⇨ Channel 1

Multi-source modes with channels 2 / 3

- Channel 2 ⇨ Channel 3 **or** Channel 3 ⇨ Channel 2

The following effects may arise on a source changeover in the event of a **time offset** between the two sources (depending on the offset of the two sources):

- **System time leap** and/or
- **System pulse leap**

(the internally controlled second mark "PPS" can leap by up to 500msec in this case)

2.6.2 Behaviour on ST/WT Changeover

At the time of a change from winter time to summer time or vice-versa, an announcement bit is normally set one hour before the ST/WT changeover. This bit is reset when the changeover has taken place.

After a ST/WT changeover has taken place no further changeover can be carried out for 61 minutes. This blocking period is maintained even after a system reset or after switching off and on again.

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Specific conditions:

- The announcement bit remains set if the system is switched off and back on again within the announcement hour. The ST/WT changeover is carried out after the announcement hour has expired.
- If the system is only switched back on again after the end of the announcement hour the system operates with the correct new time base.
- If a sync. source that was set by the announcement bit fails the announcement bit continues to be set and the ST/WT changeover is executed.
- If a changeover from one source to another takes place during the announcement hour the announcement bit continues to be set and is executed even if the second sync. source does **not** transmit an announcement bit.

If a changeover from one source to another takes place during the announcement hour the announcement bit continues to be set even if the second sync. source transmits completely different time information from the first sync. source. The ST/WT changeover then takes place at an incorrect time.

2.7 Connection of the Synchronisation Channels

The sync. sources are fed to various signal inputs in the system.

When designing the system the required and according hardware components for the input of the requested signals are to be considered.

2.7.1 GPS - Channel 1

A BNC socket is available on the front panel of the 7020RC board for connecting a GPS signal. This can be received by a ***hopf*** GPS antenna device.

2.7.2 DCF77 Pulse - Channel 2

The hardware for this signal input is only available on the internal VG strip of the 7020RC control board.

This signal input is internal to the system and must be made accessible to the customer externally. The way to achieve this depends on the respective signal level and the configuration of the system in which the DCF77 pulse is available.

This point should be considered when planning the system.

7020RC Board VG Strip Assignment		
Vcc (5V DC)	**Power Supply**	a32, b32 ,c32
Gnd		a31, b31, c31
DCF77 pulse Input (TTL)	**Synchronisation Channel 2**	a22

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2.7.3 Master/Slave-String - Channel 3

The hardware for this signal input is only available on the internal VG strip of the 7020RC control board.

This signal input is internal to the system and must be made accessible to the customer externally. The way to achieve this depends on the respective signal level and the configuration of the system in which the Master/Slave-String is available.

This point should be considered when planning the system.

7020RC Board VG Strip Assignment		
Vcc (5V DC)	**Power Supply**	a32, b32 ,c32
Gnd		a31, b31, c31
Rxd (TTL)	**Synchronisation Channel 3**	a15
Option Txd (TTL)		a14

2.8 Synchronisation Process

2.8.1 Synchronisation via GPS (Channel 1)

With satellite reception (1 satellite in Fixed Position mode or at least 4 satellites in 3D mode; see technical specification of the 7001RC system), the received date and **UTC** time information is transferred to the system. The local time is calculated from the information internal to the 7001RC system in respect of time difference and ST/WT changeover. The local time and the UTC time are displayed and are available to the implemented boards on the 7001RC bus. On continuous satellite reception the sync. source status changes from "**-**" to "**R**". As soon as the sync. source status has reached "**R**" synchronisation of the system begins. The system status synchronises from quartz operation "**C**" via radio synchronous "**r**" to radio synchronous with quartz control "**R**".

Synchronisation via GPS:

- The received time is UTC time
- The system local time is a calculated time

In the event of satellite failure the system status changes from "**R**" ⇨ "**r**" ⇨ "**C**", after expiry of the delay time set in the 7001RC system for the reset of the radio bit.

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2.8.2 Synchronisation via DCF77 Pulse (Channel 2)

The **local time**, including summertime/wintertime information and announcement bits for summertime/wintertime changeover, are transferred to the 7001RC system via the DCF77 pulse. The 7001RC system calculates the correct UTC time from the local time based on this and on the internally set time difference.

Synchronisation via DCF77 pulse:

- The received time is local time
- The system UTC time is a calculated time

The DCF77 pulse transmitted by the sync. source must be correctly read by the multi-source system at least three times and recognised as plausible before the sync. source status changes from "**-**" to "**R**". As soon as the sync. source status reaches "**R**" synchronisation of the system begins. The system status synchronises from quartz operation "**C**" via radio synchronous "**r**" to radio synchronous with quartz control "**R**".

In the event of DCF77 pulse failure the system status changes from "**R**" ⇨ "**r**" ⇨ "**C**", after expiry of the delay time set in the 7001RC system for the reset of the radio bit.

2.8.3 Synchronisation via Master/Slave-String (Channel 3)

The Master/Slave-String transmitted by the sync. source must be correctly read by the multi-source system at least twice and recognised as plausible before the sync. source status changes from "**-**" to "**R**". As soon as the sync. source status reaches "**R**" synchronisation of the system begins. The system status synchronises from quartz operation "**C**" via radio synchronous "**r**" to radio synchronous with quartz control "**R**".

In the event of Master/Slave-String failure the system status changes from "**R**" ⇨ "**r**" ⇨ "**C**", after expiry of the delay time set in the 7001RC system for the reset of the radio bit.

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2.9 Error Messages

The 7001RC system monitors itself and the installed system bus function boards for any errors. The synchronisation status of the sync. sources and the system bus itself are also monitored. In the event that any sync. source is lost the corresponding error bits are set in the error byte. In this way it is possible to differentiate between errors in the individual synchronisation channels:

ERROR-1 GPS ERROR

0 / 1 Bit 1 changes from **"0"** to **"1"** when the system in **GPS mode (Synchronisation Channel 1)** is set as sync. source for the system but has no GPS reception.

ERROR-2 DCF77 pulse - ERROR

0 / 1 Bit 2 changes from **"0"** to **"1"** when the system in **DCF77 pulse mode (Synchronisation Channel 2)** is set as sync. source for the system but is not receiving DCF77 pulses or they are faulty.

ERROR-4 Master/Slave-String - ERROR (failure)

0 / 1 Bit 4 changes from **"0"** to **"1"** when the system in **Master/Slave-String mode (Synchronisation Channel 3)** is set as sync. source for the system but the Master/Slave-String was read incorrectly or is not available.

ERROR-5 Master/Slave-String - ERROR (quartz only)

0 / 1 Bit 5 changes from **"0"** to **"1"** when the system in **Master/Slave-String mode (Synchronisation Channel 3)** is set as sync. source for the system but the serial Master/Slave-String reports "Quartz operation".

ERROR-9 System Synchronisations Status - ERROR

0 / 1 Bit 9 changes from logic **"0"** to logic **"1"** when the **System Synchronisation Status** is not radio synchronous.

The options available for evaluating error bits are described in detail in the 7001RC system specification.

The non active sync. mode is not error controlled.

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3 Appendix

3.1 Data String Master/Slave

This Master/Slave-String can be used to synchronise slave systems with the time data of the master system up to a high accuracy.

3.1.1 Local Time as Time Base in Master/Slave-String (Standard)

By default the system 7001RC will be synchronised by the Master/Slave-String with the local time information. Settings see ***Chapter 2.3.5 Configuration of the Master/Slave-String Time Base***.

By the local time and the system internal values for difference time UTC - local time such as the status information for summer- and winter time the system UTC time will be calculated.

3.1.2 UTC as Time Base in Master/Slave-String

If the UTC time should be sent by the Master/Slave-String refer to ***Chapter 2.3.5 Configuration of the Master/Slave-String Time Base***.

By the UTC time and the system internal values for difference time UTC - local time such as the status information for summer- and winter time the system local time will be calculated.

3.1.3 Structure of the Master/Slave-String

The Master/Slave-Strings transmits

- the complete time information (hour, minute, second),
- the date (day, month, year [2 digits]),
- the difference time local time to UTC (hour, minute),
- the day of the week
- and status information (announcement of a ST/WT change over, announcement of a leap second and the reception status of the Master/Slave-String source).

The difference time is transmitted in hours and minutes following the year. The transmission is done in BCD. The difference time may be up to ± 11.59 h.

The sign is shown as the highest bit in the tens hours.

logic **1** = local time before UTC
logic **0** = local time after UTC

Example:

data string	tens difference time nibble	difference time
(STX)831234560301960300(LF)(CR)(ETX)	**0000**	- 03:00h
(STX)831234560301961100(LF)(CR)(ETX)	**0001**	- 11:00h
(STX)831234560301968230(LF)(CR)(ETX)	**1000**	+ 02:30h
(STX)831234560301969100(LF)(CR)(ETX)	**1001**	+ 11:00h

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character no.	meaning	hex value
1	STX (start of text)	$02
2	status	$30-39, $41-46
3	day of the week	$31-37
4	tens hour	$30-32
5	unit hour	$30-39
6	tens minute	$30-35
7	unit minute	$30-39
8	tens second	$30-36
9	unit second	$30-39
10	tens day	$30-33
11	unit day	$30-39
12	tens month	$30-31
13	unit month	$30-39
14	tens year	$30-39
15	unit year	$30-39
16	difference time tens hour / sign	$30-31, $38-39
17	difference time unit hour	$30-39
18	difference time tens minutes	$30-35
19	difference time unit minutes	$30-39
20	LF (line feed)	$0A
21	CR (carriage Return)	$0D
22	ETX (end of text)	$03

3.1.4 Status in the Master/Slave-String

Nibble	b3	b2	b1	b0	meaning
status	x	x	x	**0**	no announcement hour
	x	x	x	**1**	announcement (ST-WT-ST)
	x	x	**0**	x	standard time (WT)
	x	x	**1**	x	daylight saving time(ST)
	x	**0**	x	x	no announcement leap second
	x	**1**	x	x	announcement leap second
	0	x	x	x	crystal 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

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3.1.5 Example of a Transmitted Master/Slave-String

(STX)831234560301968230(LF)(CR)(ETX)

- Radio operation
- no announcement
- standard time
- It is Wednesday 03 Jan. 1996 - 12:34:56 h
- The difference to UTC is +2.30 hours

3.1.6 Settings

The following settings are required for the synchronisation of the ***hopf*** slave-systems:

- output every minute
- output second advance
- ETX on the second change; selectable: data string at the beginning or at the end of the 59. second.
- local time
- 9600 baud, 8 bit, 1 stop bit, no parity

This setting guarantees the best control of the time basis in the multi-source systems.

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3.2 DCF77 Signal

The DCF77 radio controlled clocks receive the time signal from a long wave transmitter in Frankfurt/Main (Germany).

The DCF77 Signal transmits the central European time (CET) or the central European summer time (CEST). This time will be calculated by the UTC time plus one hour (CET) resp. two hours (CEST).

The DCF77 signal contains the complete time information (minute, hour, day of the week and date). Sending by default:

- in local time
- with the actual time zone (St or WT)
- with announcement bit for ST/WT change over
- with announcement bit for leap second

The difference time, local time to UTC must be known by the receiver. In CET area the difference time is +1 hour east direction. The system 7001RC calculates the exact UTC time of the local time from the set difference time.

3.2.1 Structure of the Data String DCF77 Signal

Every second of a minute a particular time information is transmitted, except for the 59th second. The missing signal in this second indicates an imminent minute change in the next second.

At the beginning of every second a pulse is put out for 100 or 200ms. The initial edge of the pulse marks the exact beginning of the second.

The duration of the second markers of 100 and 200 ms (binary 0 and 1) are transformed into a BCD-Code to decode the transmitted data string.

The time data string is divided into 3 different groups, each followed by a parity check:

- P1 = number of minutes
- P2 = number of hours
- P3 = current day of the year , the day of the week and the year

The binary ones of a group are determined and increased to an even number by the parity bit.

When a valid time information (CEST) is transmitted the 17th second marker takes 200ms. One hour before the changeovers from CEST to CET or vice versa the 16th second marker takes 200ms.

The coding is shown below:

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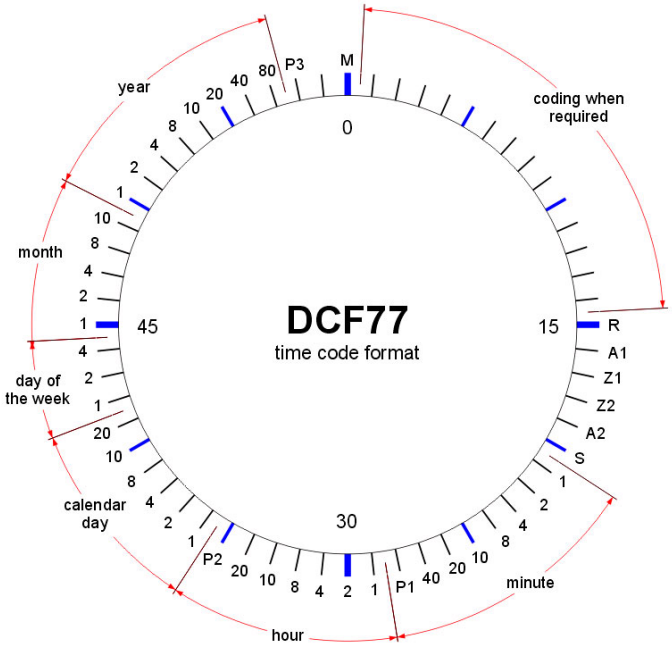

M	minute marker (0.1 s)
R	in the simulation this bit is permanently set to logic "0". In the transmitted data string via the DCF77 transmitter this bit becomes logic "1" when a spare antenna is used for the radiation.
A1	announcement of an imminent changeover from CET to CEST or vice versa.
Z1, Z2	time zone bits
A2	announcement of a leap second
S	initial bit of the coded time information
P1, P2, P3	check bits

DCF77 : D = German, C = Long wave signal, F = Frankfurt, 77 = frequency

3.2.2 DCF77 Pulse (1Hz)

The DCF77 pulse uses the same coding as the signal which is transmitted from the long wave DCF77 transmitter in Frankfurt/Main. The difference is that no amplitude modulated carrier signal is used for the transmission. The 100 and 200ms long lowering are showed with logic signals.

3.2.3 Fault Mode

The DCF77 telegram is not output if the base system has no plausible time or is not radio synchronous.

The output levels of the individual interfaces then remain in the idle position. This, however, could also simulate a line break to the connected device.

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