Reference Generator

Part No: 10292

Functions

- **GPS Receiver**
- **Reference Signal Distributor**
- **NTP Server / Client**
- **Synchronisation to Optical Link input ***
- **Internal Oscillator**
  - High Performance OCXO or
  - Disciplined Rubidium
- **Optical Link to remote slave unit with transmission delay compensation ***

Synchronizes to one of

- **5 MHz**
- **10 MHz**
- **1 PPS**
- **NTP Client****
- **Serial Time Code****
- **Optical link from master REFGEN***
- **GPS**

*) Option

**) Time reference only

Generated outputs

- **5 MHz**
- **10 MHz**
- **100 MHz***
- **1 PPS**
- **NTP Server**
- **Serial Time Code**
- **Optical link to slave REFGEN***
- **IRIG**

The photo shows a REFGEN with option 6 (additional IRIG distributor) equipped in slot #4. The connectors (number and type) on slot #0 on the photo (3 x SMA) are different from the product definition (2 x BNC).

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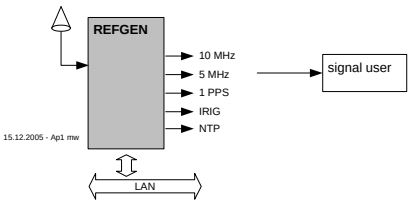
Reference Generator front panel label: Ref Generator
Reference Generator acronym in text: REFGEN

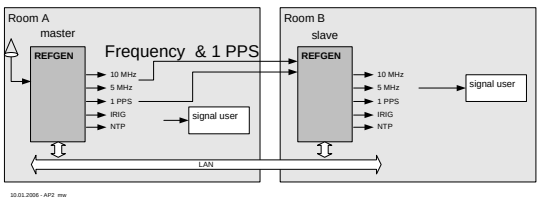
Reference Generator Applications

I Standard GPS based Time & Frequency Generation



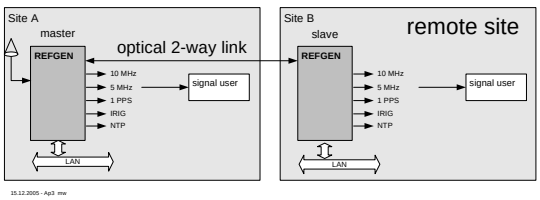
- Generation of time code signals and standard frequency signals from the GPS reference.
- The highly stable internal oscillator allows for extensive averaging of the GPS raw data for generating stable and low jitter output signals.
- In case of loss of the GPS input the internal oscillator provides a stable holdover mode.
- LAN interface for M&C purposes and for NTP server output.

II Intra-Building Distribution



- Time and frequency is transferred to a slave unit in another room.
- References of frequency (5 or 10 MHz) and of 1 PPS transmitted by coax cables to the slave unit.
- Time tag is transferred to the remote site over the LAN via NTP.
- Time offset between master and slave due to transmission delay.

III Optical Link to remote site



Option 4 (optical 2-way interface) required.

- Time and frequency is transferred to a remote site over a distance of up to 2 km.
- The transmission delay is dynamically compensated by the 2-way method. Standard optical cable can be used.
- The optical link signal supports all: frequency, ambiguity resolution, time tag and maintenance signals.
- Single 2-fiber optical cable interconnection. No LAN connection between the sites is required, not even for M&C of the remote site.

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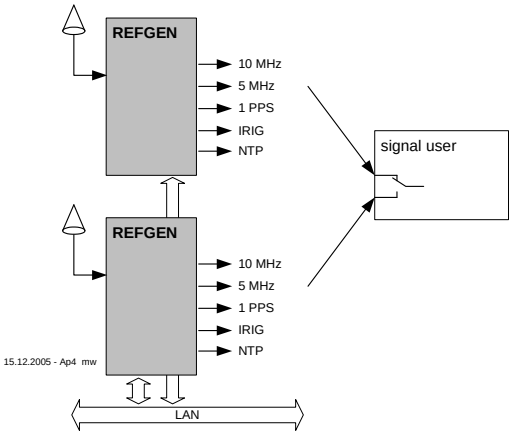
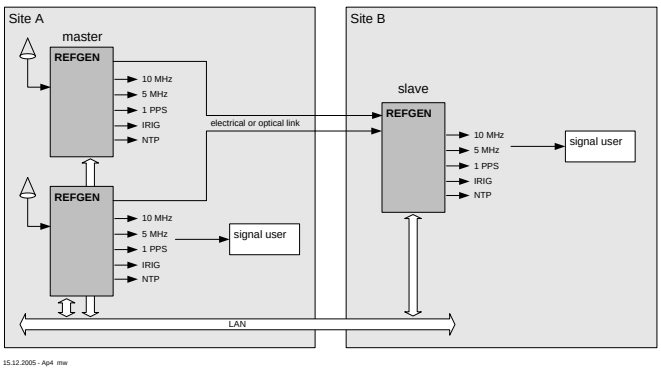
IV Redundant GPS based Time & Frequency Generation



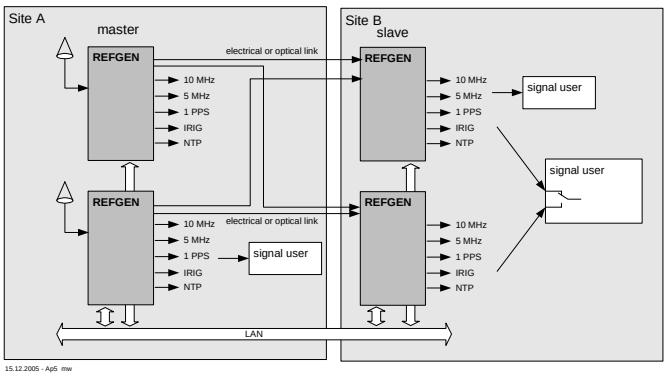
- Basic redundant REFGEN implementation.
- Requires signal users that have an input selector for gaining advantage from the redundancy.
- The REFGEN M&C interface can provide the operational state of the REFGEN to a station controller. Such controller may control the selector function of the signal users for improving the redundancy performance.

V Redundant GPS based Time & Frequency Generation with Selector



- A slave REFGEN implements a selector function. Thus it provides single protected outputs for signal users that have no input selector.
- The system may be implemented on a single site.

VI Fully Redundant GPS based Time & Frequency Generation



- Cross strapping between the both master REFGENs and the both slave REFGENs improves the reliability of the output signals at site B.
- The system reliability can be improved by splitting the site A into two rooms (e.g. to protect against common failure by fire).

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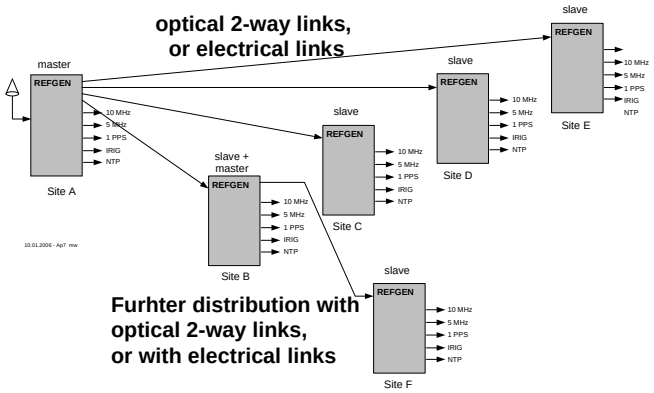
VII Distribution to a large number of sites



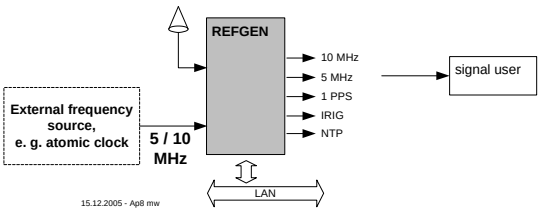
The optical link interface provides 4 optical interfaces for connecting up to 4 remote slave REFGENs to a single master REFGEN. Alternatively and additionally electrical links can be used for slaving remote sites.

Each slave REFGEN can act as a master for further distribution to further slave REFGENs.

This allows for creating virtually an infinite network of REFGENs being located at individual sites.

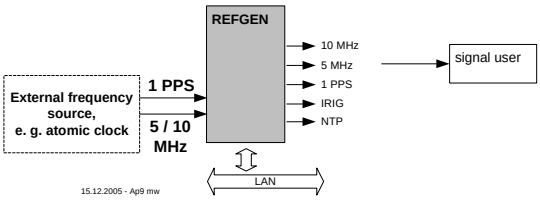
The option 4 (optical 2-way interface) provides the optical links if required.

VIII Frequency input from external atomic clock & GPS time reference



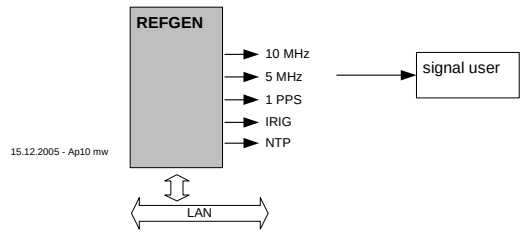
- An external frequency input is used for locking the internal oscillator and for generating the internal 1 PPS signal.
- The 1 PPS signal and the time tag of the GPS input are used as time reference on start-up.
- If the GPS reference is not stable enough to serve as frequency reference.
- If the Rubidium option of the REFGEN doesn't have sufficient long term stability.
- If coherence to the external frequency source is required rather than coherence to GPS.

IX Frequency input from external atomic clock & NTP time reference



- An external frequency input is used for locking the internal oscillator and for generating the internal 1 PPS signal.
- The time tag of the NTP input is used as time reference on start-up.
- The external source needs to supply a frequency reference and a 1 PPS signal to the REFGEN for start-up 1PPS alignment.
- If the Rubidium option of the REFGEN doesn't have sufficient long term stability.
- If no GPS reference is available.

X Holdover mode operation



- The internal oscillator is the active frequency source and the reference for generation of the internal 1 PPS signal.
- The system time is continued from the previous synchronized state.
- The system time can manually be set for test purposes.

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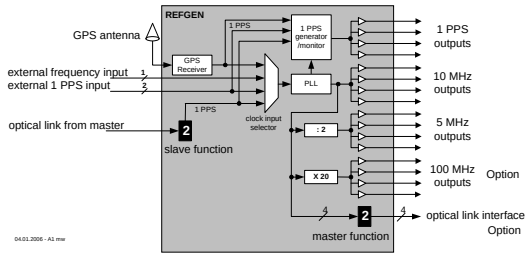
Reference Generator Functions

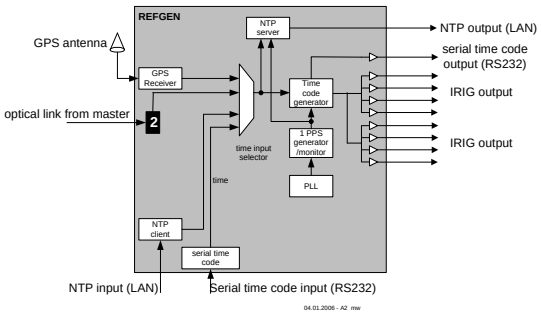
Frequency synchronisation functions



The REFGEN can be configured to lock to one of the following input reference signals for frequency generation:

- GPS 1 PPS
- External frequency input 5 or 10 MHz
- External 1 PPS input
- Optical link from master REFGEN.

Time synchronisation functions



The REFGEN can be configured to synchronise its internal time to one of these sources at start-up

- GPS time reference
- NTP time reference
- Serial time code input
- Optical link from master REFGEN.
- Manual time setting if no other input is available.

Normally the REFGEN is synchronised to the time reference on start-up of the unit. Afterwards the internal system time is continued by dividing the output frequency of the internal oscillator. The system time is monitored against the defined time reference and an alarm is issued if the time offset exceeds the configured threshold.

Reference Generator Modular Architecture and Options

Modular unit design

The References Generator is a two height unit rack mountable unit consisting of up to 10 modules in 10 slots. A further slot (the slot #0) provides two connectors for 1 PPS input signals. The distributor modules can be hot plugged without impacting the operation of the unit. Dedicated slots are holding the essential modules such as the AC/DC Converter, the DC Supply Module, the PC Module, the Oscillator Module and the IRIG generator module. All modules are mounted from the rear side. All signal inputs and outputs are at the rear side.

REFGEN Frame

The front side of the frame has a one inch high date and time display showing the day of the year (1 … 366) and the time (hours, minutes, seconds). Furthermore it has a LCD display and 8 push buttons for local control of the unit. LEDs on the front side show the over all alarm state (ERROR) of the unit, the DC power supply integrity and the remote control disabling (LOCAL).

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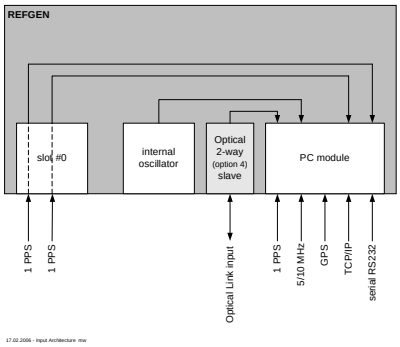
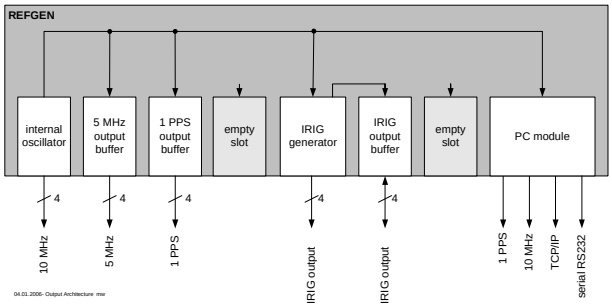
Internal oscillator

The standard product is equipped with a high stability low phase noise crystal oscillator for internal frequency generation. For applications requesting even better phase noise performance or better frequency stability performance the following options are provided:

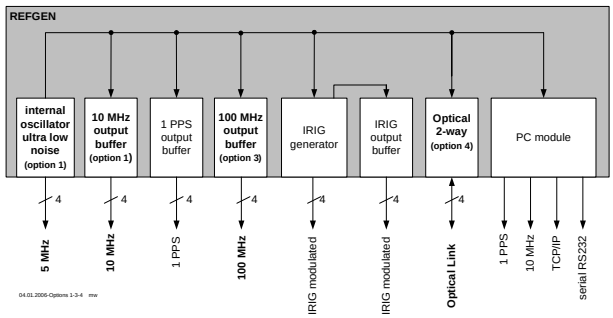
- Option 1: Ultra Low Phase Noise Oscillator (BVA-OCXO)
- Option 2: Rubidium oscillator
- Option 5: High Performance Oscillator with active temperature compensation.



Modules supporting input signals



Modules supporting output signals (standard configuration)



Modules supporting output signals (with options 1, 3 and 4 equipped)

Frequency outputs

All output signals of the unit are generated from the internal oscillator output. The oscillator module itself has 4 outputs of 10 MHz. Dedicated distributor modules are used for providing further outputs, i. e. 4 outputs each of 5 MHz and 100 MHz (Option 3).

With the Option 1 the internal oscillator operates at 5 MHz and thus it distributes 5 MHz (instead of 10 MHz) and the 10 MHz output is provided by a frequency distributor module.

1 PPS outputs

1PPS output signals are derived from the internal oscillator frequency and are distributed by a dedicated 1 PPS distributor with 4 outputs. A further 1 PPS output signal is available on the PC module as a test output.

Time code outputs

IRIG signal output is supported, see the chapter on IRIG Features below

Serial ASCII-style time code output is supported using the serial interface.

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Oscillator control by GPS or other inputs
The oscillator can be synchronized to the 1 PPS output of the GPS receiver or to the other reference inputs of 1 PPS or 5 MHz or 10 MHz. The frequency of the external input signal is automatically detected and accommodated. The oscillator control loop can be disabled. Then the oscillator is operating in the holdover mode freezing the frequency of the input it had been synchronized to before. 'Manual' tuning of the oscillators is possible via a 24 bit DAC.

Time interval counting function
The PC module of the unit has four time interval counters (TICs). In the normal synchronized mode one of these TICs is used for the control loop while the other three TICs can be used for comparing selected input signals versus the internal oscillator output for measurement purposes.

NTP interface via TCP/IP
The unit integrates a network interface with TCP/UDP services. It can act as NTP client or as NTP server. If the unit runs on GPS, the NTP server acts as a stratum 1 server.

Optical Two-Way Link
A module with optical interfaces can be added (option 4) for connecting up to 4 slave units at remote sites. In this case, the slave units synchronise to the master unit. A two-way measurement of the optical path eliminates any effect of travelling delay in the fibres and let the slaves sync accurately to the master unit.

Included Peripheral Equipment
- Active GPS antenna with cable (30m),
- Hirschmann Stak 20 connector for self cable mounting for connection to the Stakei 2 DC connector at the unit,
- AC supply cord
- Serial interface cable

Controlling the Reference Generator

Local Control
The References Generator front panel has a 2 lines 40 characters LCD display and 8 push buttons. This interface allows local control and monitoring of the unit. Especially the IP address of the unit is set via this interface.

Remote Control by Telnet
The Reference Generator allows for remote control via telnet using its TCP/IP port #23.

TCP Command & Data Output Interface, and Serial Interface
The References Generator supports a management and control interface (M/C) on its TCP/IP ports #2000 and #2001. The same function is also available via a serial RS232 interface. Regularly issued status reports as well as status reports on request are provided. For the data being available for such state reports see the list of monitored parameters below.

UDP Interface
The state reports can be made available also at UDP ports. This allows any external station controller for getting the REFGEN state just by listening to this port.

Configurable Parameters
The following parameters can be configured either via Local Control or via Telnet. Individual configurations are possible for any type of output, i. e. all 10 MHz outputs show the same behaviour, but the configuration for the 5 MHz outputs and the 10 MHz outputs may be different.

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Function	Configurable Parameter
GPS	- Mode of operation
IRIG	- Time code channel #1 - Time code channel #2 - Amplitude channel #1 - Amplitude channel #2
1 PPS	- Input signal trigger level individually for every interface - Output: amplitude (2 levels)
Outputs	- Enable/disable(mute) - Set time error threshold for enabling the output - Set auto-muting during holdover

Function	Configurable Parameter
Oscillator	- Select input reference signal - Enable/disable the control loop (tracking/holdover) - Regulation offset (time offset versus the input reference)
M&C	- Save interval (time interval of regular state reports) - Clear system event record
LAN	- TCP/IP configuration - Remote control enable/disable - Telnet connection enable/disable

Monitored Parameters

The Reference Generator monitors all essential states of its internal hardware as well as the states of the inputs signals, the states of the output signals, the state of the internal oscillator control loop, and the states of the time interval counters.

Function	Monitored Parameters
Hardware	- Internal DC voltages - Internal currents - Unit internal temperature
Outputs	- Signal power - Signal muted
Oscillator	- Control loop offset and status

Function	Monitored Parameters
GPS	- Number of satellites being tracked & C/No - Antenna signal - RAIM - Current position
TIC	- Time Interval Counter current values for TIC#1, TIC#2, TIC#3, and TIC#4 - Measurement history

IRIG Features

Supported IRIG codes and IRIG channels

Format	IRIG A	IRIG B	(IRIG D)	IRIG E	IRIG G	IRIG H	NASA-36
Bit Rate (ER)	1 kPPS	100 PPS	1 PPM	10 PPS	10 kPPS	1 PPS	100 PPS
Carrier Fr. (F)	10 kHz	1 kHz 1 MHz 5 MHz	100 Hz 1 kHz	100 Hz 1 kHz	100 kHz	100 Hz 1 kHz	1 kHz
Frame Rate	10 FPS (= 100 ER)	1 FPS (= 100 ER)	1 FPH (= 60 ER)	0.1 FPS (= 100 ER)	100 FPS (= 100 ER)	1 FPM (= 60 ER)	1 FPS (= 100 ER)
Ratio F / ER	10 : 1	10 : 1	6000 : 1 60000 : 1	10 : 1 100 : 1	10 : 1	100 : 1 1000 : 1	10 : 1
Binary Zero [cycles / sec]	2 / 0.2 ms	2 / 2 ms	1200 / 12 s 12000 / 12 s	2 / 20 ms 20 / 20 ms	2 / 20 us	20 / 0.2 s 200 / 0.2 s	2 / 2 ms
Binary One [cycles / sec]	5 / 0.5 ms	5 / 5 ms	3000 / 30 s 30000 / 30 s	5 / 50 ms 50 / 50 ms	5 / 50 us	50 / 0.5 s 500 / 0.5 s	6 / 6 ms
Reference [cycles / sec]	8 / 0.8 ms	8 / 8 ms	4800 / 48 s 48000 / 48 s	8 / 80 ms 80 / 80 ms	8 / 80 us	80 / 0.8 s 800 / 0.8 s	6 / 6 ms
Mark-Space R Nominal/Range	10:3 / 3:1 to 6:1	10:3 / 3:1 to 6:1	10:3 / 3:1 to 6:1	10:3 / 3:1 to 6:1	10:3 / 3:1 to 6:1	10:3 / 3:1 to 6:1	3:1

The table shows the available IRIG codes. In addition to the well known IRIG codes, a IRIG B code with a 5 MHz carrier frequency is available. IRIG codes are output as modulated codes and as DC shift outputs. The IRIG generator supports 4 independent IRIG channels transporting IRIG codes. Each channel can be configured for an individual IRIG code. The generator provides 4 channels with configurable modulation property at external output interfaces and distributes these IRIG channels internally to the IRIG distributor modules. Each IRIG distributor is configured for distribution of one of these channels providing 4 equal IRIG outputs according to the selected IRIG channel.

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Supported IRIG Configurations

	IRIG Generator				IRIG Distributor
OUT	1	2	3	4	1 - 4
IRIG channel 1	X	-	-	-	Select one channel
IRIG channel 2	-	X	-	-	
IRIG channel 3	-	-	X	-	
IRIG channel 4	-	-	-	X	

Additional to the IRIG code configuration each IRIG channel can be configured for

- Modulated format, or DC-shift RS232 format, or DC-shift TTL format
- Amplitude

REFGEN Configurations

Standard REFGEN Module Configuration

Slot 0	Slot 1	Slot 2	Slot 3	Slot 4	Slot 5	Slot 6	Slot 7	Slot 8	Slot 9	Slot 10
Input Panel 1 PPS 2 inputs	Oscillator Module 10MHz 4 outputs	Distributor Module 5 MHz 4 outputs	Distributor Module 1 PPS 4 outputs	Option slot	IRIG Generator& Distributor Module 4 outputs	Distributor Module IRIG 4 outputs	Option slot	PC module GPS receiver LAN IF inputs/outputs*	DC/DC Power Input DC 18-32 V	AC/DC Power Input AC 90-265 V

*) Inputs:
- 1 PPS (SMA connector)
- 5/10 MHz (SMA connector)
- GPS antenna signal with DC supply output for LNB (SMA connector)

Output:
- 1 PPS (SMA connector)

Option	Function	Slot*
1	Ultra Low Phase Noise Oscillator (no option slot occupied) (Oscillator module 5 MHz output at slot 1, 10 MHz output at slot 2.)	1 & 2
2	Rubidium Oscillator (no option slot occupied)	1
3	100 MHz distributor, 4 outputs (1 slot)	4
4	Optical two-way interface to another REFFGEN (4 x master function + 2 x slave function, 1 slot)	7
5	High Performance Oscillator	1
6	Additional IRIG distributor, 4 outputs (1 slot)	4 or 7

*) This column indicates the slot that needs a module to be added or changed.

The simultaneous implementation of several options is limited by the capacity of the two option slots. The oscillator options (options 1, 2 and 5) do not occupy any option slot.

Numbers of Outputs - Summary

	5 MHz	10 MHz	100 MHz	1 PPS	IRIG	Optical 2-Way
Standard	4	4	-	4	8	-
Option 1	4	4	-	4	8	-
Option 2	4	4	-	4	8	-
Option 3	4	4	4	4	8	-
Option 4	4	4	-	4	8	4
Option 5	4	4	-	4	8	-
Option 6	4	4	-	4	12	-
Options 3 + 4	4	4	4	4	8	4
Options 3 + 6	4	4	4	4	12	-
Options 4 + 6	4	4	-	4	12	4

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Specification

Internal Oscillator

Oscillator option		Standard	Option 1 Ultra Low PN	Option 2 Rubidium	Option 5 spec	Option 5 typical*
Osc. frequency		10 MHz	5 MHz	10 MHz	10 MHz	10 MHz
Short term stability	1 s	2×10^{-12}	1.3×10^{-13}	3×10^{-11}	1×10^{-12}	4×10^{-13}
	10 s	3×10^{-12}	8.0×10^{-14}	1×10^{-11}		5×10^{-13}
	100 s			3×10^{-12}		1.1×10^{-12}
Phase noise	1 Hz	- 100 dBc/Hz	- 125 dBc/Hz	- 70 dBc/Hz	- 105 dBc/Hz	
	10 Hz	- 125 dBc/Hz	- 145 dBc/Hz	- 80 dBc/Hz	- 135 dBc/Hz	
	100 Hz	- 140 dBc/Hz	- 153 dBc/Hz	- 115 dBc/Hz	- 145 dBc/Hz	
	1 kHz	- 145 dBc/Hz	- 156 dBc/Hz	- 135 dBc/Hz	- 150 dBc/Hz	
	10 kHz	- 150 dBc/Hz	- 156 dBc/Hz	- 145 dBc/Hz	- 150 dBc/Hz	
Ageing**	per day		2×10^{-11}		5×10^{-10}	
	per month		5×10^{-10}	5×10^{-11}		
	per year	3×10^{-8}	4×10^{-9}		7.5×10^{-8}	

*) In temperature controlled environment, 0.5 Kpp. Active temperature compensation is implemented.

**) The aging performance specification applies after 30 days of continuous operation.

Optical Link

Oscillator option of slave REFGEN

Residual ADEV	Standard	Ultra Low PN Option 1	Rubidium Option 2
1 s	1×10^{-12}	2×10^{-13}	3×10^{-11}
10 s	1×10^{-12}	2×10^{-13}	1×10^{-11}
100 s	5×10^{-13}	8×10^{-14}	2×10^{-12}
1 000 s	6×10^{-14}	9×10^{-15}	6×10^{-14}
10 000 s	7×10^{-15}	1×10^{-15}	2×10^{-15}

This specification applies to an optical link length of up to 200 m. All equipment and the optical fibre cable shall be in the temperature range 18 to 24°C with variation max. 1Kpp over one day, slope <0.3K/h. A higher optical link distance than 200 m may cause higher ADEV values due to temperature effects.

Signal Inputs

		Connector
Frequency Inputs		
Number of inputs	1	SMA
Impedance	50 Ω	
Input Level	+3 .. +10 dBm	
Frequency	5 or 10 MHz, sine wave	
Frequency configuration	Automatic frequency detection	
Input return loss	> 45 dB	
Pulse Inputs		1 x SMA (PC module)
Number of inputs	3	2 x BNC (slot #0)
Impedance	50 Ω or high impedance,	
Input level	1 Vpp .. 5 Vpp	
Trigger level	Configurable	
Signal type	1 PPS	
Time Code Inputs		
Serial Time Code	RS232	Sub-D 9
NTP	TCP/IP 10 Mbit/s	RJ45
GPS Input		
GPS	12 channel timing receiver Motorola M12+	SMA

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Frequency Outputs

Connector

5 MHz Signal Output

Number of outputs	4				BNC
Impedance	50 Ω				
Output Level	+12.5 ± 0.5 dBm				
Output return loss	> 35 dB				
Output / Output Isolation	> 80 (88 typ.) dB				
Harmonics (1^{st}, 2^{nd}, 3^{rd})	-73	-69	-82	dBc	

10 MHz Signal Output

Number of outputs	4				BNC
Impedance	50 Ω				
Output Level	+12.5 ± 0.5 dBm				
Output return loss	> 35 dB				
Output / Output Isolation	> 90 (100 typ.) dB				
Harmonics (1^{st}, 2^{nd}, 3^{rd})	-65	-55	-65	dBc	

100 MHz Signal Output (Option 3)

Number of outputs	4				SMA
Impedance	50 Ω				
Output level	+11.5 ± 0.5 dBm				
Output return loss	> 30 (–35 typ.) dB				
Output / Output Isolation	> 75 (83 typ.) dB				
Harmonics (1^{st}, 2^{nd}, 3^{rd})	-42	-40	-55	dBc	

Pulse Outputs

1 PPS Pulse Outputs

SMA (PC module)
BNC (output buffer)

Number of outputs	5 (4 x BNC + 1 x SMA)
Impedance	50 Ω
Level	5 Vpp (unloaded), 2.5 Vpp (loaded with 50 Ω)
Rise / fall times / width	t_r < 6 ns, t_f < 6 ns, pulse width ~ 20 µs

Time Code Outputs

IRIG Code Generator

IRIG codes	IRIG A, B, D, E, G, H, NASA 36, IRIG B 5 MHz
Number of codes	4 different codes on 4 channels is possible
Data content	BCD hour, minute, seconds, day of year straight binary seconds, extension field: year

IRIG Signal Outputs

BNC

Number of outputs	8 (with option 6: 12 outputs) (4 outputs on IRIG generator and on IRIG distributor each)
Configurable items	Code, amplitude, modulation frequency, DC shift
Signal amplitude	
Modulated output	0.3 to 10 Vpp (loaded with 50 Ω)
DC shift output	RS232 interface spec with +10V/-10V (unloaded) or TTL level (0V/+5V) into 50 Ω load, configurable
Output impedance	50 Ω (or 600 Ω, select on order)

Time Code Output

Number of outputs	1 (uses serial interface)	9 pin Sub-D male
Protocol	European Telephone Time code or plain ASCII, configurable	
Level	RS232	

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Connector

Optical Two-Way Interface (option 4)

Number of interfaces	4	Fiber specification	MT-RJ
Link range	220 m	62.5/125 µm MMF 160 MHz*km	
	275 m	62.5/125 µm MMF 200 MHz*km	
	500 m	50/125 µm MMF 400 MHz*km	
	550 m	50/125 µm MMF 500 MHz*km	
Eye safety	IEC 60825-1 Class 1/CDRH Class 1		

Electrical interface

Supply voltage DC	18 to 32 V DC	Hirschmann Stakei 2
Supply voltage AC	90 to 265 V AC, 47 to 65 Hz	IEC320
Source selection	Load sharing between AC and DC inputs	
Power Consumption	< 35 Watts on AC, < 30 Watts on DC	

M & C interface

Serial line	RS232	9 pin Sub-D male
Protocol	19200 bps 8N1, plain ASCII	
Availability	If not used for time code input or output.	

Ethernet — 10 Mbit/s twisted pair — RJ45

	Service	Port	Service	Port
TCP services	Telnetd	23	Data output	2001
	Command	2000		
UDP services	Syslog client	514	Data output	configurable
	TFTP server	69	NTP	123

Front panel

Time Display:	Bright red LED 7 segment display, 1” high showing: Day of year, hour, minute, seconds.	
Control Display:	2 lines, 40 characters LCD display showing: Instrument status & configuration, levels of inputs and outputs, selected input, alarms and messages, event history.	
Push Buttons:	8 function keys giving access to all vital functions such as: Instrument setup & configuration, input and output monitoring, input selection.	
Alarm LEDs:	ERROR: Any malfunction of the unit POWER: Supply voltage is o.k.	OPER: Processor alive status LOCAL: Remote control state.

Mechanical

Width, height	19 inch, 2 height units (448.8 mm ∗ 88 mm), rack mountable	
Depth, weight	Standard and with options 3, 4, and 6:	depth 264 mm, weight: 5 kg
	With options 1, 2, and 5:	depth 448 mm, weight: 6 kg

Environmental

Transportation and Storage	
Temperature.	-20°C to +75°C
Humidity	10% to 90% (non condensing)
Altitude	< 20 000 m
Shock	max 10g acceleration for 11 ms
Vibration	max. 0.15 mm at 5 to 8 Hz, max 1g acceleration at 8 to 500 Hz
Operation	
Temperature	-10°C to +50°C (Option 2 [Rubidium] limited to +40°C)
Humidity	20% to 90% (non condensing)
Altitude	< 3 000 m

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