SATRE

Satellite Time and Ranging Equipment

Part No's: 10140 (1 Channel), 10139 (2 Channels), 10221 (3 Channels)

The Photo shows a 2 channel SATRE.

Key features:

- Automated measurements
- Features unmanned, 24 hours / 7 days operation
- Complete remote control over TCP/IP
- Internal measurement database for the last three months on a minutely basis
- Sub-nanosecond TWSTFT with real time results
- Sub-nanosecond TimeSync
- 1 – 3 receiver channels

TimeTech GmbH
Curiestrasse 2
D-70563 Stuttgart
Germany

Tel.: ++49 711 67808-0
Fax: ++49 711 67808-99
e-mail: info@TimeTech.de
web: www.TimeTech.de

The SATRE modem has three main fields of application:

- Precise satellite ranging and orbit determination
- Precise monitoring and comparison of distant clocks
- Time transfer and synchronisation of remote clocks to a central master clock

Accuracies of 1 nsec are well within the capabilities of the system with a precision as high as 30 psec. These values are obtainable within the first minutes of operation. Intercontinental links are possible using geo-synchronous communication satellites.

The instrument may be easily integrated into existing satellite earth stations, turnkey systems for Ku-Band links are optional available. Radio frequency power requirements are very low and transmissions can use "occupied" transponder channels without significant degradation of interference to the primary transponder user. Spread spectrum signals ensure compatibility with other services. Simultaneous operation of several units using a single satellite transponder channel is possible.

The signal links are designed to compensate for most unknown delays of the signal propagation path and within the satellite transponder itself. Ranging information about the transponder in use is obtained at the same time. System integrity data and time information are distributed on the same RF links as the time signals. Fibre-optical links may be used as an alternative for very short to medium distance links.

Each SATRE Modem has an external data interface to communicate user and ranging information.

The SATRE modem can be expanded to contain up to three receiver channels which operate independently and simultaneously. The system can be freely configured. For example, one channel can be assigned to receive the own re-transmitted signal and the remaining two channels can receive signals from remote sites. The unique combination of time and data transmission in one instrument allows efficient time synchronisation and maintenance of large networks.

TimeTech GmbH
Curiestrasse 2
D-70563 Stuttgart
Germany

Tel.: ++49 711 67808-0
Fax: ++49 711 67808-99
e-mail: info@TimeTech.de
web: www.TimeTech.de

Specification

Spread Spectrum Capabilities

Chiprates	0.5, 1, 2.5, 5, 10 and 20 MChip
Number of PN Codes	16 predefined (20 and 10 MChip) 32 predefined (5 MChip and below) user codes **à** contact factory
Compatibility	MITREX compatible on 2.5 MChip, codes 0..7

Transmitter

	SATRE mode	MITREX mode
Center frequency	70 MHz ± 18 MHz[1]	70 MHz ± 18 MHz
Tuning resolution	0.001 Hz	0.001 Hz
Bandwidth	1.5 * Chiprate (-6 dB)	2.6 MHz (-7 dB) 3.5 MHz (-17 dB)
RF output level	0 .. –40 dBm	0 .. –40 dBm
RF output (CW)	0 .. –30 dBm	0 .. –30 dBm
Output Impedance	50 Ω (75 Ω optional)	50 Ω

Receiver

	SATRE mode	MITREX mode
Center frequency	70 MHz ± 18 MHz[1]	70 MHz ± 18 MHz
Tuning resolution	continuous	continuous
Frequency measurement	0.001 Hz (1 sec integration)	0.001 Hz (1 sec integration)
Input Bandwidth	30 MHz (> 2.5 Mchip) 7 MHz (≤ 2.5 Mchip)	7 MHz
Input Level (S + N)	-20 .. –60 dBm	-20 .. –60 dBm
Input Level (Signal) optimum	-50 .. –75 dBm -50 .. –60 dBm	-50 .. –75 dBm -50 .. –60 dBm
Input Impedance	50 Ω (75 Ω optional)	50 Ω
Number of channels	1 to 3 (completely independent)	1 to 3 (completely independent)

Signal Input

Signal input	BNC (option: TNC, N)
Reference Frequency	BNC, 5 / 10 MHz, +3 .. +10 dBm
Pulse reference	1pps, rising slope, trigger level 0..4V programmable, impedance 50 Ω / 2kΩ selectable
Time reference	NTP (RJ45, 10 Mbit/s), serial line (RS232, ASCII codes)

Signal Output

Signal output	BNC (option: TNC, N)
Time pulses	0..4V unloaded, impedance 50 Ω Tx: PPS, Frame Rate, PN sequence Rx: PPS, Frame Rate
Tx Monitor	fixed output (Tx signal) –10 dBm

[1] ±18 MHz tuning range for 2.5 Mchip and below. ±15 for 5 MChip, ±10 MHz for 10 and 20 MChip.

TimeTech GmbH
Curiestrasse 2
D-70563 Stuttgart
Germany

Tel.: ++49 711 67808-0
Fax: ++49 711 67808-99
e-mail: info@TimeTech.de
web: www.TimeTech.de

Guaranteed performance

Signal acquisition*	> 44 dBHz, ≤ 5 MChip: < 30 sec > 44 dBHz, > 5 MChip: < 150 sec
Signal acquisition using lookup tables*	< 20 sec
Signal acquisition, high sensitivity mode*	40 dBHz, < 5 MChip; < 90 sec 40 dBHz, > 5 MChip: < 260 sec
Signal tracking in carrier lock*	< 36 dBHz
Carrier frequency preset*	± 500 Hz from actual, ± 800 Hz (3 dB degradation)

Higher chipping rates benefit from lookup tables, which allow partial search of the PN sequence only. High sensitivity is enabled by slowing down the search process; this gives additional 4 .. 6 dB.

This performance data is guaranteed by system test which is part of factory acceptance test.

* tested with input signal at –30 dBm and ranging signal between –50 dBm and –75 dBm

Data interface

Physical	RS232 (19200 bps) or network (TCP, UDP)
Contents	delay measurements, first, second, third order regression, real time estimate, system health status, …
Output rate	1 / second maximum.
Internal database	1 / minute, averaged values from delay and real time solution up to 90 days with integrated harddisk
Data recorded in internal data base	Ranging mode: measurement (minutely mean), jitter, C/No, signal power, current configuration, receiver frequency, pseudorange (slant range) if modem is used in slave mode TWSTFT: measurement (minutely mean), jitter, C/No, signal power, current configuration, receiver frequency, external delay (RefDelay), real time TWSTFT delay estimation Time sync: same data as TWSTFT plus clock model (estimated offset of steered clock)
RF data transfer	All relevant data embedded in RF signal, can be monitored / decoded by remote station. A system of SATRE's does not need to be connected to each other; all necessary data is exchanged by RF.

TimeTech GmbH
Curiestrasse 2
D-70563 Stuttgart
Germany

Tel.: ++49 711 67808-0
Fax: ++49 711 67808-99
e-mail: info@TimeTech.de
web: www.TimeTech.de

Functions (TWSTFT mode)

Round trip delay	0 .. 600 ms
Resolution @ 1 s	10 ps
Stability	≤30 ps/day (Tx, Rx, Tx-Rx)
Thermal stability	≤30 ps/K (Tx, Rx, Tx-Rx)
Measurements	round trip delay, real time TWSTFT

Functions (Ranging mode)

Round trip delay	0 .. 200000 km
Resolution @ 1 s	0.3 cm (round trip)
Stability	≤1 cm/day
Thermal stability	≤1 cm/K
Measurements	round trip, pseudo range (slave mode)

Functions (TimeSync mode)

Round trip delay	0 .. 600 ms		
Resolution @ 1 s	10 ps		
Stability	≤30 ps/day (Tx, Rx, Tx-Rx)		
Thermal stability	≤30 ps/K (Tx, Rx, Tx-Rx)		
Slave Oscillators	OXO (8607)[2]	Rubidium[3]	Caesium[2]
Frequency	< 10^{-14}/day	< 10^{-14}/day	< 10^{-14}/day
Time Stability	< 250 ps	< 250 ps	< 250 ps

Mechanical

Outline, Weight	19 inch, 4 height units (448.8 mm ∗ 177,8 mm) depth 448 mm, 17 kg

Environmental

Transportation and Storage

Temperature, Humidity	-20°C to +75°C, 10% to 90% (non condensing)
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
Altitude	< 20000 m

Operation

Temperature	0°C to +50°C (spec. valid for +18..+24°C, slope < 0.2K/h)
Humidity	20% to 90% (non condensing)
Altitude	< 3000 m

[2] based on regular measurements via TWSTFT, 2.5 Mchip, quarter-hourly, at least 5 minutes per run, C/No > 50 dBHz. Ground station stability is not accounted in these figures

[3] based on regular measurements via TWSTFT, 2.5 Mchip, hourly, at least 10 minutes per hour, C/No > 50 dBHz. Ground station stability is not accounted in these figures. Values are preliminary.

TimeTech GmbH
Curiestrasse 2
D-70563 Stuttgart
Germany

Tel.: ++49 711 67808-0
Fax: ++49 711 67808-99
e-mail: info@TimeTech.de
web: www.TimeTech.de

Configuration Overview

Item	SATRE Ranging	SATRE TWSTFT	SATRE TimeSync
Real time data evaluation (max. 5 seconds delay)	**ü**	**ü**	**ü**
High resolution receive frequency measurement (0.001 Hz resolution at 1 second)	**ü**	**ü**	**ü**
500 MB integrated harddisk	**t**	**ü**	**t**
internal time interval counter for RefDelay measurement	**t**	**ü**	**ü**
integrated GPS receiver as timesource	**t**	**t**	**t**
I/F to external Cs clocks (Agilent / HP) for steering / slaving	**û**	**t**	**ü**
I/F to Comtech and SSE G/S transceivers (contact factory for other available drivers)	**t**	**t**	**t**
I/F to SATSIM station delay monitor	**t**	**t**	**t**
Second receiver channel	**t**	**t**	**t**
Third receiver channel	**t**	**t**	**t**

(**ü** integrated, **t** selectable as option, **û** not possible)

Ranging Jitter [cm, oneway]

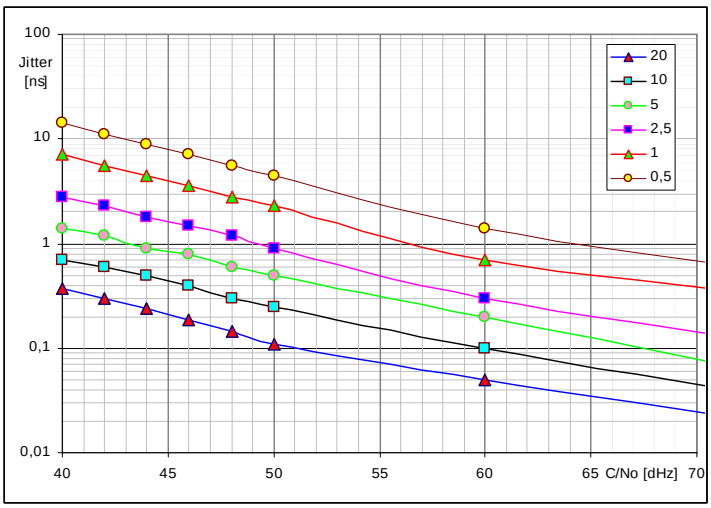
C/No	ChipRate [MChip/s] ®					
–	**20**	**10**	**5**	**2,5**	**1**	**0,5**
40	5,3	10,6	21,2	42,4	106,1	212,1
42	4,2	8,4	16,9	33,7	84,3	168,5
44	3,3	6,7	13,4	26,8	66,9	133,8
46	2,7	5,3	10,6	21,3	53,2	106,3
48	2,1	4,2	8,4	16,9	42,2	84,5
50	1,7	3,4	6,7	13,4	33,5	67,1
60	0,5	1,1	2,1	4,2	10,6	21,2
>=75	0,2	0,4	0,7	1,4	3,6	7,2

Typical ranging performance depending from chiprate and C/No. Unit is cm one-way

TWSTFT Jitter [ns, round trip]

C/No	ChipRate [MChip/s] ®					
–	**20**	**10**	**5**	**2,5**	**1**	**0,5**
40	0,4	0,7	1,4	2,8	7,1	14,1
42	0,3	0,6	1,2	2,3	5,6	11,2
44	0,3	0,5	0,9	1,8	4,5	8,9
46	0,2	0,4	0,8	1,5	3,6	7,1
48	0,15	0,3	0,6	1,2	2,8	5,6
50	0,1	0,2	0,5	0,9	2,3	4,5
60	0,05	0,1	0,2	0,3	0,7	1,4
>=75	0,02	0,03	0,05	0,1	0,3	0,5

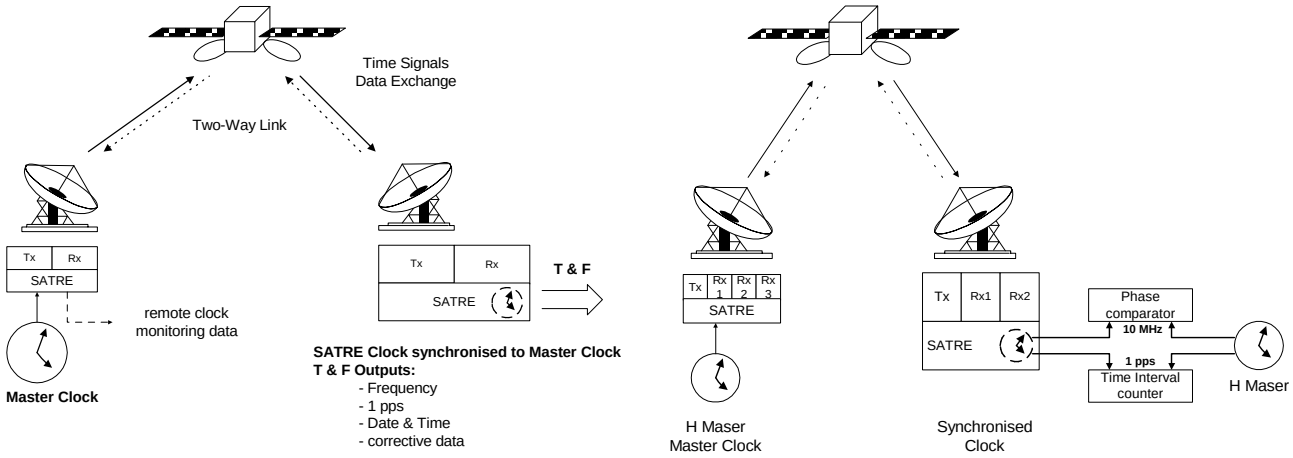
Typical measurement jitter depending from chiprate and C/No. Unit is ns roundtrip



TimeTech GmbH
Curiestrasse 2
D-70563 Stuttgart
Germany

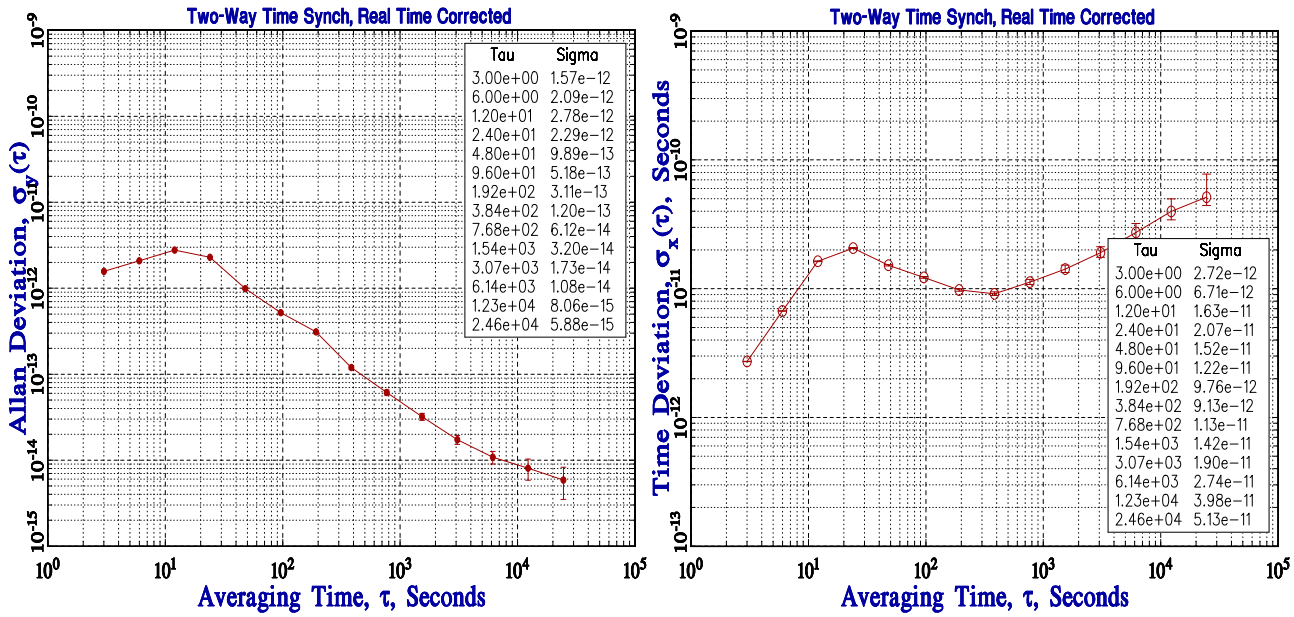
Tel.: ++49 711 67808-0
Fax: ++49 711 67808-99
e-mail: info@TimeTech.de
web: www.TimeTech.de

Time Syncronisation Principle



TimeSync setup (left) and verification (right)

TimeSync Synchronisation Performance



Typical Frequency Stability (Allan Deviation) via satellite, corrective data applied. Continuously locked over satellite; 5 Mchip. Master clock was maser, slave clock OXO OSA 8607 (high performance 5 MHz S/C cut oscillator). Ramp for 10^4 seconds is due to ground station instabilities.

TimeTech GmbH
Curiestrasse 2
D-70563 Stuttgart
Germany

Tel.: ++49 711 67808-0
Fax: ++49 711 67808-99
e-mail: info@TimeTech.de
web: www.TimeTech.de