The STS 54500 Synchronization Timing System is designed for use in T1, E1, 2.048 MHz, Composite Clock, 5 MHz, and 10 MHz digital transmission environments.

The STS 54500 Timing System is a totally integrated system for T1, E1, 2.048 MHz square, RS422, composite clock, and 5 and 10 MHz timing. All outputs for Stratum 1, 2, 2E, and 3E are mounted in the system in configurations meeting specified timing requirements. Corresponding E1 applications are the Primary Reference Clock (PRC), Transit Node Clock (TNC), and Local Node Clock (LNC).

STS 54500 circuit card provisioning settings and operating functions are software generated, affording both speed and flexibility in system application changes, testing, and monitoring. The expanded output card selection includes T1 and E1 rates, Composite Clock, 2.048 MHz, EIA/TIA RS-422, 1.544 MHz and 8 kHz Square Wave, Time of Day, 5/10 MHz sine, Network Time Protocol (NTP) and IRIG-B. Except for the 5/10 MHz and NTP, each of these cards provides 20 outputs and the Larus rack-mounted shelf can accommodate up to 10 output cards. The maximum number of outputs per shelf is 200, which can be arranged in 100 protected pairs if desired. Optional modules include track and hold cards with integral DS1/E1 or GPS or receivers.

Designed to provide timing for transmultiplexers, digital access and cross-connect systems (DACS), SONET equipment, digital switches, and channel banks, the STS 54500 system provides flexible and cost effective solutions to Stratum 1 (PRC), 2 (TNC), and 3E (LNC) digital transmission timing and synchronization applications. The system supports SNMP.

The STS 54500 offers internal system monitoring and performance measurement combined with remote and local reporting in TL1 format or pull down menu. All system configurations, including GPS, DS1 and E1 clocks are mounted in the system shelf and operate in similar or dissimilar pairs. Stratum upgrades are achieved by replacing plug-in circuit packs. Performance monitoring and reporting are not required for basic system operation but may be installed for system enhancement at any time. Output protection is available. A locking bar prevents accidental card movement.

**Features**

- Stratum 1/PRC, 2/TNC, or 3E/LNC Synchronization Timing System
- Specialized output cards providing DS1; Composite Clock; E1; 2.048 MHz Square Wave; EIA/TIA RS-422, 1.544 MHz and 8 kHz Square Wave; Time of Day; 5/10 MHz; Network Time Protocol (NTP) and IRIG-B outputs
- Outputs are synchronized to one of two redundant input references
- Synchronization status messages meet Bellcore GR-378 and ANSI T1X1.3 TR-33
- Monitored performance of up to 10 inputs
- 200 outputs
- 100 Protected outputs
- -48 Vdc power
- Redundant power feeds
- NEBS Level 3 certification: GR 63, 78,1089 CORE
- NEBS 19/23' rack mounting
- Patented DDFS synthesizer for all Stratum levels
- CleverClock™ oscillator predictability algorithm
- Local and remote alarm reporting
- TCP/IP and RS232 ports for remote system configuration and reporting
- Hitless switching between input references, clock cards and protected outputs
- Reduction of jitter and wander
- Stratum 2/TNC and 3E/LNC reference oscillators
- SNMP
- Graphical User Interface
- Phase locked composite clock outputs
- Inputs T1, 1.544 MHz, E1, 2.048 MHz, Composite Clock
- Outputs T1, 1.544 MHz, E1, 2.048 MHz, RS-422, Composite Clock, 1 PPS, NTP, IRIG-B
- Earthquake protected
- Conforms with all relevant Bellcore documents
- Tracks GPS down to one satellite
- New Features

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The STS 54500 Synchronization Timing System is available in Stratum 1/PRC, Stratum 2/TNC, and Stratum 3E/LNC versions. All systems use two 54511 T1, 54512 E1/2.048 MHz, or 54513 Composite Clock/5 MHz/10 MHz Input Cards. Stratum 3E/LNC systems add two 54522 Stratum 3E/LNC, Track and Hold Cards while Stratum 2E, 2/TNC configurations include two 54523 2E, Stratum 2/TNC Track and Hold Cards. Stratum 1/PRC configurations are equipped with two 54591 GPS Stratum 1/PRC Track and Stratum 3E/LNC Hold Cards (Stratum 3E holdover) or two 54593 GPS Stratum 1/PRC Track and Stratum 2/TNC Hold Cards (Stratum 2 holdover). Each 54591 and 54593 module incorporates a radio receiver and timing processor for use with either the Global Positioning System of satellites or transmitted cellular carrier. Performance above STR2 and ST3E is accomplished by a predictability algorithm, CleverClock™, that corrects for the drift characteristic of a given oscillator.

Input cards convert inputs into reference timing for the track and hold circuits. The track and hold cards provide the essential features of phase tracking, jitter smoothing, and holdover clock on input reference failure. Output driver cards supply any mix of twenty DS1 or E1 framed all-ones, Composite Clock, 2.048 MHz Square Wave, 1.544 MHz EIA RS-422 Square Wave, 8 kHz EIA RS-422 Square Wave, and Time of Day outputs or four 5/10 MHz outputs for driving D type channel banks, DACS, transmuxes (LTs), PBXs, or other network transmission and switching equipment. Performance measurement and monitoring as well as local and remote reporting features can be selected initially or installed later as system upgrades. The clock cards typically lock on multiple satellites, but will lock to one satellite and provide the required tracking accuracy.
Two additional modules, the Network Time Server plug in Card 54580 enable Network Time Protocol and IRIG-B outputs, and the Output Protection Unit 54585, which provides output protection from failed output timing between outputs from separate shelves. Output protection, card to card, in the same shelf is provided by the output cards and does not require the 54585 unit.

**Input Cards.** The 54511, 54512 and 54513 bridges or terminates existing DS1 circuits, E1/2.048 MHz or Composite Clock, respectively, to extract data and timing information for use by the 54522, 54523, 54591, and 54593 Track and Hold Clock Cards. The 54512 performs this function for E1 and 2.048 MHz circuits and the 54513 for Composite Clock, 5 MHz, and 10 MHz circuits.

**Track & Hold Clock Cards.** The 54522 (Stratum 3E/LNC) and 54523 (Stratum 2/TNC) operate from either direct DS1, E1, 2.048 MHz or CC inputs or the outputs from the bridging input cards (54511/54512/54513). They process the information to derive a stable 1.544 Mbps timing signal for the output cards. The 54591 (GPS or CDMA Stratum 1/PTR/track and Stratum 3E/LNC Hold) operates similar to the 54522 but takes primary input from its integral GPS or CDMA receiver and direct wire inputs if the radio signal fails. The 54593 (GPS or CDMA Stratum 1/PTR/track and Stratum 2/TNC Hold) operates similar to the 54523 but also takes primary input from its integral GPS or CDMA receiver with direct wire inputs as back up if the radio signal fails. GPS is traceable to UTC. The 54591 GPS and 54593 GPS operate while tracking only one satellite.

**Monitor & Alarm Cards.** The 54541 Synchronization Monitor Card measures DS1 input performance while the 54542 measures E1/2.048 MHz input performance. The 54550 Information Management Card supplies local and remote status reporting and control through RS232 and TCP/IP ports. Alarm status information from other cards is gathered by the 54560 Alarm Interface Card which transmits relay contact closures.

**Output Cards** receive the timing signal from the track and hold cards and furnish multiple outputs for driving channel banks or other equipment. 54571 provides DS1 framed ones outputs; 54572 provides Composite Clock outputs (64/8 kbps); 54573 provides framed ones E1 square wave outputs; 54574 provides 2.048 MHz square wave outputs; 54575 provides EIA/TIA RS-422 1544 or 8 kHz square wave outputs; 54576 provides Time of Day outputs; and 54577 provides 5 and 10 MHz outputs. The 54578 provides 10 separate CDM101 (CEU) compatible 3.24 MHz differential square wave output signals. The 54579 provides 10 separate 1 pulse per second differential output signals into 50 ohm terminations. The 54580 provides IRIG-B, 10 MHz and 1PPS outputs, as well as an NTP output.

**Network Time Protocol/IRIG-B Server.** The 54580 card, in conjunction with the GPS track and hold modules, distributes time for precise synchronization of client computer clocks over a network. Timing is acquired from GPS satellites and distributed to the customer’s network using Network Time Protocol (NTP). The card also provides an IRIG-B output as an option.
Output Protection. The 54585 module is designed to switch away from a failed synchronization output to an alternate working output in a separate shelf (where such a configuration is required), in order to provide timing to network elements that do not have a primary and secondary input. Up to 100 shelf to shelf outputs are protected. For card to card output protection in the same shelf, a 54585 module is not required. Up to 100 protected outputs are provided, card to card, in one shelf.

The STS 54500 is designed as a fully redundant wander and jitter free source of framed ones, square waves, or composite clock synchronized to an accurate framed input reference source.

Output driver cards are available for DS1, Composite Clock, E1, 2.048 MHz square wave, RS-422 1.544 MHz or 8 kHz square wave, time of day, and 5/10 MHz sinewave. All except the 5/10 MHz provide ten outputs for up to 100 outputs per STS 54500 single shelf system (the 54577 outputs, 2 each 5 MHz & 2 each 10 MHz). The system provides two bridging or terminating reference inputs. The average bit rate of the input reference must be in the range of ±7.1 bits/sec for Stratum 3E or ±0.02 bit/sec for Stratum 2 oscillators to "pull-in." Digitally controlled phase-lock oscillators track separate DS1 or E1 framed input signals, if so configured, while the inputs are within the above limits. When one input is lost, its oscillator holds to the last known phase and the outputs are switched to the oscillator that is still tracking. If both inputs are lost, the worst case output drift results in less than two frame slips in the first 24 hours (Stratum 3) while not locked to a network source of timing. For Stratum 2, the time to the first frame slip is typically 36 hours. In the event of catastrophic failure of both oscillators, the system will use either input defined as valid (by the qualification circuitry in the input card) to drive the outputs directly.

The Network Time Server Card is available only with a system equipped with GPS track and hold capability. Precision timing inputs are automatically provided when the card is plugged into the shelf behind a working GPS track and hold card. Outputs include IRIG B, 1PPS (accurate to 130 nanoseconds), 10 MHz sine, and alarm status.

The rack-mountable Output Protection Module operates with network elements such as D4 channel banks that require a timing input but do not provide for redundancy. Two output signals are wired to the A and B inputs of the unit. If the A side fails, the B side input is selected to drive the channel bank. Switch time is less than 3 milliseconds.
Performance monitoring and alarm reporting functions are controlled by the T1 or E1/2.048 MHz Synchronization Monitor Card, Information Management Card, and Alarm Interface Card. These cards provide system status, data collection, and alarm functions. The Synchronization Monitor Card measures the performance of the two reference DS1 or E1/2.048 MHz inputs and three external DS1 or E1/2.048 MHz inputs. The addition of a second SMU provides performance monitoring of 5 additional inputs. The Information Management Card provides local and remote status reporting via RS232 and TCP/IP interface ports. The Alarm Card reports alarms by means of front panel LED indicators and dry relay contact closures. The STS 54500 complies with Belcore TANPL-000436, AT&T Pub 60110, ANSI/T1.101-1994, and CCITT G.703-1998. Wander and jitter attenuation conforms to Belcore TATSY-000378.

Designed for mounting in 19/23" NEBS racks, the STS 54500 is a card family system housed in a Larus 54500 shelf. The STS 54500 is available in Stratum 1 (PRC), Stratum 2 (TNC), and Stratum 3E (LNC) versions.

**Stratum Level Definitions**

Stratum 2 and Stratum 3E (or comparable) clock systems track the DS1/E1/2.048 MHz/CC/5 MHz/10 MHz input under normal operating conditions and hold to the last best estimate of the input reference frequency during impaired operating conditions. Stratum 1 systems track GPS or Cesium input under normal operating conditions and hold to Stratum 2 (54593) or Stratum 3E (54591) during impaired operating conditions.

**Stratum 1** normally tracks Cesium or GPS input signals from four to eight satellites maintained to be traceable to UTC time to an accuracy of $1 \times 10^{-11}$. The unit is also capable of deriving timing when tracking only one satellite. If no GPS input is available, the 54593 or 54591 card will track a connected input reference or, in the absence of inputs, operate in Holdover mode as Stratum 2 or Stratum 3E from an internal rubidium (54593) or crystal (54591) oscillator.

**Stratum 2/2E** tracks an input under normal conditions, and holds to the last best estimate during impaired conditions. The long term drift with no input reference is less than $1.6 \times 10^{-8}$ in one year for ST2 and $1 \times 10^{-8}$ per year for ST2E. The short term drift is less than $1 \times 10^{-10}$ in 24 hours, equivalent to one frame slip in 7 days in holdover mode. Larus’ Stratum 2 clock drifts less than $7.5 \times 10^{-11}$ per day, or the first frame slip in about 9.6 days. In reality, the first frame slip will happen in about 60 days under typical conditions. The ST2E drift is less than $1 \times 10^{-11}$ per day at 22 °C.
**ST54500**

**OPERATION**

**Stratum 3E** tracks input signals within ±7.1 Hz of 1.544 MHz from a Stratum 3 or better source. The drift with no input reference is less than $5 \times 10^{-8}$ in 24 hours. This equates to less than two frame slips in 24 hours as compared to 255 slips for Stratum 3. Typical drift performance is less than $9 \times 10^{-9}$ in 24 hours and less than one slip in 36 hours.

**DESIGN FEATURES**

The STS 54500 Synchronization Timing System comprises a series of plug-in cards mounted in Larus 54500 NEBS certified 18-slot 19/23” rack mount shelves. Each card provides its own conversion from office battery to logic power level (this allows cards to be hot swappable) as well as alarm contacts to the shelf fuse alarm bus. Two -48V power buses supply redundant power to each card. All cards are equipped with a front panel alarm indicator and a GMT power fuse.

**Input Cards**

**54511 T1 Input Card**

The 54511 card provides a bridging or terminating input, recovers clock from the received signal for use by the 54522 Stratum 3E/LNC, 54523 Stratum 2/TNC, or 54591 or 54593 Stratum 1/PRC card, and sends clock to the output cards (used only if both track and hold cards fail). The 54511 also forwards monitoring and alarm information to the 54560 card to report loss of input signal, loss of frame, or excess bipolar violations.

The framing format SF (D4) or ESF is automatically selected by the corresponding track and hold card or set from the 54550 Information Management Card. Line coding is AMI or BBZS, with automatic selection on each input.

Output signals are 1.544 MHz from either DS1 input selected by the corresponding track and hold card.

**54512 E1/2.048 MHz Input Card**

The 54512 card operates similarly to the 54511 with these exceptions.

The framing format CAS or CCS and CRC ON or OFF (for E1 inputs only) is automatically selected by the corresponding track and hold card or set from the 54550 remove. Line coding is HDB3 on each E1 input.

Output signals of 2.048 MHz, from either E1 or 2.048 MHz input selected by the corresponding track and hold card, are converted to 1.544 MHz.

**54513 Composite Clock/5 MHz/10 MHz Input Card**

The 54513 card operates similarly to the 54511 with the following differences.

The 54513 is factory set through hardware to 64/8 kHz Composite Clock, 5 MHz (sine or square), or 10 MHz (sine or square). No framing or line coding is supported.

**Track & Hold Cards**

**54522 Stratum 3E/LNC Track & Hold Card**

The 54522 card accepts 1.544 MHz data and clock from a corresponding 54511, 54512, or 54513 input card and provides a smoothed and jitter free tracking signal to the output cards.

The 54522 monitors its inputs for framing and CRC-6 errors. An out of specification input signal forces the unit to switch to the other input card. If neither input is valid, the 54522 holds to the last known reference. The signal to the output cards is continuous during any switch from track to hold or any switch of input reference. There is no phase hit during the switch.

**54523 Stratum 2/TNC Track & Hold Card**

The 54523 card accepts two 1.544 MHz input reference signals, extracts the timing, and provides a smoothed and jitter free tracking rubidium oscillator signal to the output cards. Input signals are monitored for framing and CRC-6 errors. An out of specification input signal forces the unit to switch to the other input. If neither input is valid, the unit holds to the last known reference. The signal to the output cards is continuous during any switch from track to hold, and there is no phase hit during the switch.

The 54523 has an alternative 10 MHz input for a high stability timing source such as a GPS receiver or a cesium clock. With this input, phase tracking of the input reference does not occur.

**54591 GPS Stratum 1/PRC Track & Stratum 3E/LNC Hold Card**

The 54591 card integrates a GPS receiver to realize a primary reference source for Stratum 1/PRC operation with backup Stratum 3E/LNC performance during a GPS failure. It also accepts and monitors two 1.544 MHz signals from 54511, 54512, and 54513 Input Cards. The system will switch to the 1.544 MHz inputs in the event of a GPS failure and the 54591 will automatically switch back to GPS tracking when the failure clears.

When not in GPS mode, the 54591 monitors the input reference signals for framing and CRC-6 errors if so configured. An out of specification input signal forces the unit to switch to the other input. If neither input is valid, the unit holds to the last known reference.

The 54591 provides a smoothed, essentially jitter free tracking crystal oscillator signal to the output cards. The phase of the output signal is continuous during any switch from track to hold. There is no output phase hit during the switch.

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Track and Hold Cards (Continued)

54593 GPS Stratum 1/PRC Track & Stratum 2/TNC Hold Card

The 54593 card integrates a GPS receiver to realize a primary reference source for Stratum 1/PRC operation, thus maintaining long term frequency accuracy $1 \times 10^{-11}$ or better per Bellcore GR-2830-CORE and ITU-T G.811. The card also accepts and monitors two 1.544 MHz reference input signals and extracts timing for Stratum 2/TNC operation. The system will switch to the reference signal inputs in the event of a GPS failure and the 54593 will automatically switch back to GPS tracking when the failure clears.

When not in GPS mode, the 54593 monitors the input reference signals for framing and CRC-6 errors if so configured. An out of specification input signal forces the unit to switch to the other input. If neither input is valid, the unit holds to the last known reference.

The 54593 provides a smoothed, essentially jitter free tracking rubidium oscillator signal to the output cards. The phase of the output signal to the output cards is continuous during any switch from track to hold. There is no output phase hit during the switch.

Synchronization Monitor Cards

54541 T1 or 54542 E1/2.048 MHz Square Wave Synchronization Monitor Card

The 54541/54542 is microprocessor-controlled input signal testing and measurement card providing information of TIE, MTIE and JITTER. The card allows for local or remote selection of alarm thresholds, inputs to be monitored, observation interval, number of consecutive intervals, and manual or automatic mode. The default mode is an automatic scan with observation intervals of 100 seconds per input. Other available intervals are from 1 to 100,000 in decade steps.

Two independent phase detectors allow two of the five inputs to be measured simultaneously. The five are input references A and B and three external inputs on the primary SMU. The second SMU card (optional) monitors five additional external inputs.

Information Management Card

54550 Information Management Card

The 54550 IMC features include local and remote status reporting, performance monitoring, and alarm reporting through an RS232 or TCP/IP port to a local type craft terminal operating at 1200 to 9600 baud asynchronous. A separate RS232 or TCP/IP port for remote access connection to a Network Management System can be configured to interface with an X.25 synchronous network with menu or TL1 language messages.

The IMC provides a serial data link to set alarm thresholds, measurement intervals, scanning mode, and configuration. A serial data link to the track and hold cards sets A-B input selection, functions, and configuration. Serial port information is available through TL1 or menu option.

Alarm Interface Card

54560 Alarm Interface Card

The 54560 collects alarm status information from all the other cards in the system and determines whether the overall alarm state is major or minor. The card provides floating relay contact closure for major, minor, audible, and visual summary alarms.

Output Cards

General

The input signal to the 54571 through 54577 output cards is differential 1.544 MHz TTL clock sync from one of the two 54522/54523/54591/54593 track and hold cards. The input signal is automatically obtained from one of the two input reference signals should both track and hold clock cards fail. One or more failed outputs activate an alarm. All output cards allow for 1 for 1 protection with hitless digitally controlled switching.

54571 T1 Output Driver Card

The 54571 card provides twenty (20) DS1 DSX compatible framed ones drive signals with either SF or ESF framing. The 54571 will drive any standard DS1 receiver through up to 655 feet of cable. Outputs allow card to card protection and provide ten (10) protected outputs per card.

Output jitter is less than 0.03 UI peak-to-peak (10 Hz to 40 MHz). The output pulse amplitude of 3 V ± 0.3 V peak meets AT&T CB119 and CCITT G.703 requirements.

An alarm output signal notifies the 54560 Alarm Interface Card when one or more outputs have failed.

54572 Composite Clock Output Driver Card

The 54572 card provides twenty (20) unprotected, or ten (10) protected, composite clock outputs for driving D4 channel banks and other equipment that require composite clock inputs.

The output signals are 64/8 kbps, 5/8 duty cycle pulses, with bipolar pulse violation every eight pulses. The output waveform meets CCITT G.703. Outputs are byte phase synchronized to within less than 520 nS per GR378 core. Each output can drive up to 1500 feet of 22 AWG office cable. All composite clock outputs are phase locked whether in one shelf or multiple shelf arrangements.
54573 E1 Output Driver Card
The 54573 provides twenty (20) unprotected or ten (10) protected outputs supporting bipolar E1 framed all ones at 2.048 MHz CAS, CCS, or CRC-4 framing (switch selectable). Outputs are common frame and multi-frame synchronized with other E1 output cards.

Output signals meet CCITT G.703 and output jitter is less than 0.03 UI p-p from 20 Hz to 100 kHz.

Each output will drive a 120 ohm load through up to 655 feet of 22 AWG cable.

54574 2.048 MHz Square Wave Output Driver
The 54574 provides twenty (20) unprotected or ten (10) protected 2.048 MHz square wave outputs. The card accepts a differential 1.544 MHz TTL clock signal from one of the two track and hold cards or from one of the two input reference signals if both track and hold cards have failed.

The 2.048 MHz square wave meets the CCITT G.703 standard. Each output can drive up to 200 meters of 22 AWG shielded cable pairs.

54575 RS-422 Output Driver Card
The 54575 provides twenty (20) protected or ten (10) unprotected EIA/TIA RS-422 differential TTL square wave outputs remove. List options are available for 1.544 MHz or 8 kHz outputs.

The card will drive any standard RS-422 receiver through up to 400 feet of 22 AWG office cable.

54576 Time of Day Output Driver Card
The 54576 provides twenty (20) unprotected and ten (10) protected 9600 baud Time of Day RS-232 level outputs per card. An alarm output signal notifies the 54560 Alarm Interface Card when one or more outputs have failed. Outputs allow card to card protection.

54577 5/10 MHz Output Driver Card
The 54577 provides two (2) 5 MHz and two 10 MHz sinewave outputs with automatic selection of input references. Automatic selection can be overridden by manual/remote selection.

54578 3.24 MHz Output Driver Card
The 54578 provides 10 separate CDM101 (CEU) compatible 3.24 MHz differential square wave output signals. The card will drive the outputs through 100 ft. of 22 AWG cable. An alarm output provides an indication to the 54560 Alarm Interface Card that one or more outputs have failed.

54579 1PPS Output Driver Card
The 54579 provides 10 separate 1 pulse per second differential output signals into 50 ohm terminations. The card will drive the outputs through 100 ft. of 22 AWG cable. An alarm output provides an indication to the 54560 Alarm Interface Card that one or more outputs have failed.

Special Purpose Units

54580 Network Time Server Card
The 54580 provides IRIG-B, 10 MHz, and 1PPS outputs on rear access BNC connectors as well as an NTP output through a 15 pin AUI (Attachment Unit Interface) connector to a customer provided MAU (Media Access Unit). Initial setup commands are integrated into the command set for the entire 54500 timing shelf.

54585 Output Protection Module
For shelf to shelf protection applications the 54585 switches away from a failed output to provide a second protected output from a separate shelf. The 54585 provides 100 protected outputs. Switch time is typically 1 mS. The unit is compatible with all types of ±3 volts to 4 volt alternate mark timing signals; E1, DSI, or composite clock.

Card to card protection is provided in ‘same’ shelf configurations and the 54585 module is not required in this application. 100 protected outputs are provided from a 200 output shelf.

Features and specifications subject to change without notice.