



# 58503B

## GPS Time and Frequency Reference Receiver

### KEY FEATURES

- SmartClock Technology
- Designed for R&D Labs, Manufacturing and Calibration Labs
- Low Cost Source for Precision Time and Frequency

### INTRODUCTION

The Symmetricom 58503B GPS time and frequency reference receiver is a high quality source of precision time, time interval, and frequency in a lightweight compact package. The high-performance 58503B ensures excellent accuracy and reliability—the 58503B delivers precise time and frequency virtually anywhere in the world at an affordable price.

When locked to the GPS signal, the 58503B provides a 10 MHz signal with an accuracy of better than  $1 \times 10^{-12}$  using a 1 day average. A 1 pulse per second (1 PPS) signal with timing jitter of  $<750$  ps rms is provided. Time accuracy relative to GPS of 20ns (1 Sigma, typical) can be obtained once the unit is properly installed and all systematic offsets have been compensated out.

If the GPS signal is interrupted, the 58503B enters an intelligent holdover mode, which ensures frequency is maintained to better than  $1 \times 10^{-10}$  per day (phase accumulation  $<8.6$   $\mu$ sec after 24 hours). The technology which does this is called SmartClock.™

### SMARTCLOCK

SmartClock technology contributes significantly to the performance of the 58503B GPS time and frequency reference receiver. SmartClock learns and corrects for the effects of oscillator aging and temperature. This technology, combined with a highly reliable oscillator, contributes to the superior price, performance, size and reliability delivered by the 58503B.



58503B GPS Time and Frequency Receiver

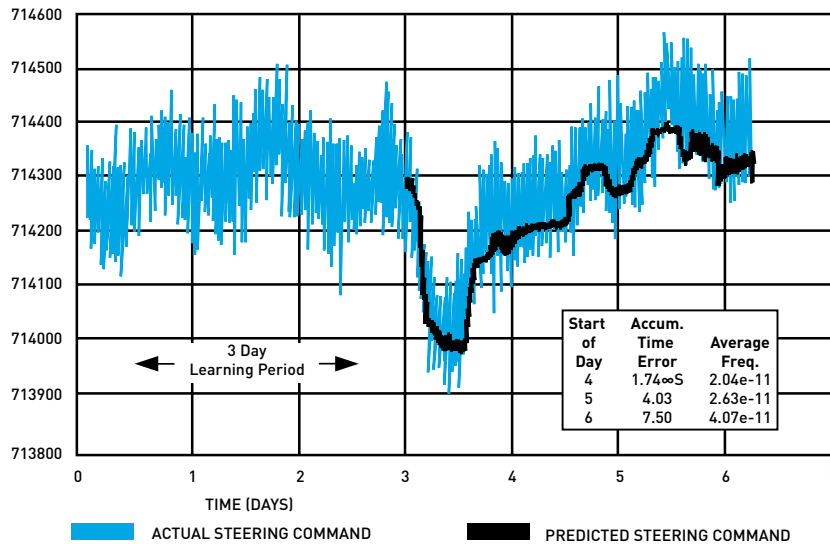


FIG. 1 SmartClock Operation

### SMARTCLOCK TECHNOLOGY

Integrated with the quartz oscillator, SmartClock greatly enhances the performance of the 58503B GPS time and frequency reference receiver under both locked and unlocked conditions. In the locked condition, it has all the desirable short-term stability attributes of a state-of-the-art quartz oscillator, but it is drift free. In the event the GPS reference is lost, the combination of the quartz oscillator and SmartClock delivers performance which approaches the performance of rubidium oscillators.

Figure 1 gives typical data illustrating the operation of SmartClock. All data is taken with the unit locked to GPS. During the first three days, SmartClock uses the GPS reference to "learn" the aging behavior of the quartz oscillator. This information, along with the temperature compensation that is taught to SmartClock when the unit is tested at the factory, is used to steer the oscillator. The light, shaded line shows the actual digital steering commands sent to the oscillator to keep it synchronized with GPS time.

The heavy, solid line shows a plot of the steering commands computed using the SmartClock algorithm starting with Day four. The dominant effects during the predicting period are changes due to external temperature. If the GPS signal

had not been present, the oscillator would have been steered in holdover by SmartClock using the corrections that it had determined from the learning period. Holdover performance can be computed from the difference between the actual steered performance and the predicted performance. The data for the first three days in holdover are shown in Figure 1.

### ENHANCED GPS

Enhanced GPS includes digital filtering designed to remove most of the effects of SA (Selective Availability) on the timing performance of the 58503B. Enhanced GPS is based on extensive study of the spectrum of SA, a method superior to simple averaging techniques. Enhanced GPS couples SA data with clock instability models to derive optimum digital filters which minimize the effects of SA. The benefits of Enhanced GPS apply only to stationary 58503B GPS time and frequency reference receivers.

When a Symmetricom GPS receiver is initially turned on and locked to the GPS satellite system, it will achieve GPS lock within 30 minutes of operation. It has a 95% probability of meeting unlocked (holdover) specifications after 48 hours of GPS operation, followed by 24 hours of learning. The longer the GPS receiver (and its quartz oscillator) operates, the better its stability and unlocked (holdover) performance becomes.

### SATSTAT PROGRAM

The Symmetricom 58503B comes with a Windows® 3.1 program called "SatStat" which displays important internal parameters. SatStat operates on any PC which can run Windows 3.1 programs and which has a serial interface available.

SatStat provides several useful functions. It continuously polls the RS-232 interface and displays receiver information most likely to be of interest. This includes satellites being tracked along with their elevation and azimuth, receiver state (locked, holdover, etc.), antenna coordinates, time and frequency figures of merit and other data. In addition, a clock window is provided to display time of day in real time. Finally, SatStat allows you to easily change many receiver parameters, such as antenna delay, by simply picking the item from a pop-up menu and entering a new value. With SatStat and a PC, you can monitor and control many aspects of the receiver status without developing software.

### OPTIONAL 16-CHARACTER FRONT PANEL DISPLAY

Available options include a built-in front panel display. The standard 58503B GPS time and frequency reference receiver does not include a display. While a display is not necessary, it may be convenient to track the receiver's progress during installation and startup by monitoring the satellites being tracked, location, time, and other parameters.

### OPTIONAL 1 PP2S OUTPUT (EVEN-SECOND OUTPUT)

An even-second (1 PP2S) output is available as an option to the 58503B. The even-second output option provides one pulse every other second, synchronized to the even seconds in GPS time. This is the reference time used in CDMA base stations. GPS even-second pulses from the 1 PP2S option are used to synchronize the Agilent® 8921A (Option 600) and the Agilent 8935A cellular base station test sets. Synchronizing the test set from an independent source permits remote base station testing and independent base station frequency and time reference accuracy checks.

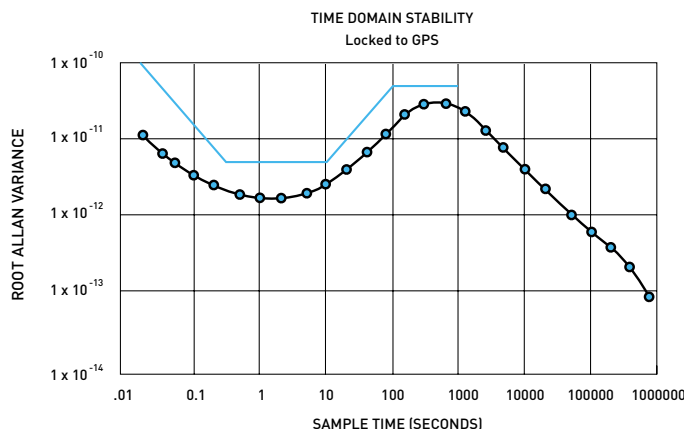


FIG. 2 Time Domain Stability

## ANTENNA AND CABLING INFORMATION

The 58532A GPS L1 Reference antenna is recommended to ensure specified performance of the 58503B. For optimum performance, the antenna should be installed in a location which gives it a clear view of the entire sky.

### TYPE

- Active antenna  
Power supplied to the antenna by the 58503B: 5 volts nominal, 50 mA max

### ANTENNA CONNECTOR (58503B)

- Type-N jack (female)

### ANTENNA CABLE

- 58521A cables are recommended. These cables are LMR 400 with Type-N connectors (male) on both ends. A variety of lengths are available.

### ADDITIONAL ACCESSORIES

- 58502A broadband distribution amplifier; provides 12-Channel broadband (0.1 to 10 MHz) sinewave distribution.
- 58535A/36A/17A GPS L1 signal distribution amplifiers/splitters allows multiple receivers (2, 4, or 8) to share a single antenna.
- 58529A GPS line amplifier with L1 bandpass filter; provides the gain to overcome cable loss and protection against noise and interference signals.
- 58530A GPS L1 bandpass filter; provides protection against noise and interference signals.
- 58538A/ 58539A lightning arrestors; provides protection against nearby lightning strikes.

## 58503B SPECIFICATIONS AND CHARACTERISTICS

### GENERAL SPECIFICATIONS

- Eight channel, parallel tracking GPS engine
- C/A code, L1 carrier
- SmartClock/enhanced GPS
- Optional DC power operation available

### 10 MHz OUTPUT SPECIFICATIONS (WITH SA ON)

- Locked  
Frequency accuracy: better than  $1 \times 10^{-12}$ , for a one day average, 0° C to 50° C
- Unlocked  
Holdover aging:  $<1 \times 10^{-10}$  per day average frequency change in 24 hours of unlocked operation. (See Notes 1 and 2.)
- Phase noise (locked)

Offset from signal (Hz)	SSB phase noise (dBc)
1	-85
10	-125
100	-135
1000	-140
10000	-145

- Time domain stability (locked)  
(See Figure 3)

Averaging time seconds	Root Allan variance
0.01	$1.5 \times 10^{-10}$
0.1	$1.5 \times 10^{-11}$
1	$5 \times 10^{-12}$
10	$5 \times 10^{-12}$
100	$5 \times 10^{-11}$
1000	$5 \times 10^{-11}$

### SUPPLEMENTAL INFORMATION

- Waveform: Sine wave
- Amplitude:  $>1.7$  volts p-p (+8 to +10dBm) into a 50Ω load
- Harmonic distortion:  $<-25$ dBc (typical)
- Non-harmonic signals:  $<-80$ dBc (typical)
- Source impedance: 50Ω (nominal)
- Coupling: AC
- Connector: BNC

### 1 PPS OUTPUT/1 PP2S OUTPUT (OPTION 002) SPECIFICATIONS (WITH SA ON)

- Locked  
Jitter of leading edge:  $<750$  ps rms with at least one satellite in view.
- Time accuracy  
20ns typical (1 Sigma) SA off with respect to UTC (USNO MC) and all systematic offsets have been removed, calibrated, and locked to GPS.
- Unlocked  
Accumulated time error:  $<8.6$  μs accumulated in 24 hours of unlocked operation. (See Notes 1 and 2.)

### SUPPLEMENTAL INFORMATION

- Pulse width: 26 μs
- Amplitude:  $>2.4$  volts into 50Ω load. (TTL compatible)
- Connector: BNC
- Rise time: 40 ns typical

## 58503B ADDITIONAL SPECIFICATIONS

### ADDITIONAL FEATURES

- Alarm output:
  - TTL open collector with internal pull-up resistor. Circuit can sink up to 10 ma.
  - Provides a logic output to allow monitoring of normal (H) and abnormal (L) operation externally and remotely. BNC connector.

### FRONT PANEL INDICATORS (LEDs)

- Front panel indicators: Power, GPS lock, Holdover mode, Alarm

### REMOTE INTERFACE

- RS-232C DTE configuration: Complete remote control and interrogation of all instrument functions and parameters.
- Factory defaults: Baud rate 9600, 8 data bits, 1 start bit, 1 stop bit, no parity. Other settings are programmable.
- Connector: 25-pin female rectangular D subminiature on rear panel.
- Time code output is available to a computer immediately preceding the 1 PPS signal for the current second.

### NOTE 1

This specification has a 95% probability, and is based on the availability of four or more GPS satellites during three days of locked operation with a fixed antenna location. The temperature must remain within a 10° C range between 10° C and 40° C.

### NOTE 2

When a quartz oscillator has not been operated for a period of time, or if it has been subjected to severe thermal or mechanical shock as might be encountered during product shipment, the oscillator may take some time to stabilize. In most cases, the oscillator will drift and then stabilize at or below its specified rate within a few days after being turned on. In isolated cases, depending upon the amount of time the oscillator has been off and the environmental conditions it has experienced, the oscillator may take up to one week to reach its specified aging rate and to operate without significant frequency "jumps."

When a Symmetricom GPS receiver is initially turned on and locked to the GPS satellite system, it will achieve GPS lock within 30 minutes of operation. It has a 95% probability of meeting unlocked (holdover) specifications after 48 hours of GPS operation, followed by 24 hours of learning. The longer the GPS receiver (and its quartz oscillator) operates, the better its stability and unlocked (holdover) performance becomes.

### ENVIRONMENTAL SPECIFICATIONS

- Time and frequency reference receiver (58503B)
  - Operating: 0° C to +50° C
  - Storage: -40° C to +80° C
- Antenna (58532A)
  - Operating: -40° C to +85° C
  - Storage: -45° C to +90° C

### ADDITIONAL INFORMATION

- Power requirements: AC power (standard)
- Auto ranging: 100 to 127 Vac, nominal  
220 to 240 Vac, nominal
- Ranges: 90 to 132 Vac  
198 to 264 Vac  
47 to 63 Hz
  - Option AWQ (replaces AC power operation with DC power operation)
- Auto ranging: 24 to 48 Vdc, nominal
- Range: 20 to 60 Vdc,  
greater than +23 Vdc required to start
- Input power (all options): <35 watts (nominal)
- Dimensions: 88.5 mm H x 212.6 mm W x 348.3 mm D  
Half-rack module

## QUICK CONFIGURATION GUIDE

Use this quick configuration guide to easily configure your GPS antenna system. The simplified antenna component selection procedure will work very well for the majority of antenna systems. Figure 3 shows the key components which may be used in an antenna installation. Please note that this quick configuration guide works only for 58503B, 55300A, and custom GPS timing receivers which have a type-N antenna input connector. The 58533A and 58540A GPS timing receivers are covered in a separate document, Symmetricom publication number QCG/ 58533A-540A. Simple rules for placing or using the

various elements of an antenna system are given beginning on page four. These rules will be referenced in each section where they apply. Installation and technical support is also available from Symmetricom Global Services.

## ELEMENTS OF A TYPICAL GPS ANTENNA SYSTEM

The following elements will be used in most GPS antenna systems:

- A GPS antenna (required)
- Cable(s) to interconnect the elements (required)
- Lightning arrestor(s)
- Amplifiers or filters: The rules will help determine if these are needed.

## GETTING STARTED

First, determine the following:

- Where to place the antenna (see Rule 1

to follow)

- Where to place the lightning arrestor if used (see Rule 3)
- Where to place the GPS receiver
- The lengths of cable(s) needed to interconnect these elements. Be sure to consider the length of the cable route, not the direct point-to-point distance.
- The total length of all cables determined above

Once this information is known, your GPS antenna system can be easily configured by selecting the necessary components on the checklist on the next page.

## CHECKLIST

### GPS antenna

Every GPS receiver needs an antenna in

Note: Conceptual drawing. Use rules to determine actual accessories needed for your installation.

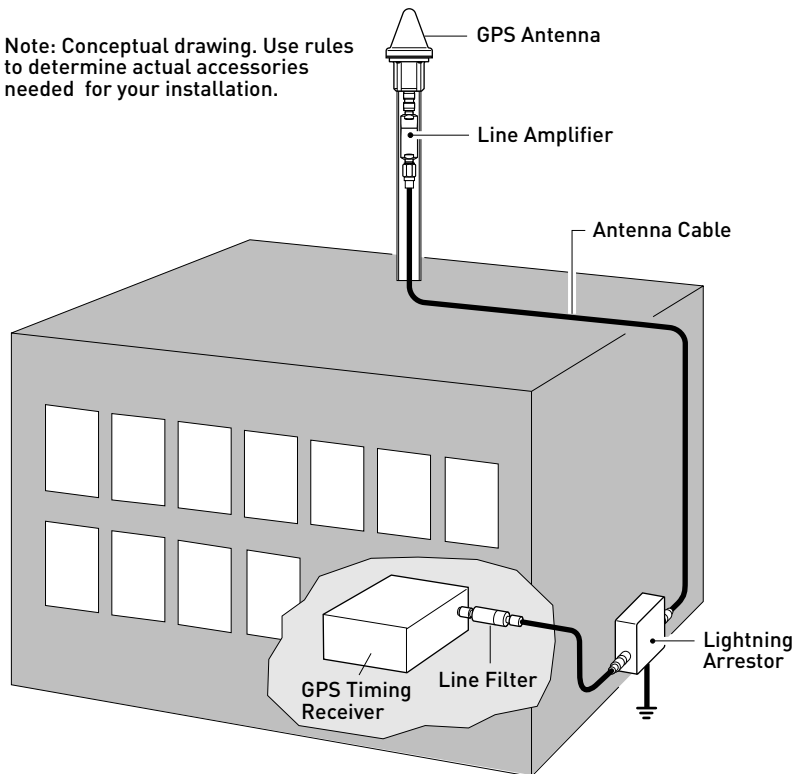


FIG. 3 Key GPS antenna system components

order to operate. See Rule 1 to follow for information on antenna placement, and optional mounting hardware.

- 58532A GPS L1 reference antenna. Quantity: 1
- Option AUB, antenna mast. Quantity: 1

Select one of the following as needed:

- SDI8101G, antenna wall mount.
- SDI8106G, antenna pipe mount.

Order these parts through Talley at 1-800-223-4949.

### Line amplifier/filter

If used, the line amplifier should be attached directly to the antenna. See Rule 2 to determine if an amplifier is needed.

- 58529A GPS L1 line amplifier/filter. Quantity: \_\_\_\_  
(Quantity: 0, 1, or 2) See Rule 2

### Interconnect cables

Use these cables to connect between elements of the antenna system and the GPS receiver. See Rule 5 for more information. Select an option for each length of cable needed. For example, you might need a 58521A Option 010 to connect between the GPS antenna and a lightning arrestor, and a 58521A Option 002 to connect the lightning arrestor to the GPS receiver.

**Note.** A cable is not needed to connect between the antenna and a line amplifier/filter.

- 58521A interconnect cable (LMR-400, Type-N connectors).
  - Option 001 - 1 meter length. Quantity: \_\_\_\_
  - Option 002 - 2 meter length. Quantity: \_\_\_\_
  - Option 005 - 5 meter length. Quantity: \_\_\_\_
  - Option 010 - 10 meter length. Quantity: \_\_\_\_
  - Option 015 - 15 meter length. Quantity: \_\_\_\_
  - Option 030 - 30 meter length. Quantity: \_\_\_\_
  - Option 060 - 60 meter length. Quantity: \_\_\_\_
  - Option 110 - 110 meter length. Quantity: \_\_\_\_
  - Option 220 - 220 meter length. Quantity: \_\_\_\_
  - Option 330 - 330 meter length. Quantity: \_\_\_\_

### Lightning arrestors

Lightning arrestors will protect your system from lightning damage. Some systems may require more than one lightning arrestor for full protection. See Rule 3 to follow for more information on selecting a lightning arrestor and its options.

- 58539A lightning arrestor(s). Quantity: \_\_\_\_  
(Usually 1 or more) See Rule 3.
  - Extra gas capsule, Option 001. Quantity: \_\_\_\_
  - Grounding strap, Option 002. Quantity: \_\_\_\_

### L1 bandpass filter

See Rule 4 to determine the need for a line filter.

- 58530A GPS L1 filter.
- Option AUB, mounting bracket

## GPS ANTENNA RULES

### Rule 1. Antenna placement.

#### A. View of the sky

Select an area where the GPS antenna will have an unobstructed view of the sky. An ideal position has no obstructions above a point 10 degrees above the horizon. The total blockage of the sky (due to buildings, mountains, etc.) should be less than 50%. For installation help or to order a site survey, contact Symmetricom Global Services.

#### B. Lightning considerations

Locate the antenna at least 15 meters away from lightning rods, towers, or structures that attract lightning. GPS antenna damage is usually not the result of a direct lightning strike, but the effects of a lightning strike on a nearby structure. Locate the GPS antenna lower than any structures that will attract a strike.

#### C. Maintenance considerations

If the GPS antenna fails or must be checked, having the antenna positioned in an easily accessible location will facilitate maintenance. Avoid installing the antenna on a tower, which requires a specialist to maintain.

#### D. Interference considerations

Avoid the direct radiation from transmitting antennas (such as TV or Cellular). Symmetricom has filters to minimize this problem. See Rule 4.

#### E. Mounting brackets

All brackets are designed to attach to the 58532A antenna mast (Option AUB).

1. **Wall mount**—attaches the antenna to a wall with 4 fasteners.
2. **Pipe mount**—attaches the antenna to either a vertical pipe or rod. The pipe or rod must have a diameter between 20 and 50 mm.

### Rule 2. Is a GPS line amplifier/filter needed?

#### A. Cable length

Add up the total length of all the cables determined in the Getting Started section. If this length is 115 meters or less, no amplifier is needed. If the total length is between 115 meters and 240 meters, you must use a line amplifier. If the length is between 240 meters and 360 meters, use two line amplifiers. If the total length is greater than 360 meters, contact Symmetricom Global Services for further assistance.

#### B. Placement

Mount line amplifiers as close to the antenna as possible. Connect one amplifier directly to the antenna using the hardware that is included. If using two line amplifiers, connect the second line amplifier directly to the first line amplifier using included hardware. The line amplifiers fit nicely inside the antenna mast where they are protected from the weather.

**Note.** The 58529A GPS line amplifier also filters the GPS signal. For systems that need filtering but not signal amplification, use the 58530A GPS L1 filter described in Rule 4.

### Rule 3. Lightning arrestors.

#### A. Is a lightning arrestor needed?

Very probably, yes. Lightning does not have to strike the antenna to significantly damage the antenna and GPS receiver. Lightning strikes induce damaging voltages in the antenna system when striking nearby objects.

#### B. What do I need?

A commonly used configuration is to place a 58539A lightning arrestor where the antenna cable enters the building (either inside or outside), because there is often a good earth ground nearby to connect to.

If the cable between this lightning arrestor and the GPS receiver is longer than four meters, it is good practice to place a second 58539A within four meters of the GPS receiver. The second arrestor reduces any lightning-induced voltages in the cable to the receiver.

These are the simplest forms of lightning protection.

#### C. Grounding

The 58539A does not need a grounding strap if it is directly bolted to a grounding plate (mounting hardware is included with the product). A 300 mm long grounding strap (Option 002), is available if you cannot connect directly to a grounding plate.

#### D. Extra gas capsule

Lightning arrestors have replaceable gas capsules. One capsule is included with each unit. The gas capsule should be replaced periodically according to your installation's maintenance code. Order Option 001 for an extra gas capsule.

### *E. Cautions*

If you are not comfortable designing your own lightning protection system, seek professional assistance in this area. This guide cannot make you an expert.

#### **Rule 4.** GPS L1 bandpass filter.

Additional antenna line filtering may be necessary if the antenna is in the near field of a radio transmitter. In most installations, a line filter is not required. Since the filter can be easily installed after the antenna system is complete, we recommend the filter be left out of the design unless operational problems are encountered. The symptom of an interfering signal is that the receiver will not lock or lock intermittently to satellites. Be aware that this symptom can be caused by a number of things besides interfering signals. If interfering signals are suspected, connect the filter directly to the antenna connector on the GPS receiver using the hardware that is included. Connect the antenna cable to the filter's input connector. Use option AUB (mounting bracket) if you prefer to mount the filter to a surface or pole.

#### **Rule 5.** Interconnect cables.

##### *A. Cable options*

The receivers and accessories described in this guide all use type-N connectors. Symmetricom's 58521A N-to-N interconnect cables are available in various lengths.

For ease of pulling antenna system cable through a conduit, or if you wish to cut the cable to an exact length, order the 58521AA. These cables are the same as the "A" cables, but the "AA" cables have a connector installed on only one end. The other connector is packaged with the cable for installation after the cable is installed (or cut). See Note below.

**Note.** To install the connector, you need the following tools: soldering iron, saw or cable cutter, knife, small scissors, and a crimp tool. The crimp tool must have a 10.7 mm hex die.

##### *B. Multiple antenna site installations*

Multiple site installations may be done more efficiently using bulk cable and a connector-installation tool kit. Extra connectors may be obtained by ordering option 800 when you order a 58529A GPS L1 line amplifier, 58530A GPS L1 filter, or 58538A and 58539A lightning arrestors.

To order these connectors separately, order Symmetricom part number 1250-2570. For more information about multiple antenna site installations or general questions about GPS antenna system installation, please contact Symmetricom Global Services.



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