FS700 10 MHz LORAN-C Frequency Standard

- 10^{-12} Long-term Stability
- NIST Traceable
- 10^{-10} Short Term Stability (Optional 10^{-11})
- Four 10 MHz Reference Outputs
- Guaranteed Reception Throughout Most of the Northern Hemisphere
- Phase Detector with Stripchart Output
- 0.01 Hz to 10 MHz TTL Output

FS700 Overview

Many complex electronic systems require a stable, highly accurate timebase. Communication, automatic test and measurement, and precision time-measurement systems - they all require accurate frequency standards. Traditionally, users have looked to atomic clocks (cesium or rubidium) for high stability and accuracy. With the *FS700 LORAN-C Frequency Standard*, cesium-clock stability is now available at a fraction of the cost of atomic standards.
The *FS700* serves as a NIST traceable frequency reference in the U.S., Europe and Asia.

Cesium Stability

More than 50 LORAN transmitters are maintained throughout the Northern Hemisphere by the US coast Guard. The timing of their transmissions is controlled by cesium clocks located at each transmitter site. The *FS700* extracts the timing information from the transmitted signal and uses it to frequency-lock its own highly stable oscillator. The result is a 10 MHz output signal with the same stability as the cesium clock used to generate the LORAN transmissions.

Four 10 MHz outputs are available at the rear panel of the instrument, in addition to an adjustable frequency front-panel source. These outputs may be used as timebase inputs to other laboratory instruments, such as frequency counters, synthesizers, spectrum analyzers, or pulse generators. The FS710 distribution amplifier can help you distribute the 10 MHz reference signal throughout your facility.

Phase Detector

A built-in phase detector measures the phase shift between an external timebase and the internal frequency source. The *FS700* can easily calibrate precision oscillators between 100 kHz and 10 MHz, providing a visual display as well as a voltage output proportional to phase difference. You can use the analog output to drive recorders for long-term frequency-stability testing or to phase-lock other sources to the *FS700*.

NIST Traceable

The timing information in the LORAN signal is constantly monitored by NIST. Detailed reports of the accuracy of each station and projected station downtime are available. With the *FS700*, you not only get the accuracy of a single atomic standard, but also an entire network of redundant, continuously monitored standards, all at a price far below that of even a single atomic clock.

LORAN Operation

LORAN stations are divided into groups called chains, each of which broadcast LORAN pulses at a common repetition rate, known as the GRI (Group Repetition Interval). Once every GRI, each station in the chain transmits a group of eight LORAN pulses each having the pulse shape shown below:

It is the third zero-crossing of these pulses which are accurately controlled by a 10 MHz cesium standard at the LORAN transmitter station. The zero crossings of the 10 MHz standard are precisely synchronous with the zero-crossings of the received 100 kHz LORAN carrier signal in the ratio of 100:1. Thus, by locking to the third zero-crossing of the 100 kHz pulses, the *FS700's* internal oscillator maintains the long term stability of the transmitter`s standard.

To operate the *FS700* you need only enter the GRI for the chain nearest your location. The *FS700* automatically adjusts its receiver gain and begins searching for LORAN pulses. You can set the *FS700* to search for the station with the largest detected signal in the chain, or you can select a particular station. Once LORAN pulses have been identified, the FS700 begins an initial frequency lock to the selected station to remove any initial gross frequency offsets. When this is accomplished, the *FS700* searches for the position of the third zero-crossing, and locks to it. The entire search process takes between 15 and 40 minutes depending on the signal-to-noise ratio of the selected station. Front panel readout of the signal-to-noise ratio for any station is available.

Continuously Monitored Output

Once locked, *the FS700* minimizes the frequency difference between its internal oscillator and the LORAN transmission by use of a firmware frequency-locked-loop (FLL). Frequency-locked-loops have much better phase-noise and short term stability than phase locked loops, which can introduce large instantaneous frequency offsets while attempting to maintain zero phase difference. While locked, the *FS700* continuously monitors the received signal for error conditions.

If errors are found, the unit suspends frequency updates for 20 minutes. If the error condition is cleared by that time, the FLL is resumed, otherwise the FS700 can either wait for the selected station to come back on-line, or search for a new station.

Frequency Outputs and Phasemeter

In addition to the four 10-MHz rear-panel sine outputs, the *FS700* has a front-panel adjustable-frequency TTL output. Frequencies between 0.01 Hz and 10 MHz, in a 1, 2.5, 5 sequence, can be selected. The frequency source has the same accuracy as the 10 MHz outputs. A built-in phasemeter allows comparison of the frequency source with an external input. You can either display a bar-graph of the phase difference between the two signals, or the *FS700* will compute the frequency difference between them by looking at the accumulated phase difference over a specified time interval. A front panel connector supplies a voltage output proportional to the measured phase, which can be used to drive recorders, or to phase-lock other sources to the *FS700*.

Antennas and Filters

The *FS700* comes complete with an 8-foot long remote active whip antenna, which is easily mounted on the roof of a building. The antenna is capable of driving up to 1000 feet of coaxial cable to the receiver. The weatherproof antenna base contains an FET preamplifier and a 100 kHz bandpass filter.

An optional lightening protection module can be inserted between the antenna and the receiver to provide protection in adverse weather conditions. Six adjustable notch filters in the receiver allow the user to reject interfering signals for optimum reception.

FS710 Distribution Amplifier

Installations requiring remote outputs will benefit from the optional *FS710* AGC distribution amplifier. This unit provides seven 10 MHz outputs from a single input at distances of up to 1 mile from the *FS700*. For more information read the "Some Questions About LORAN-C" tech note on the *FS700*.

FS700 Specifications

Receiver

Sensitivity	will lock with signal-to-atmospheric noise level of -10dB or better
LORAN Output	filtered and gain controlled antenna signal, typically 6V peak-to-peak
Station Search	all available stations pre-programmed, auto-seek finds and tracks strongest station
Notch Filters	6 adjustable -30 dB notch filters, 3 at 40 - 90 kHz, 3 at 110 - 220 kHz

Frequency

Frequency Stability:

Long Term	10^{-12}, The same as LORAN-C transmitter cesium clock.
Short Term	10^{-10}, standard oscillator 10^{-11}, low phase noise option
Outputs	four 10 MHz Outputs. 1 Vpp sine into 50 ohms
LOCK Output	rear-panel TTL indicates receiver lock.
Front Panel Output	TTL level output from .01 Hz to 10 MHz in a 1, 2.5, 5, sequence.

Internal Oscillator

	Standard	**Option 01**
Frequency	10.000 Mhz	10.000 MHz
Type	AT Cut Ovenized	SC Cut Ovenized
Aging	$5x10^{-10}$/day	$5x10^{-10}$/day
Allan Variance (1s)	$5x10^{-11}$	$5x10^{-12}$
Stability 0-50° C	0.005 ppm	0.005 ppm
Phase Noise	-130 dBc @ 100 Hz	-125dBc @ 10Hz -155dBc @ 100Hz -165dBc @ 1kHz

Phasemeter

Frequency Output	0.01 Hz to 10 MHz in 1, 2.5, 5 sequence, TTL level. can be 50 ohm terminated.
Oscillator Input	1 k ohm, 0.5 V peak-to-peak minimum level.5.0 Volts max.
Phase Output	0.01 V/degree, 0 to ±360°. Output proportional to phase difference between OSC IN and FREQUENCY OUTPUT for frequencies between 100 kHz and 10 MHz.

Computer Interface

GPIB	IEEE-488 compatible interface. All instrument functions may be controlled. GPIB interface is standard.
RS-232	Optional 300 to 19,200 baud DCE serial interface. All instrument functions may be controlled.

Antenna

Type	100 kHz active antenna, with 40 kHz bandwidth bandpass filter in base.
Height	102"
Material	Fiberglass Whip
Base	2" dia. x 7.5", PVC
Mounting	3/4" FIPT
Output	50 ohm nominal, female BNC
Environmental	-40 TO 60°C, 0-100% RH

Lightening Protection Module:

Surge	18,000 A IEEE 8/20 waveform (based on ANSI C62.1)
Frequency Range	DC to 30 MHz
Throughput Energy	< 16 uJ (based on 1 KV/nS waveform)
Insertion Loss	<.25 dB

General

Operating	0 to 50° C
Power	100, 120, 220 or 240 VAC +5% -10%. 50/60 Hz. 50 Watts.
Dimensions	17" x 17" x 3.5". Rack mounting hardware included.
Weight	14 lbs
Warranty	One year parts and labor on any defects in material or workmanship

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