SECTION XVII

October 27, 1994

DISCIPLINED QUARTZ OSCILLATOR (OPTION)

l-l INTRODUCTION

1-2 This internal oscillator option offers the user a highly accurate frequency source with good short term stability and moderate holdover performance during periods when GPS satellites are not usable. While GPS satellite data is available, the XL-DC microprocessor controls this oscillator via a 16 bit DAC in such a way as to phase lock its output to UTC. Since all time and frequency outputs of the XL-DC are coherent with this oscillator, all display the same enhanced short term stability and holdover performance.

1-3 This option consists of a 10 MHz ovenized quartz oscillator incorporating an AT-Cut crystal in a compact, hermetic enclosure.

1-4 SPECIFICATIONS

1 - 5 All standard XL-DC accuracy and stability specifications (see Section I) are valid when the XL-DC has been operating continuously for at least 24 hours with an accurate position (error < 10 m in WGS-84) and at least four satellites are visible. The ambient temperature variations within the specified operating temperature range of the XL-DC must be less than 5 °C. The addition of this option impacts the standard XL-DC specifications in these areas:

1-6 Time Domain Stability (Allan Deviation):

τ	$\sigma_y(\tau)$
1	1×10^{-11}
10	5×10^{-11}
10^2	1×10^{-10}
10^3	1×10^{-10}
10^4	1×10^{-11}
10^5	1×10^{-12}

1-8 Holdover Characteristics:

Initial Frequency Error: $< 3 \times 10^{-10}$
Drift Rate: $< 5 \times 10^{-9}$/day
Temperature Coefficient: $< 4 \times 10^{-10}$/°C

l-9 Oscillator Warm-Up:

< 15 minutes to 1 x 10-7

2-l INSTALLATION

2-2 This option is factory installed. Field installation is not available for this option.

3-l OPERATION

3-2 No special operation procedures are required, however initial acquisition of satellites after a cold start-up will be delayed relative to the standard TCXO oscillator due to the warm-up time of the ovenized oscillator. See Section III for general XL-DC operation.

4-l THEORY OF OPERATION

4-2 The XL-DC provides accurate time and frequency whenever one or more satellites are in view, with optimal performance when four or more satellites are in view. When satellite outages do occur, the XL-DC flywheels on its oscillator, either internal or, when using the External Oscillator Control option, external oscillator. During these periods, the rate that the XL-DC time and frequency outputs diverge from UTC is governed by these parameters:

1) The accuracy of the last DAC control voltage setting prior to the outage.

2) The ambient temperature change during the outage period and the temperature coefficient of the oscillator's output frequency.

3) The inherent drift or ageing rate of the oscillator's output frequency as a function of time. All quartz oscillators exhibit this drift.

Items 2) and 3) are functions of the quartz oscillator and the temperature characteristics of the environment in which the XL-DC is operated. Item 1) is determined by the stability of the GPS system and the control parameters chosen in the digital phase lock loop implemented in the microprocessor of the XL-DC.

4-3 The oscillator control algorithm employed in the XL-DC implements a Type III servo on the phase relationship of the XL-DC clock to UTC as measured via GPS clock bias solutions performed in the core GPS module. Proprietary algorithms are employed to affect multi-satellite averaging and to detect and remove data outliers so that optimally stable steering data is applied to the oscillator. The output of the control algorithm is a 16-bit DAC generated voltage which is connected to the Electronic Tuning Control input of the oscillator.

The control philosophy is to implement sufficient averaging to reduce the short term effects on stability caused by Selective Availability while maintaining the long term stability available from the GPS system. This philosophy requires that trade-offs be made between having better short and medium term stability versus having better insensitivity to environmentally induced instability, e.g. temperature induced oscillator frequency shifts which cannot be eliminated when heavy control loop averaging is in effect.

The parameters which are fixed in XL-DC EPROM firmware assume an air conditioned environment with night to day variations on the order of 5°C. Under these conditions all time and frequency performance specifications of the XL-DC will be maintained. Larger variations in temperature may induce out of specification performance.

For users whose operating environment differs significantly from the assumed environment, the available XL-DC External Oscillator Control option offers the ability to tailor the oscillator control parameters to the user environment. This option is described fully in Section III in keypad or Serial I/O functions 07 and 14 and is primarily intended for users who wish to supply their own oscillators for control by the XL-DC. However the operation with an optional internal ovenized quartz oscillator such as this one is identical in function. Keypad or Serial I/O function 14 allows user oscillator parameter set-up and function 07 allows enabling of *internal* oscillator control using these user defined parameters in exactly the same way as they would be used for a *user provided* external oscillator. The one disadvantage of this method of defining oscillator control parameters is that they are not stored in firmware. Failure of the battery backed NVRAM would cause the XL-DC to revert to the default firmware resident parameters, requiring user intervention to re-program the "forgotten" parameters and re-enable them.

Should operation via the External Oscillator Control option be desired, these function 14 parameters would yield equivalent operation as compared to the firmware resident parameters:

10 MHz OCXO

Freq:	10
Tuning Slope:	3.20e-07
DAC Nominal:	0.45
Temp Stab:	2.40e-08

5-1 MAINTENANCE

5-2 The only maintenance required for this option is periodic replacement of the oscillator when its frequency has finally drifted out of the range of the electronic tuning. The combination of low ageing rate and wide tuning range of the oscillator make this a rare requirement which should not be necessary more frequently than once every five years. By observing the DAC value returned from either keypad or Serial I/O function 71 while the XL-DC is properly locked to the GPS system, the user may determine when replacement of the oscillator is required.

Since the DAC value returned by function 71 is a signed 16 bit integer representation of the DAC output voltage, the positive and negative limits are at 32767 and -32768 respectively. Whenever the XL-DC is operating properly with locked status and the steady state DAC value is greater than 30000 or less than -30000, replacement of the oscillator will soon be necessary. The unit should be returned to the factory for performance of this procedure.