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지상파 전파항법시스템에 적용하기 위한 eLoran Emulator 개발

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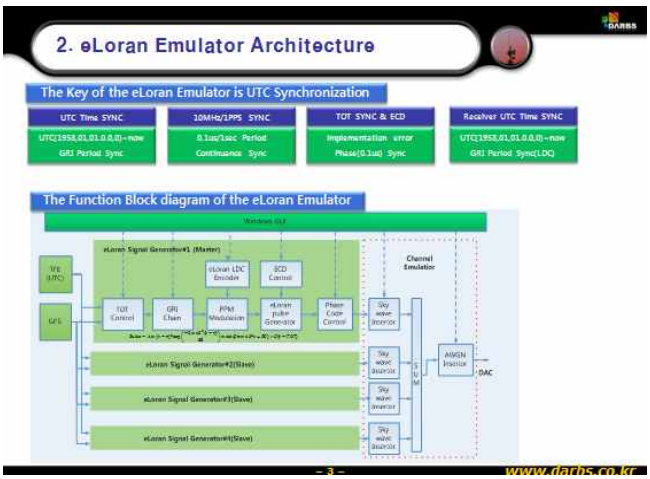
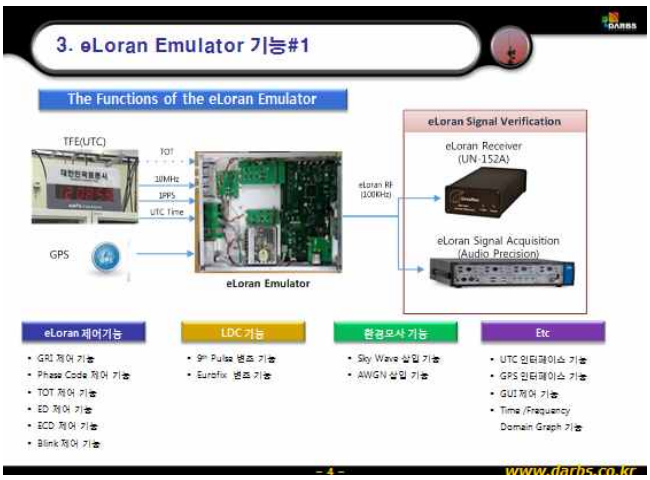
요 약 : 미국, 러시아, 중국 등 선진국에서는 GNSS와 같은 위성항법시스템의 취약성에 대한 대비하기 위한 고정밀도의 지상파 전파항법시스템을 독자적으로 개발하여 운영 중에 있지만, 우리나라는 1979년도에 도입한 외산장비로 포항 및 광주 송신국을 구축하여 Loran-C 체인으로 지상파 전파항법시스템을 운영 중에 있다. 특히 위성항법시스템이 없는 우리나라 입장에서는 어느 위성항법시스템에 종속되지 않는 고정밀도의 지상파 eLoran 전파항법시스템 개발이 더욱 절실히 요구되고 있다. 본 연구 개발에서는 고정밀도의 eLoran 지상파 항법시스템 개발에 앞서 eLoran 송수신 시스템을 검증하고, 실제 공간상의 채널환경을 모사할 수 있는 eLoran emulator를 개발하였다.

핵심용어 : eLoran, ECD, Blink, LDC, UTC, 지상파 전파항법





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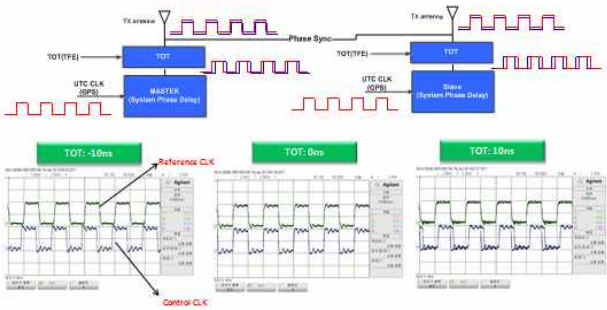
3. eLoran Emulator 기능#2

H/W

GUI

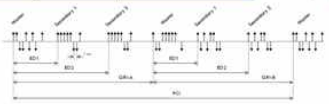
4-3. Sample Performance-TOT 제어

Synchronization of UTC and eLoran emission signal

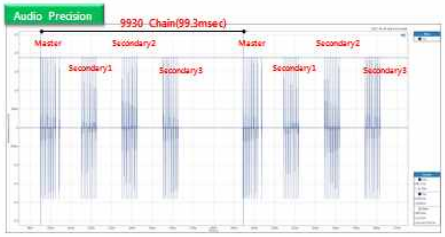


4-1. Sample Performance-GRI 제어

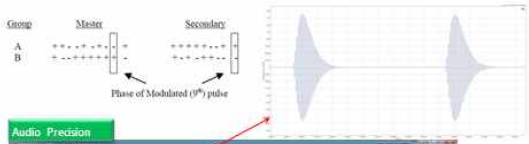
10MHz/1PPS SYNC | UTC Time SYNC → GRI Generation



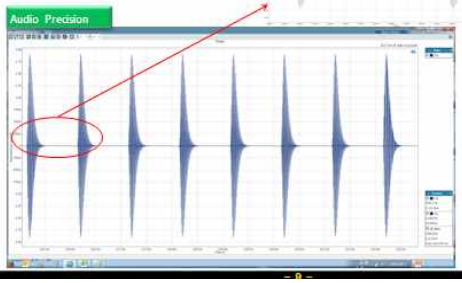
Audio Precision



4-4. Sample Performance-PCI 제어



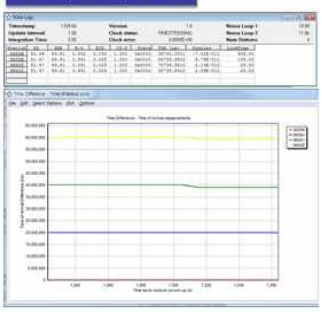
Audio Precision



4-2. Sample Performance-ED 제어

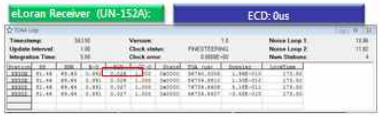
eLoran Receiver (UN-152A):
ED1: 20ms, ED2: 40ms, ED3: 60ms

eLoran Receiver (UN-152A):
ED1: 20ms, ED2: 39ms, ED3: 59ms



4-5. Sample Performance-ECD 제어

eLoran Receiver (UN-152A): ECD: 0us



eLoran Receiver (UN-152A): ECD: +1us

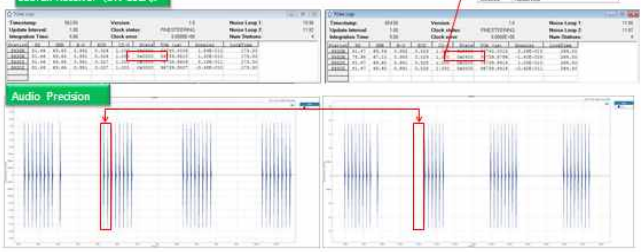
eLoran Receiver (UN-152A): ECD: -1us

4-6. Sample Performance-Blink 제어

Blink - Pulse method

- Occasionally a LORAN transmitter will malfunction so that its transmitted signal is no longer accurate
- Blink coding provides integrity to the received Loran signal
- When this occurs the master station and the affected secondary station begin blink transmissions.
- the secondary station will blink its first two pulses in 0.25 seconds on, 3.75 seconds off pattern. .

eLoran Receiver (UN-152A):



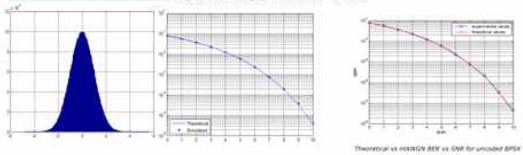
Audio Precision

4-8. Sample Performance-AWGN#1

AWGN Generator 구조 및 성능

- High accuracy by combining Box-Muller algorithm and central limit methods.
- Random distribution in the range of [-4σ...4σ], where σ is the standard deviation.
- Generally, when evaluating channel codes, one needs 100 to 1,000 bits in error to draw conclusions on a simulation with enough confidence.
- Hence, with 10^{12} samples, one can examine channel code behavior for bit error rates as low as 10^{-12} to 10^{-13}
- we need to be able to represent up to 8.1σ for a population of 10^{12} Sample

Box-Muller 구현 결과 up to 8.1σ for a population of 10^{12} Sample



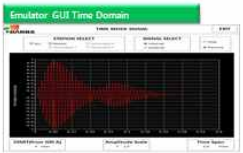
4-7. Sample Performance-SKY Wave#2

SKY WAVE (Multi Path) 결과: -10dBc@200us

Audio Precision Time Domain

Audio Precision Frequency Domain

Emulator GUI Time Domain



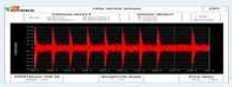
Emulator GUI Frequency Domain

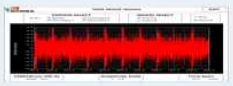
4-8. Sample Performance-AWGN#2

AWGN 20dB | AWGN 10dB

Audio Precision

Emulator GUI



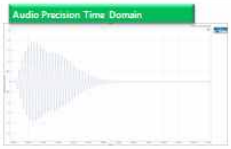


UrsaNav 수신기

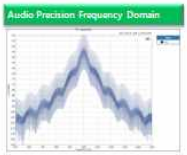
4-7. Sample Performance-SKY Wave#1

SKY WAVE (Multi Path) 결과: -10dBc@100us

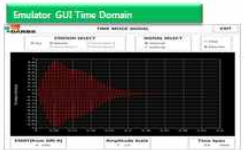
Audio Precision Time Domain



Audio Precision Frequency Domain



Emulator GUI Time Domain



Emulator GUI Frequency Domain

5. 결론

eLoran Emulator 활용

- 개발된 eLoran Emulator는 실제 공간상에서 예측되는 신호를 발생하여 수신기의 성능을 평가 할 수 있음
- GPS 또는 eLoran가 통합하는 수신기 알고리즘 (신호 중 하나의 손실 처리하는 방법)을 개발하는데 활용됨.
- 평가된 수신기 성능 바탕으로 예상되는 eLoran 서비스 지역을 예측하는데 활용됨.

향후 계획

- 정밀한 채널 환경을 모델링 할 수 있는 다양한 Parameter를 구현할 예정임(Pulse Trailing Edge, Half-Cycle Peak Amplitude, Pulse-to-Pulse Timing Tolerance, etc)