



# 고성능 Power-HIL 구축

## WithBEER

With Best Engineering & Essential Responsibility

(주)위드비어 오형록 대표



With \_\_\_\_\_  
Best  
Engineering &  
Essential  
Responsibility

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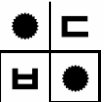
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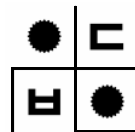
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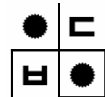




# Company overview

- 01 회사 개요
- 02 사업 및 서비스영역





# 1. 일반 현황

## 회사명

(주)위드비어 WithBEER Co., Ltd  
(With Best Engineering & Essential Responsibility)



## 설립일

2020년 5월



## 대표이사

오형록



## 임직원수

7명



## 회사위치

전라남도 나주시 교육길 13,  
스마트파크 지식산업센터 F동 209호, 204호



## 홈페이지

<https://withbeer.co.kr>



## 핵심역량

- 실시간 시뮬레이터
  - Speedgoat : 판매, 용역, 기술지원
  - OPAL-RT : 용역 및 기술지원(유료서비스)
- RCP(Rapid Control Prototyping)
  - Speedgoat 및 PI-Innovo
- 신재생에너지 시험 및 개발기기 제작
- 4상한 동작 전력 시뮬레이터  
(EGSTONE Power Electronics / Austria)
- 서비스
  - 실시간 시뮬레이션 분야 유지보수 및 기술지원, 교육



# 2. 사업 및 서비스영역 (1)

## I 제품

### 01 시스템구축

#### Speedgoat RT-Simulator & RCP



- **Speedgoat**
- HIL / P-HIL system integration for grid connected and EV application
- Including strong technical support
- **H/W based Controller HIL System**

### 02 시뮬레이션

- MATLAB/Simulink Based Power System & Power Electronics Modeling
- PSSE to Simulink 대응
- Siemens Simcenter AMESIM : Multi-Physics Modeling (플렌트모델링)



### 03 계통시뮬레이터

#### EGSTON Power Electronics

- 4Q amplifier for grid source, EV(Motor, Battery), PV, Wind...
- P-HIL application
- Including strong technical support



### 04 기타 에너지 시험장치

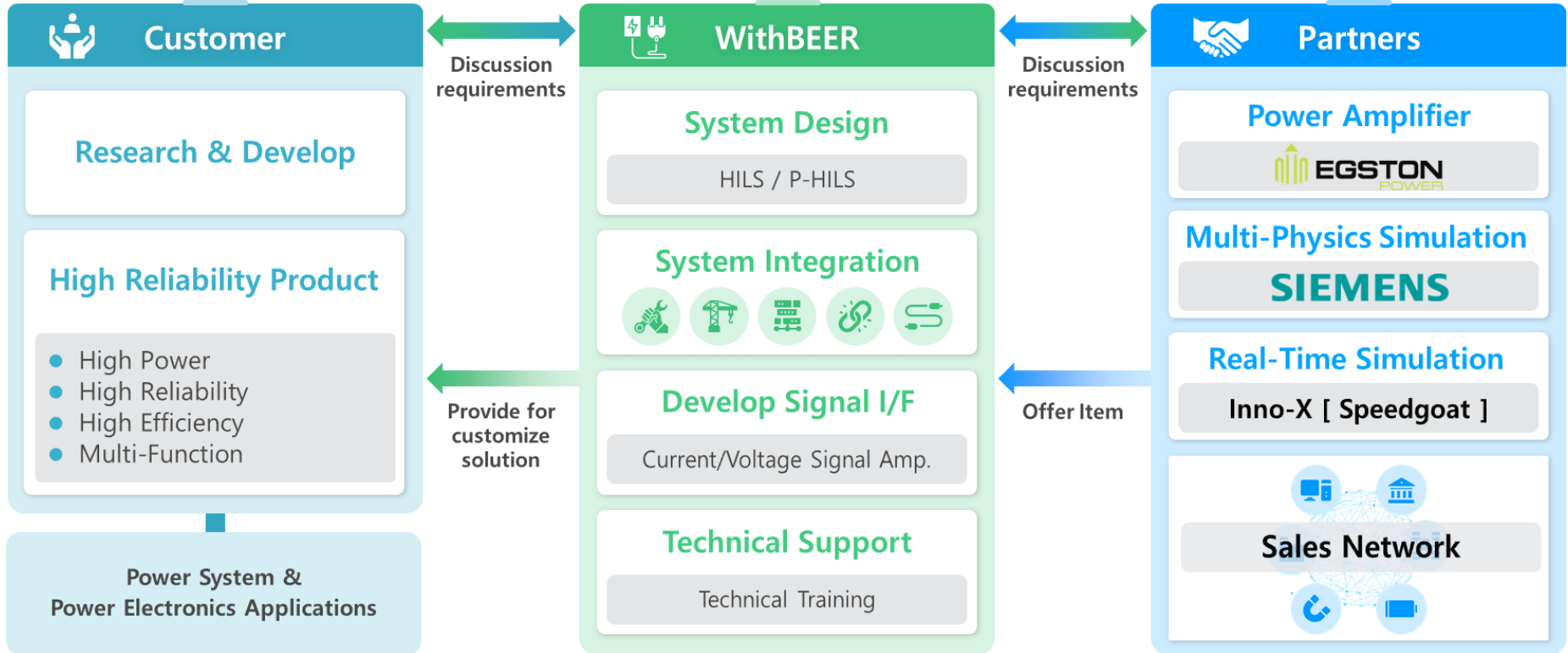
...

- Signal Amplifier : Current(5Arms)\*4Ch / Voltage(110Vrms)\*4Ch(Max 1.2kW)
- Grid measurement or control application like PMU, IED
- Including strong technical support





## 2. 사업 및 서비스영역 (2)

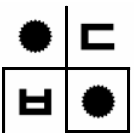




# 고성능 Power-HIL 구축사례

- 01 구축 시스템
- 02 구축 장비 사양
- 03 Power-HIL 시험을 위한 장비 구성
- 04 시험 시스템 구성
- 05 고성능 Power Amplifier 성능평가 요소
- 06 Power Amplifier 성능 시험 구성
- 07 Power Amplifier 성능 시험
- 08 Power Amplifier 성능 지표 - SFP Interface
- 09 Amplifier Parameter Tuning

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# 1. 구축 시스템



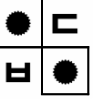
## 에너지벨리기업개발원 DX지원센터

### - 400kW Power HILS

- 가상환경용 플랫폼, 제어기용 플랫폼 [ 실시간 시뮬레이터 ]
- 개발 및 시험용 플랫폼 및 I/O, 통신장비
- 혁신 R&D 프로세스 플랫폼 구축



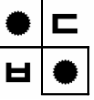




## 2. 구축 장비 사양 – 실시간 시뮬레이터



	400kW급 전력시스템 가상환경 플랫폼	에너지변환장치 가상환경 구현 플랫폼	전력시스템 가상환경 구현 시스템	모델기반제어기 플랫폼
<b>CPU</b>	Intel Xeon 4GHz, 6 Cores	Intel Core i7 4.2 GHz, 4 Cores	Intel Core i7 4.2 GHz, 4 Cores	Intel Celeron 2 GHz, 4 Cores
<b>메모리</b>	32GB	32GB	32GB	4GB
<b>RTOS</b>	Simulink Real-Time			
<b>FPGA</b>	Xilinx Kintex-7 325k	Xilinx Kintex-7 325k	Xilinx Kintex-7 UltraScale 1450K	Xilinx Artix-7 50k
<b>Analog Input</b>	16Ch Differential, 16-bit	32Ch Differential, 16-bit	-	20Ch
<b>Analog Output</b>	16Ch Single-Ended, 16-bit	24Ch Single-Ended, 16-bit	-	12Ch
<b>Digital IO</b>	56Ch TTL I/O lines	8Ch TTL I/O lines	14Ch TTL I/O lines	14Ch TTL I/O lines
<b>SFP Comm.</b>	4x SFP+ cages for Power Amplifier	-	QSFP(SFP+10Gbps)	-



## 2. 구축 장비 사양 – Power Amplifier

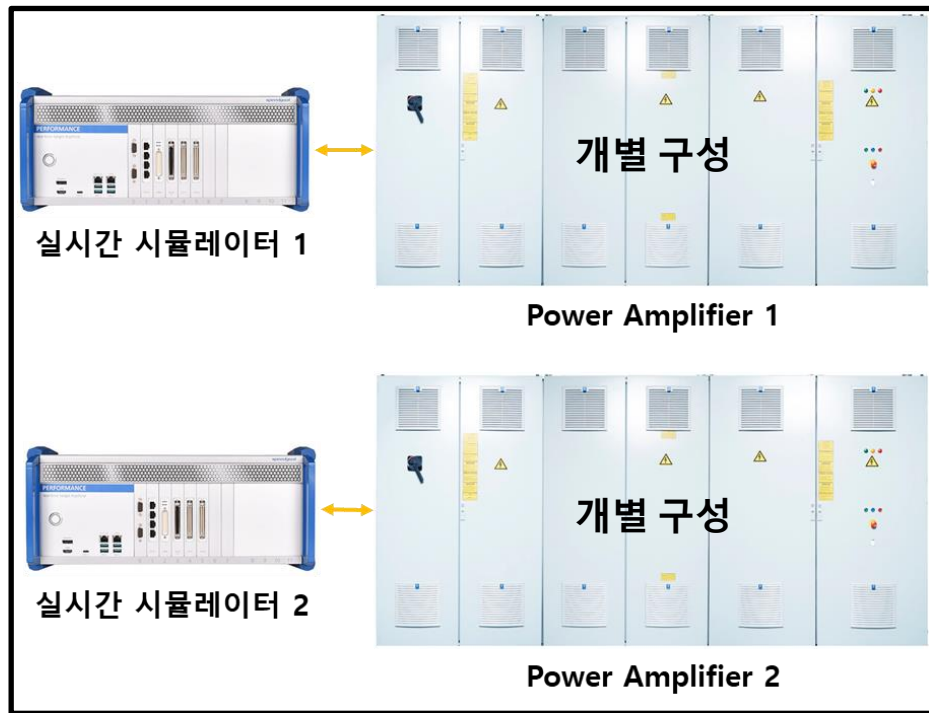
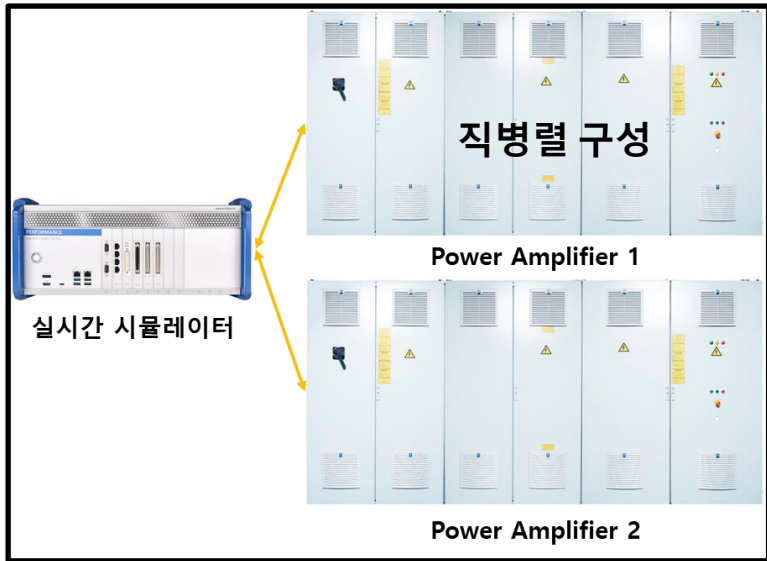


EGSTON Power Electronics GmbH - CSU200 1GAMP6-HV \* 2

Rated System Power	Total 400kW(200kW * 2)		
출력 모드	3 Phase AC / 3 Phase + N / Single Phase Single Phase + DC / DC-Bipolar / DC-Unipolar		
최대 출력 주파수[Full-Range]	~5kHz		
최대 하모닉 출력	~15kHz		
Delay Time[Typical]	28us		
HIL 인터페이스	5Gbps SFP(Fiber Optics Communication), Analog		
Setpoint Time Step	최대 4us		
	단독	직렬	병렬
최대 AC 전압/전류	3상 485Vrms / 240A 단상 565Vrms / 360A	-	3상 485Vrms / 480A 3상 565Vrms / 단상 750A
최대 DC 전압/전류	820V / 840A	1500V / 840A	820V / 1680A

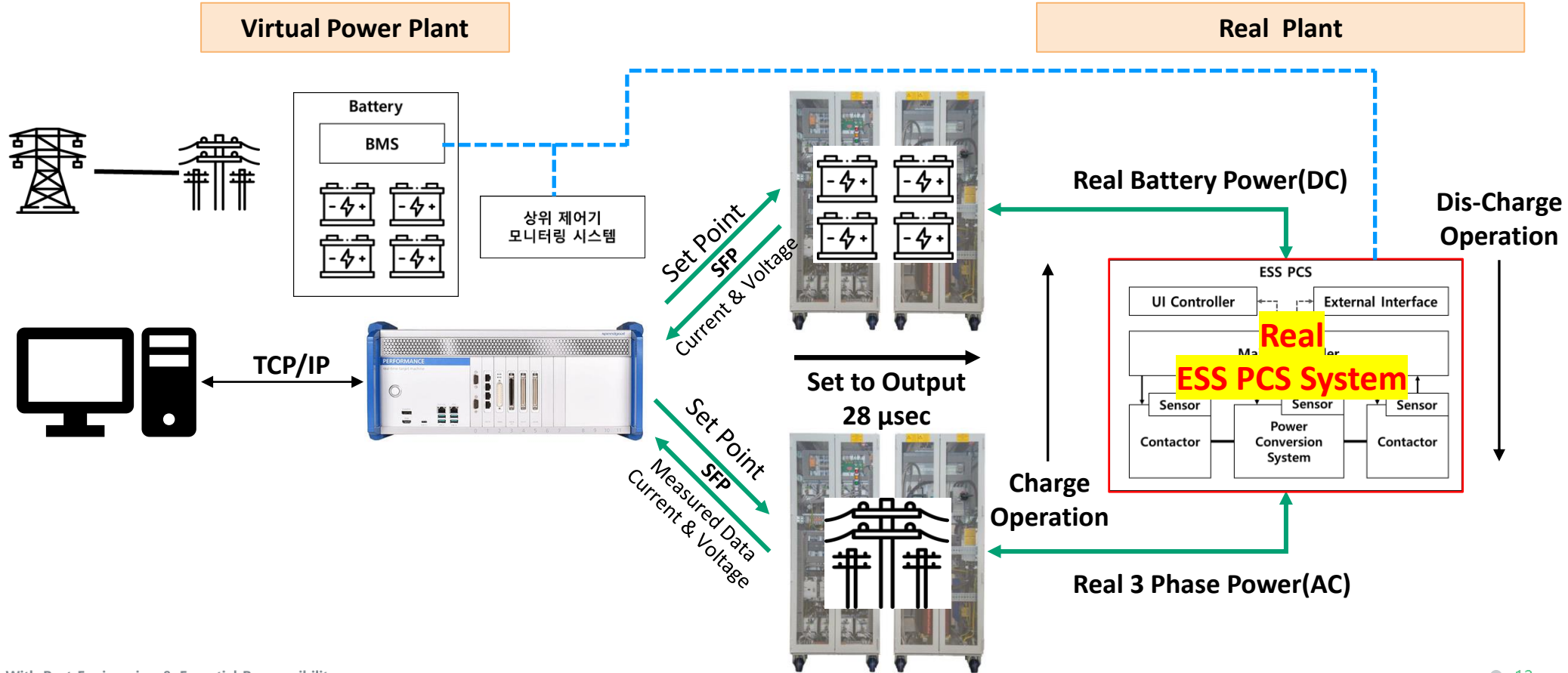
### 3. Power-HIL 시험을 위한 장비 구성

- Application 및 DUT에 따른 다양한 구성의 장비 사용
  - 다양한 구성으로 사용 가능하도록 구축[실시간 시뮬레이터:Power Amplifier]: 1:1 / 1:2 / 2:2



# 4. 시험 시스템 구성 – ESS PCS Power-HIL

- Power-HILS Configuration



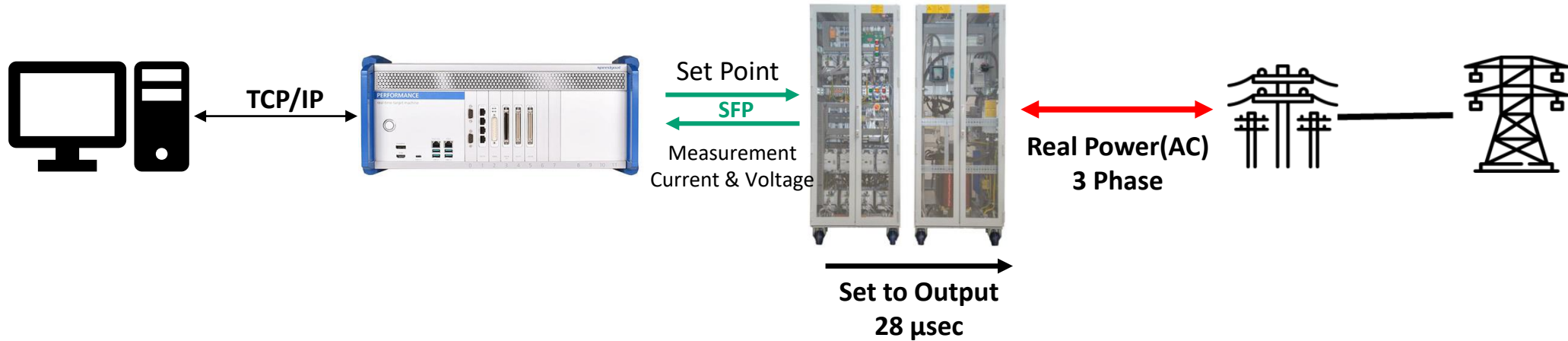
# 4. 시험 시스템 구성 – Power-HIL

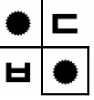
- Power-HILS Configuration

Virtual System

Real Plant

Virtual Power System  
ESS / PV / Load / Wind  
House / Factory



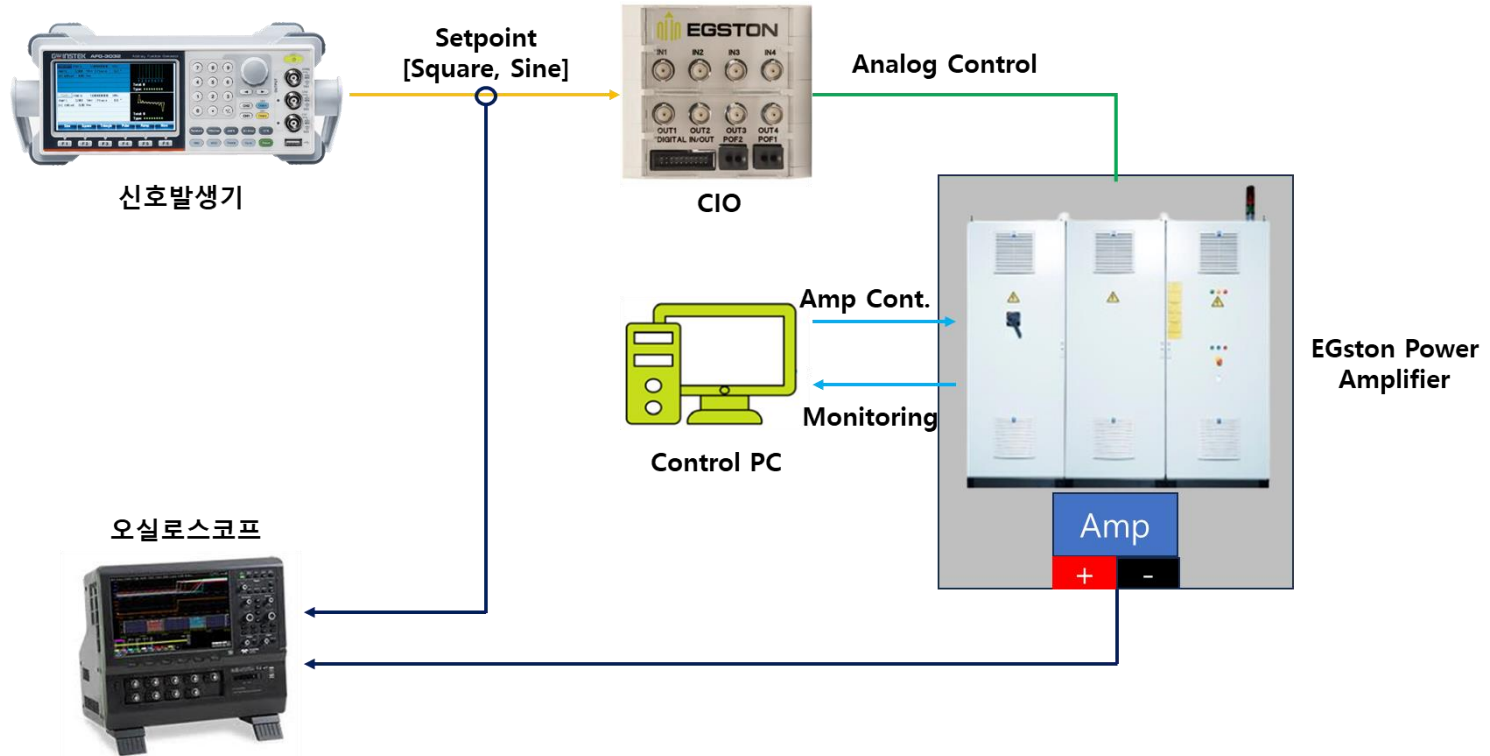


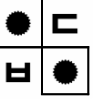
## 5. 고성능 Power Amplifier 성능평가 요소

- P-HILS의 Power Amplifier 성능평가 요소
  - Amplifier 인터페이스
    - 인터페이스 타입 : Analog
    - 통신 인터페이스 : SFP / Fiber-Optic (Aurora Protocol)
    - 통신속도 : 최대 5Gbps
    - 통신시간(시뮬레이터  $\leftrightarrow$  Amp) : 최대 5~ 10 Micro-Sec 마다
    - Setting Point : Current or Voltage
    - Sensing Data : Current & Voltage
  - Delay Time [ Input to Output ] : < 수십 Micro-Sec
  - Voltage slew rate : ex) 12V / Micro-Sec
  - High Frequency Range : DC ~ 5kHz [Full Range]
  - 주입 가능한 하모닉 : ~ 15kHz ( 100<sup>th</sup>)

## 6. Power Amplifier 성능 시험 구성

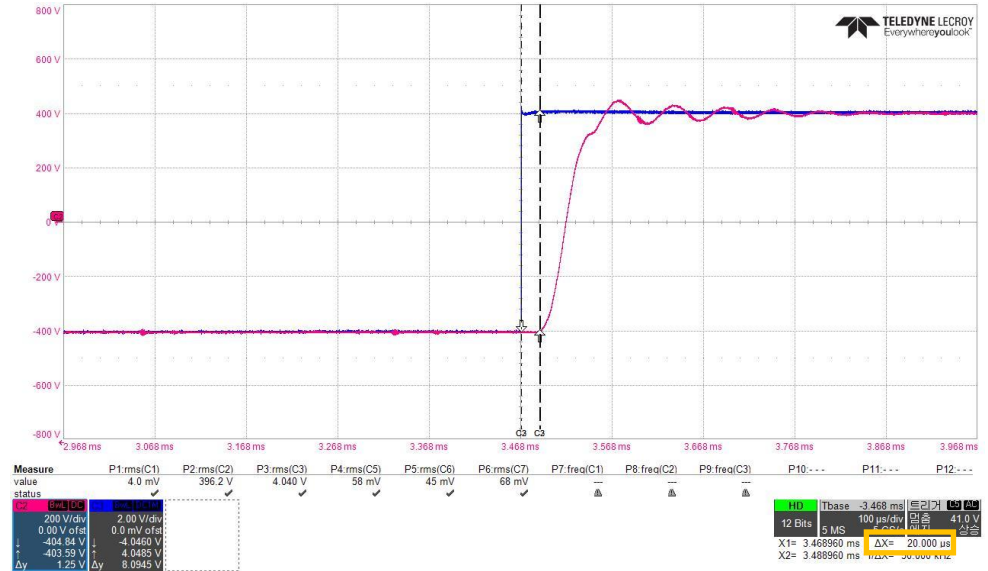
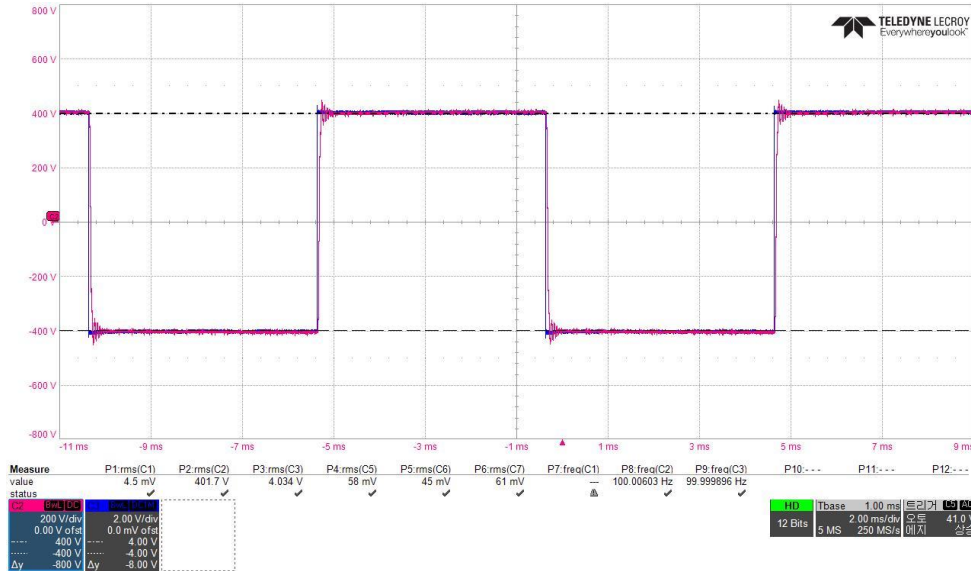
- Power Amplifier 성능 평가 시험 구성
  - 신호발생기: Analog Setpoint 출력 [구형파, 사인파]
  - 오실로스코프: Analog setpoint & Amplifier 출력 측정



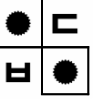


# 7. Power Amplifier 성능 시험 - 응답성

- Power Amplifier 성능 측정 - 응답성
  - Analog 입력: Square Waveform
  - 주파수: 100Hz
  - Duty: 50%
- Analog 응답성: 20us

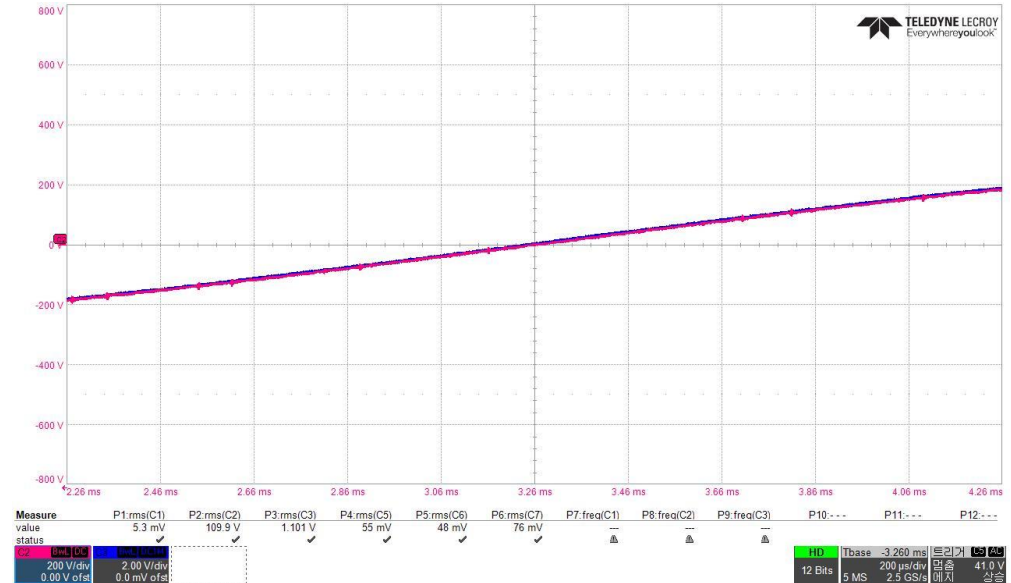
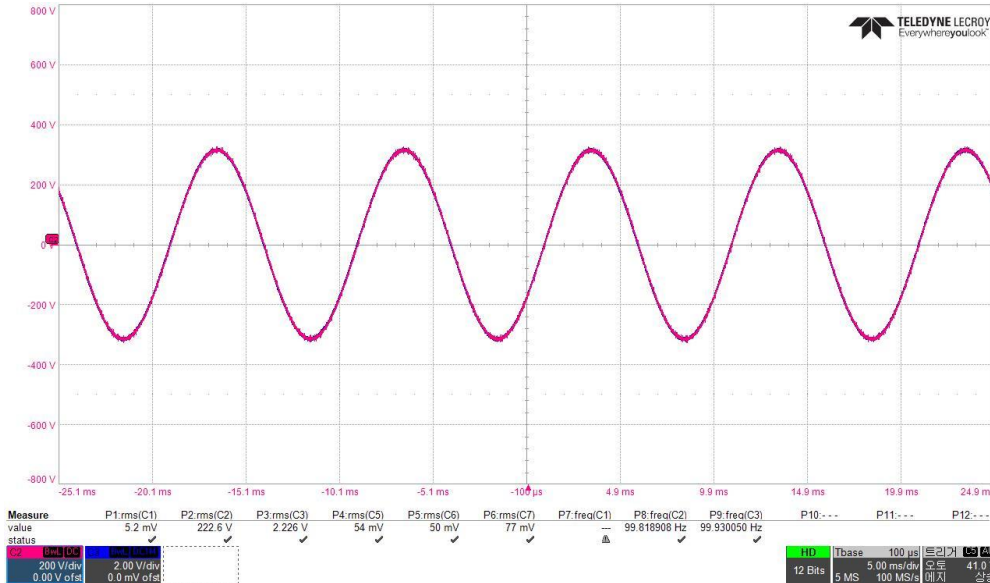






# 7. Power Amplifier 성능 시험 - 응답성

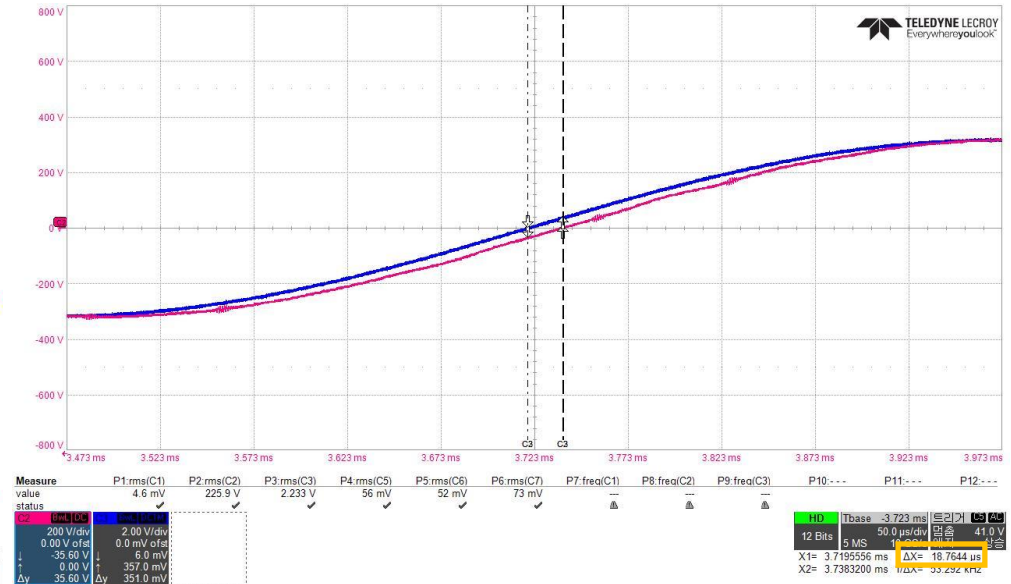
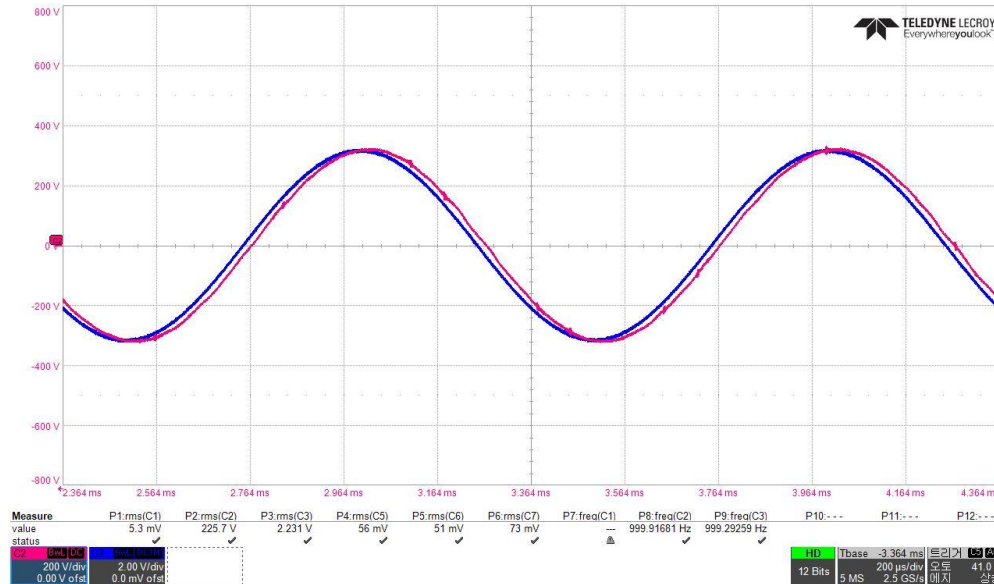
- Power Amplifier 성능 측정 - 응답성
  - Analog 입력: Sine Waveform
  - 주파수: 100Hz
- Analog 응답성: 1us 이하

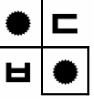




# 7. Power Amplifier 성능 시험 - 응답성

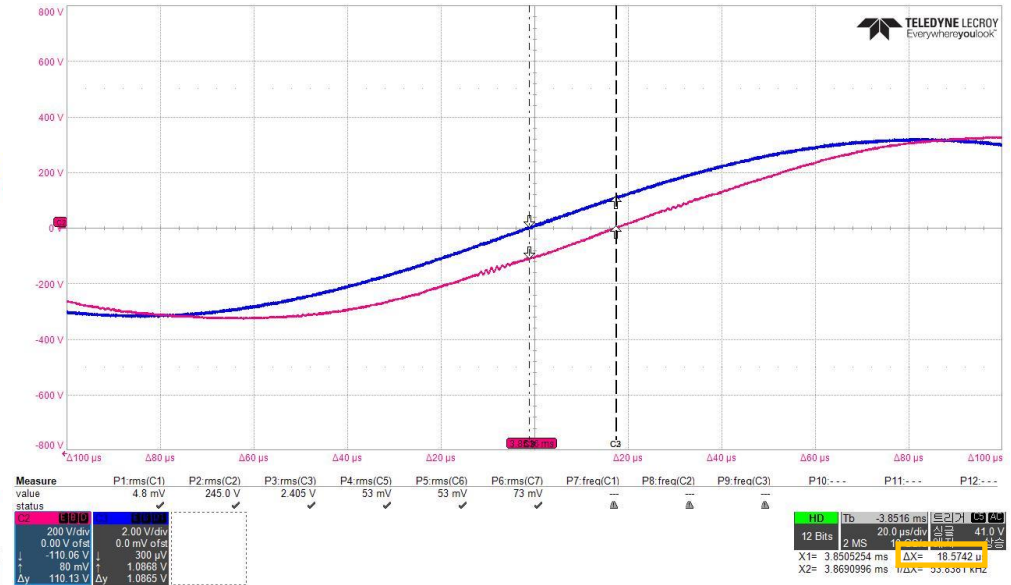
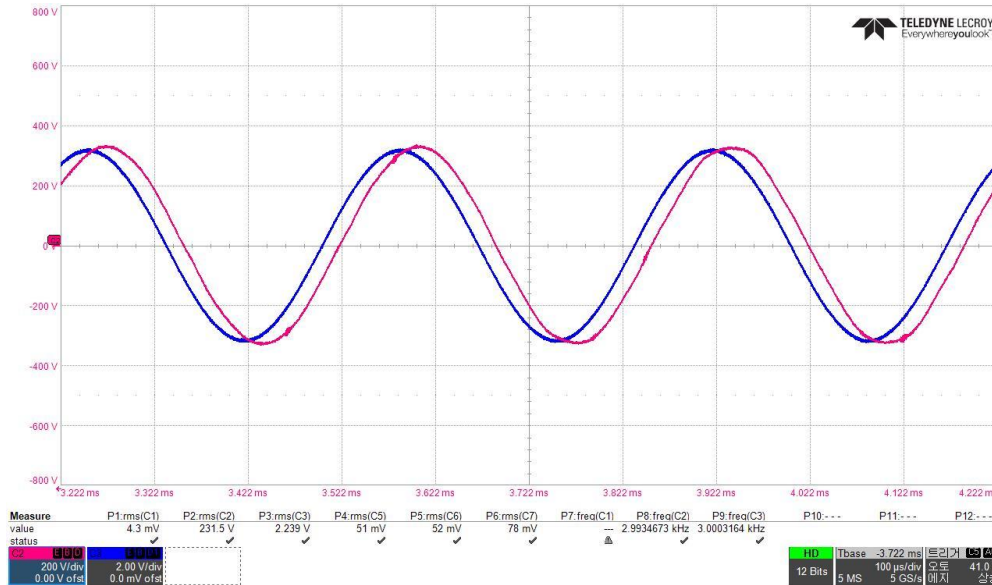
- Power Amplifier 성능 측정 - 응답성
  - Analog 입력: Sine Waveform
  - 주파수: 1kHz
- Analog 응답성: 18.7us





# 7. Power Amplifier 성능 시험 - 응답성

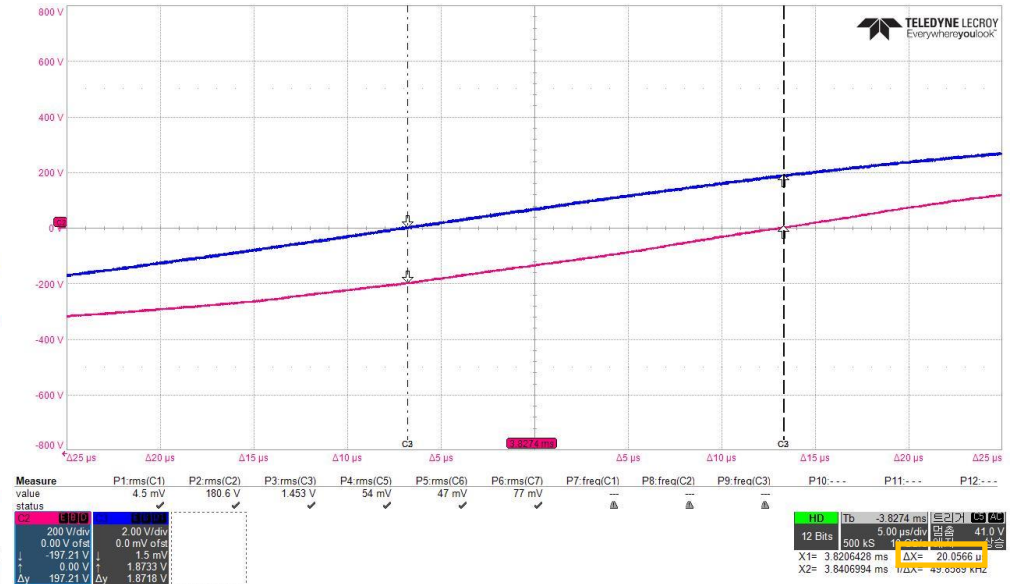
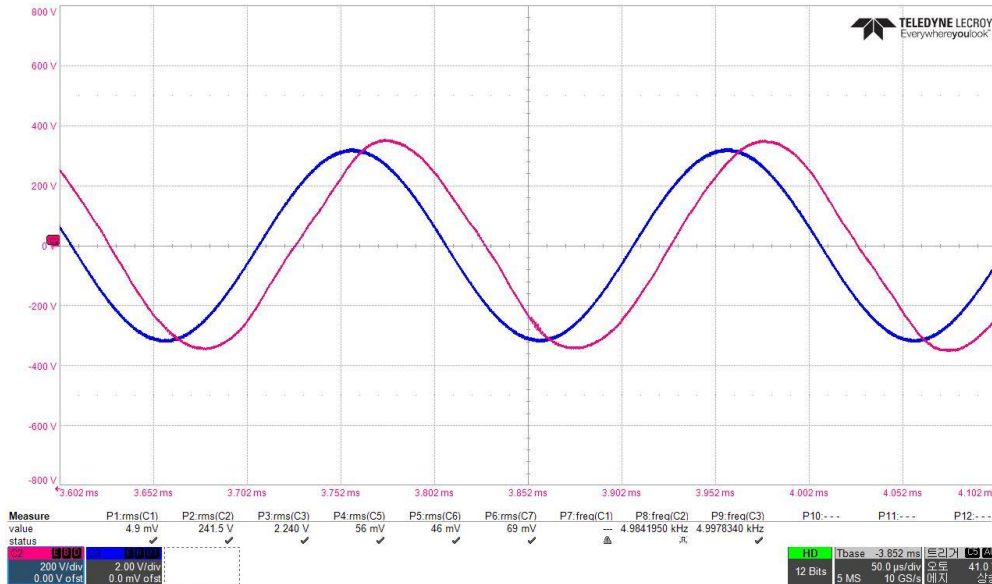
- Power Amplifier 성능 측정 - 응답성
  - Analog 입력: Sine Waveform
  - 주파수: 3kHz
- Analog 응답성: 18.5us





# 7. Power Amplifier 성능 시험 - 응답성

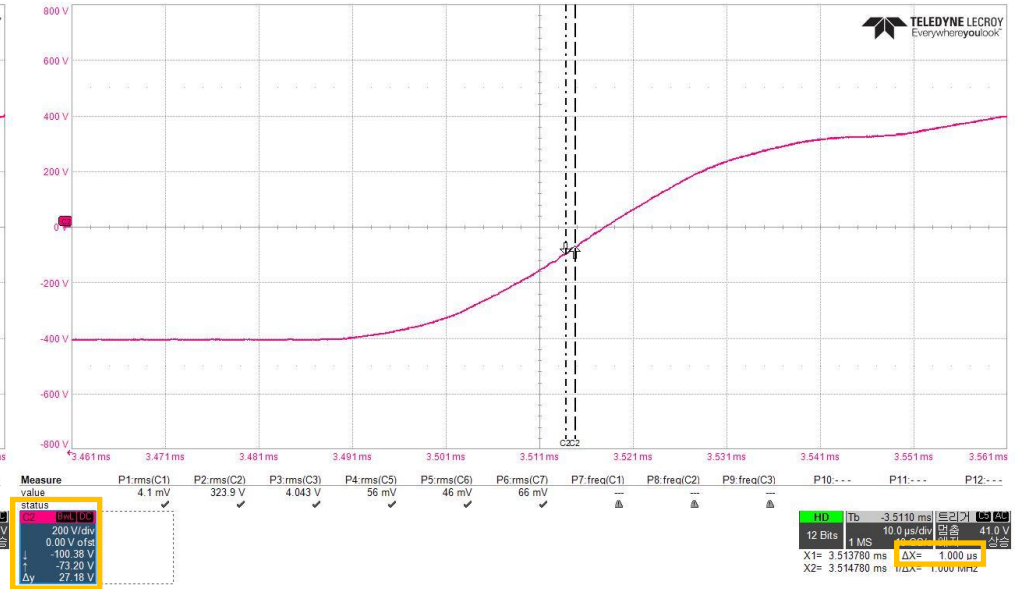
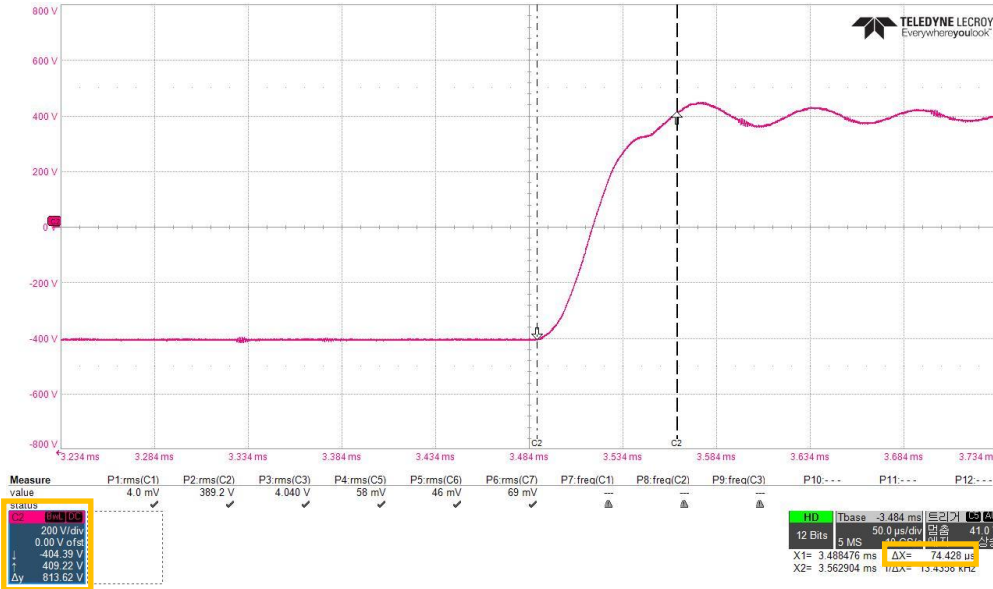
- Power Amplifier 성능 측정 - 응답성
  - Analog 입력: Sine Waveform
  - 주파수: 5kHz
- Analog 응답성: 20.0us





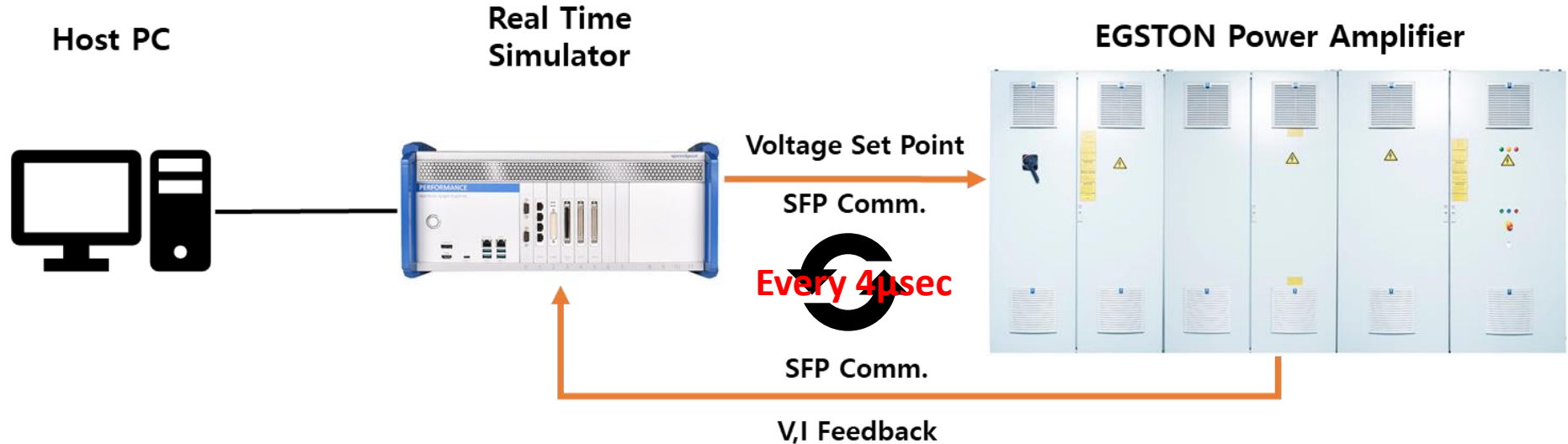
# 7. Power Amplifier 성능 시험 – Slew Rate

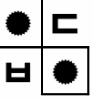
- Power Amplifier 성능 측정 – Slew Rate
  - Analog 입력: Square Waveform
  - 주파수: 100Hz
  - Duty: 50%
- Slew rate: 10.9V/74.42us (최대: 27.18V/us)



## 8. Power Amplifier 성능 지표 - SFP Interface

- Power Amplifier 성능 지표 – SFP Interface
  - PC: 모델링[계통, Amplifier 인터페이스, DUT 등]
  - 실시간 시뮬레이터: 모델 실시간 연산 수행 및
  - Power Amplifier: 전압 출력 및 전압/전류 Feedback[SFP Interface]

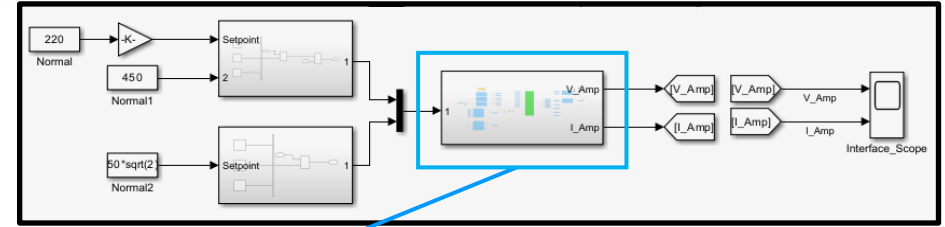




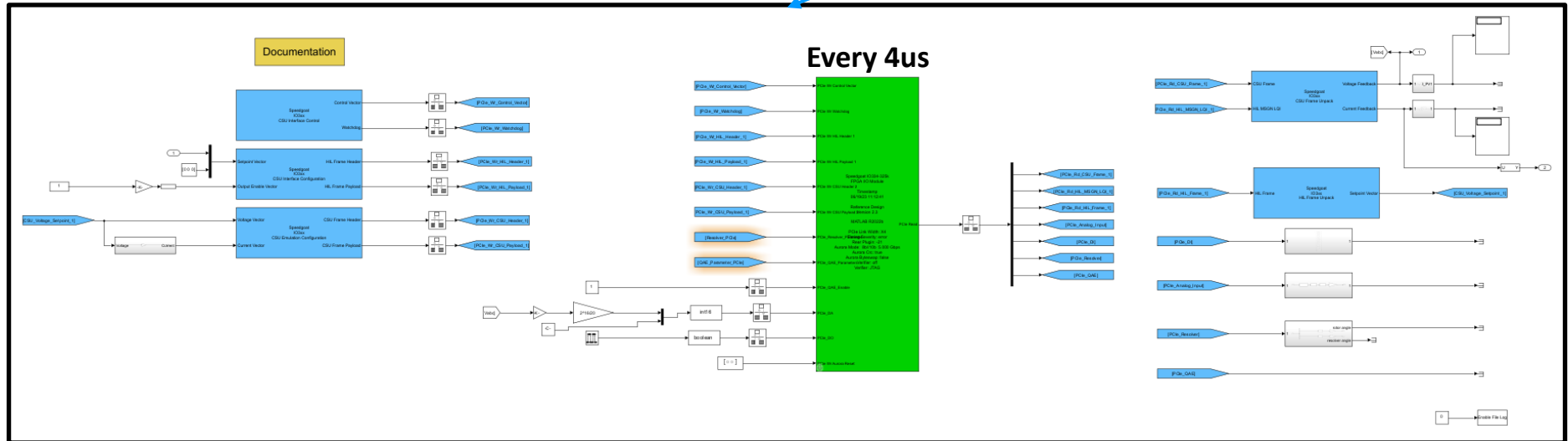
# 8. Power Amplifier 성능 지표 - SFP Interface

- Power Amplifier 성능 지표 – SFP Interface
  - SFP 인터페이스 모델
    - Voltage Setpoint 입력
    - Current Setpoint 입력
    - SFP 인터페이스
    - Voltage/Current Feedback

SFP Interface Model



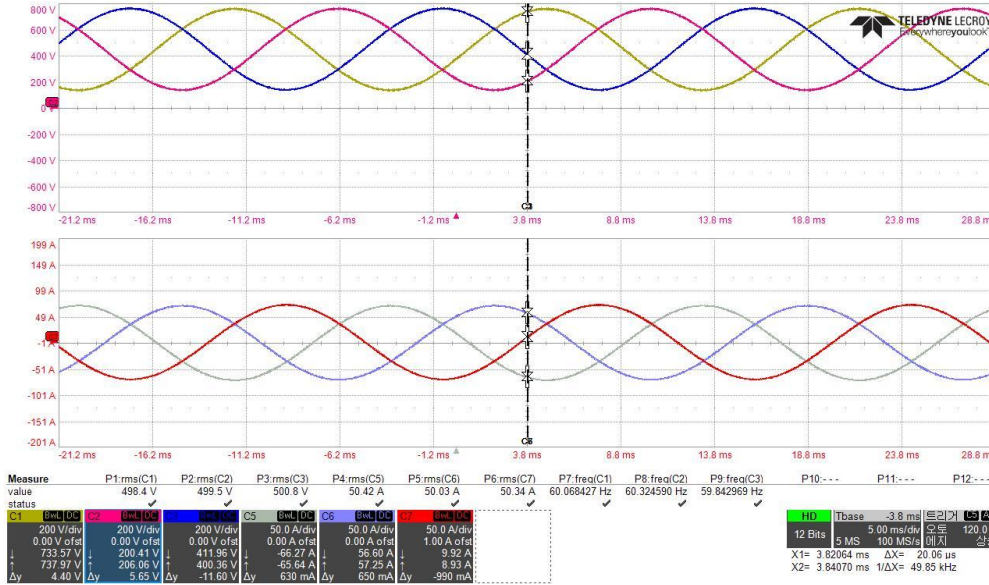
SFP Interface[FPGA]



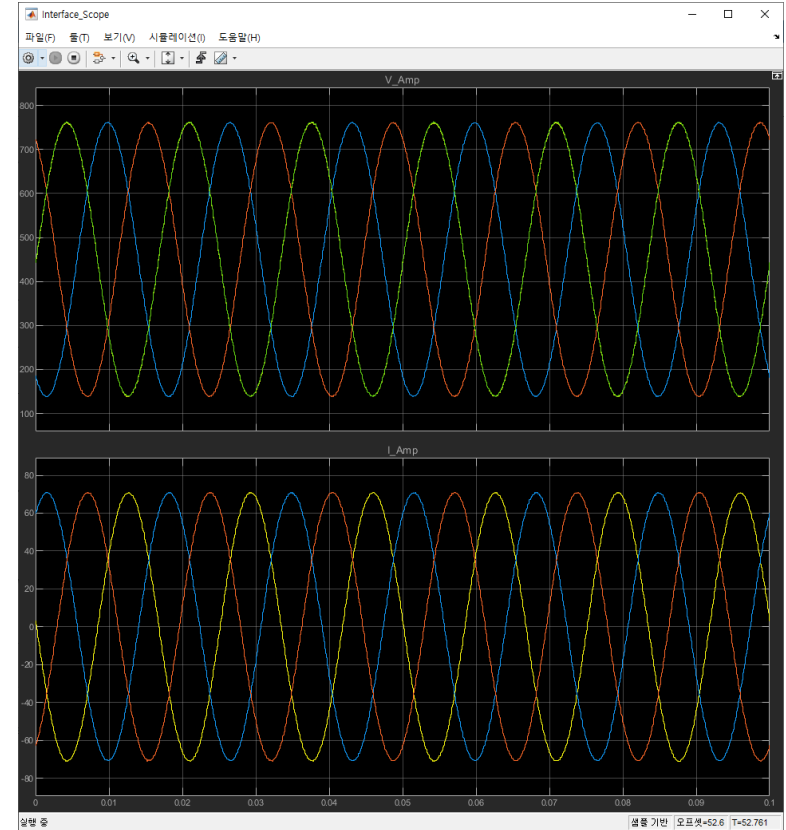


# 8. Power Amplifier 성능 지표 – SFP Interface

- Power Amplifier 성능 평가 – SFP Interface



Amplifier 출력[전압/전류]



Amplifier SFP Feedback[전압/전류]



## 9. Amplifier Parameter Tuning

- Power Amplifier Parameter Tuning
  - Tuning Factor: 전압 / 전류
  - Tuning Parameter: P, I, D,  $dU/dt[V/\mu s]$
  - Target application System을 위한 전압/전류의 응답성, Slew rate 등 최적화 가능

**Controller Parameter** ✕

▼ default\_E6\_3ACN\_CV Load

$I_{L1}$   $I_{L2}$   $I_{L3}$	$V_N$
P part [%] (0-200) <input style="width: 80px;" type="text" value="80.00"/>	P part [%] (0-200) <input style="width: 80px;" type="text" value="5.00"/>
I part [%] (0-200) <input style="width: 80px;" type="text" value="5.00"/>	I part [%] (0-200) <input style="width: 80px;" type="text" value="1.00"/>
Disturbance Feed Forward [%] (0-100) <input style="width: 80px;" type="text" value="90.00"/>	Disturbance feed forward [%] (0-100) <input style="width: 80px;" type="text" value="0.00"/>
Oscillation <span style="color: green; font-size: 1.2em;">●</span>	Oscillation <span style="color: green; font-size: 1.2em;">●</span>

$dU/dt$  max [V/ $\mu s$ ]

Clear Trips
PWM

Close
◀HW ▶HW



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