

# 원자로 열유체 실험 (4)

Department of Nuclear Engineering, Seoul National Univ.  
Hyoung Kyu Cho

# 계측기 구성 일반

## ❖ 계측

- ✓ 물리적 변수에 특정한 수치 부여, 측정 변수의 정량화

## ❖ 계측 시스템 구성

### ✓ 센서

- 측정 변수 감지 위한 자연적 현상을 이용하는 물리적 요소
- 예) 수은 온도계: 액체의 열팽창

### ✓ 변환기

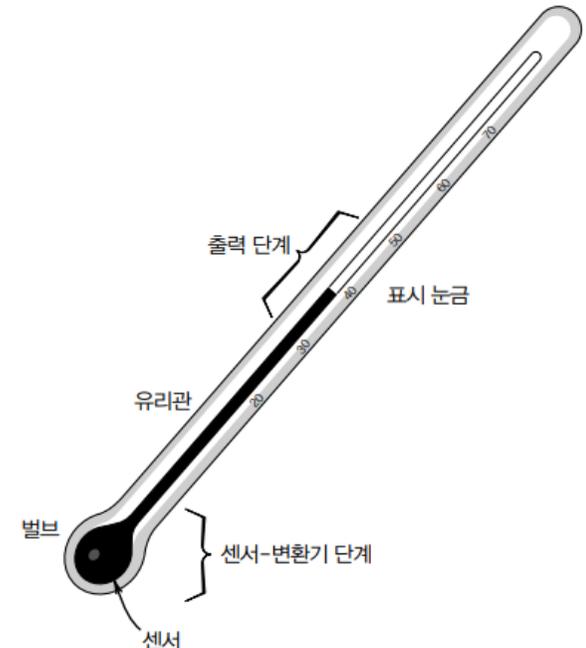
- 감지된 정보의 검출가능한 신호로의 변환
- 예) 수은 온도계: 모세관

### ✓ 신호 처리기

- 변환기 신호의 증폭, 필터링
- 예) 수은 온도계: 모세관 지름

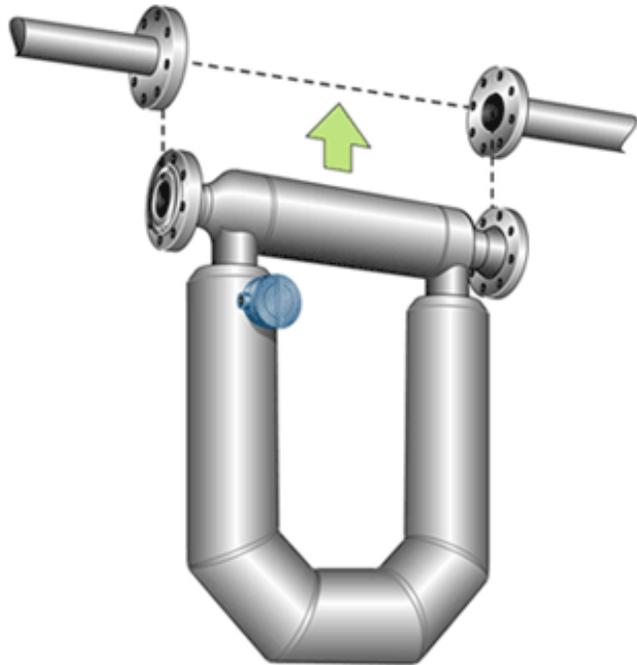
### ✓ 출력

- 감지된 정보의 정량화
- 예) 수은 온도계: 눈금



# 계측기 구성 일반

## ❖ 계측 시스템 일반 구조

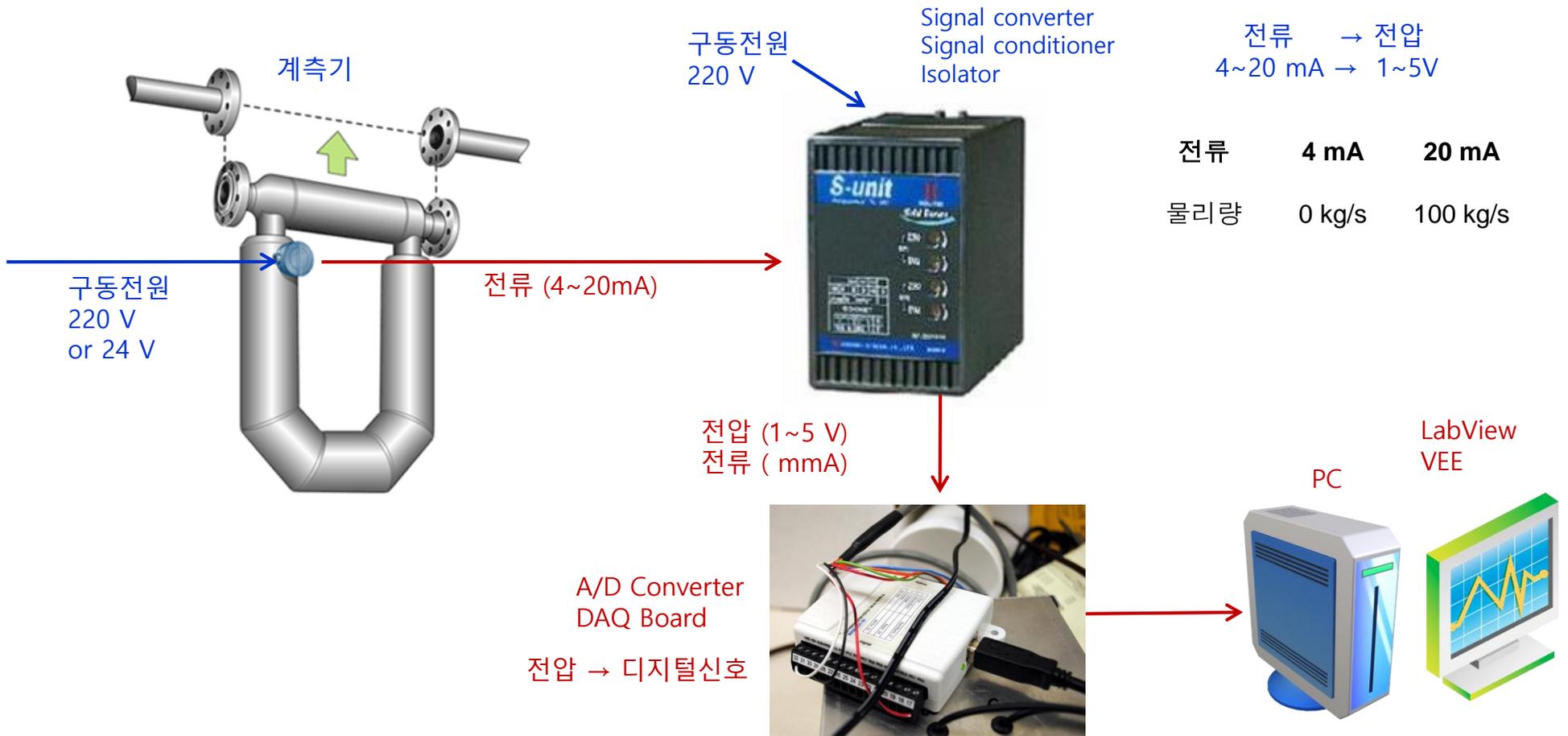


Transmitter



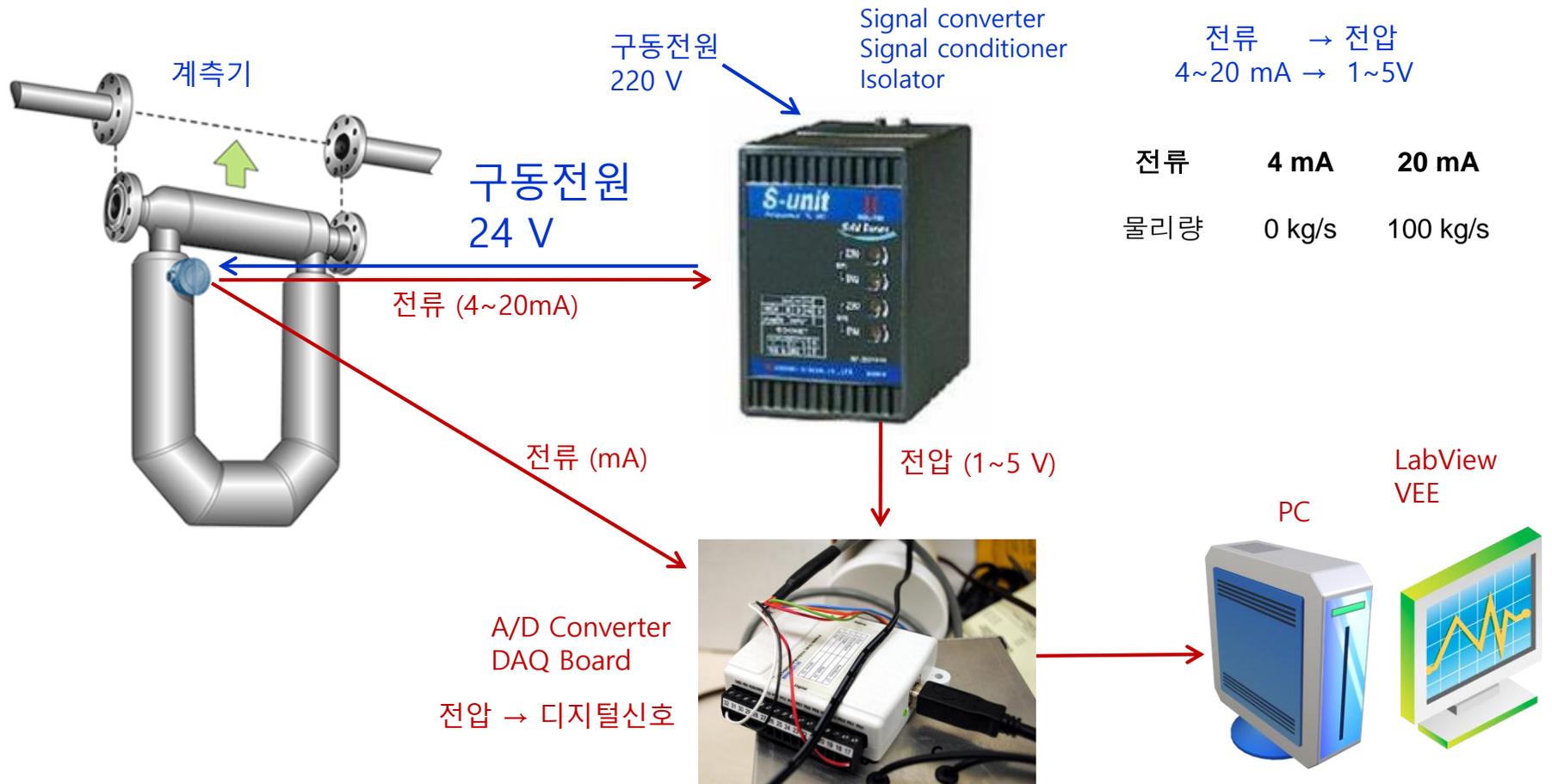
# 계측기 구성 일반

## ❖ 계측 시스템 일반 구조



# 계측기 구성 일반

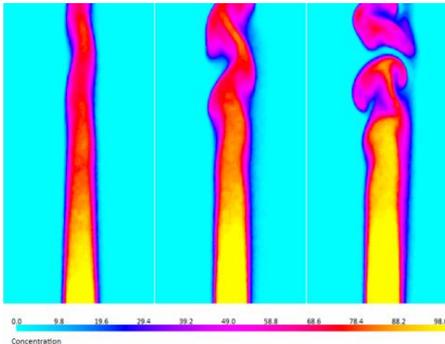
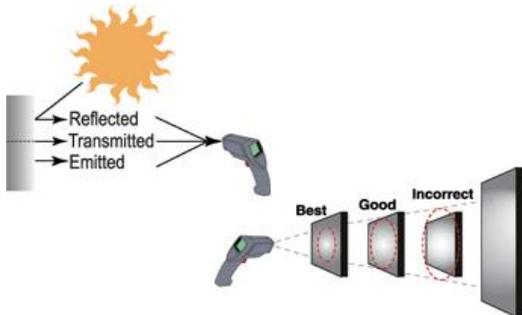
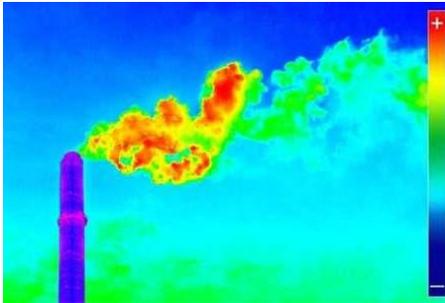
## ❖ 계측 시스템 일반 구조



# 온도 측정 방법

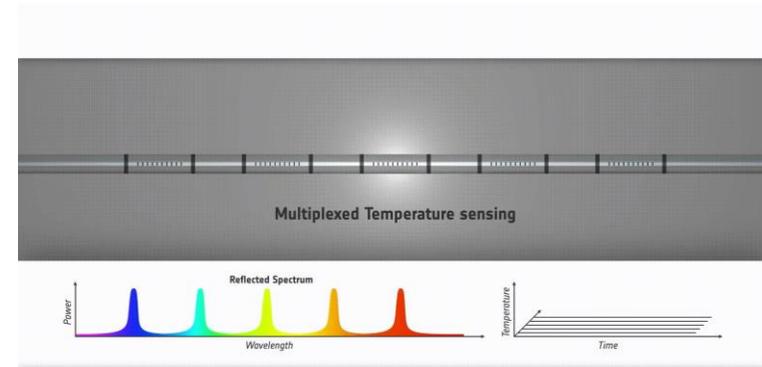
## ❖ 온도측정 기기 종류

- ✓ Glass thermometer (mercury thermometer), bimetallic element
- ✓ Thermocouple (열전대), resistance thermometer
- ✓ Radiation thermometer (방사온도계)
- ✓ IR Camera (적외선 카메라)
- ✓ LIF: Laser Induced Florescence
- ✓ Optical fiber



RTD: Resistance Temperature Detector

종류	원리	측정 범위
RTD	전기저항	-200~500°C
열전대	열기전력	-200~1600°C
방사온도계	방사열	700~2000°C



# 온도 측정 방법

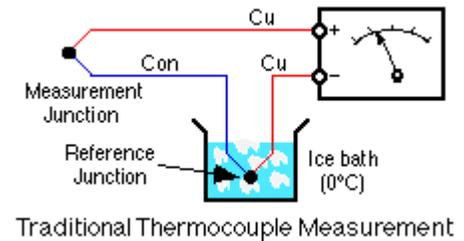
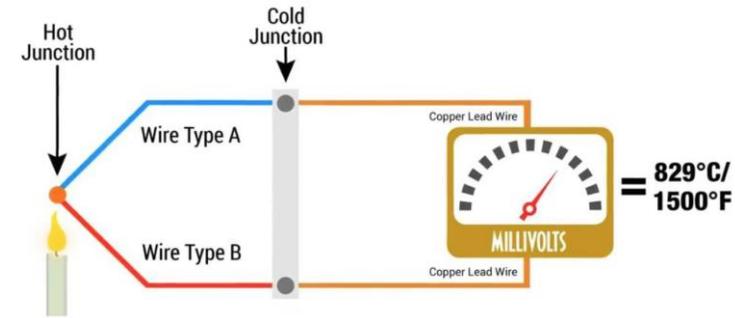
## ❖ Thermocouple (열전대, 열전쌍)

### ✓ 측정 원리

- Seebeck (제벡) 효과
  - 온도 차가 있는 금속이 접촉해 있는 경우, 열전류 발생.
- 발생하는 전압차가 온도차에 비례
- 열전대는 온도차를 측정!

### ✓ Junctions (접점)

- Hot junction (측온접점, 열접점): 온도 측정 부
- Cold junction, reference junction (기준접점, 냉접점): 온도 유지점
- Cold junction의 온도를 정확히 측정하거나 일정하게 유지해야만, 정확한 온도 측정이 가능함.
- Signal converter 또는 DAQ 장비가 cold junction compensation (냉접점 보상) 수행

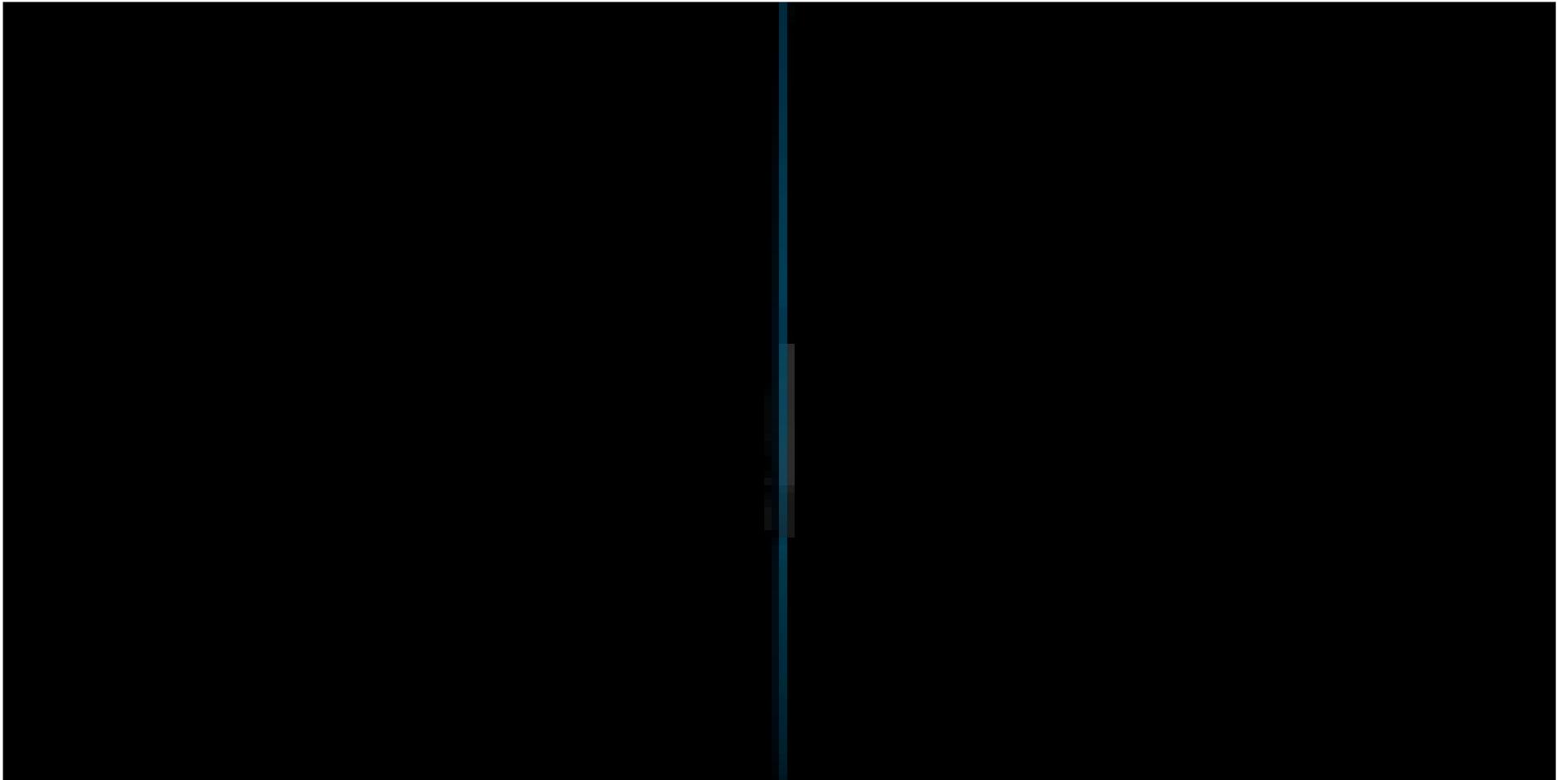


Traditional Thermocouple Measurement

# 온도 측정 방법

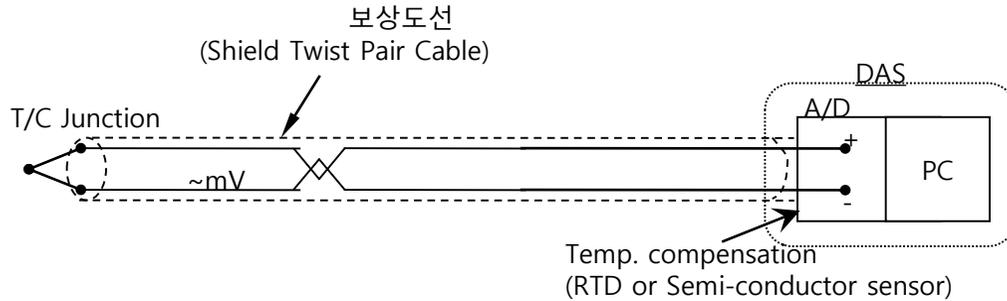
## ❖ Thermocouple (열전대, 열전쌍)

- ✓ 측정 원리 (<https://www.youtube.com/watch?v=0qQjVzpHjsg>)

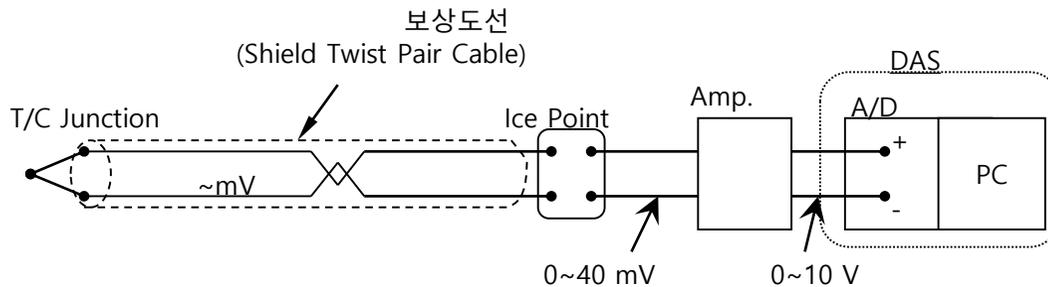


# 온도 측정 방법

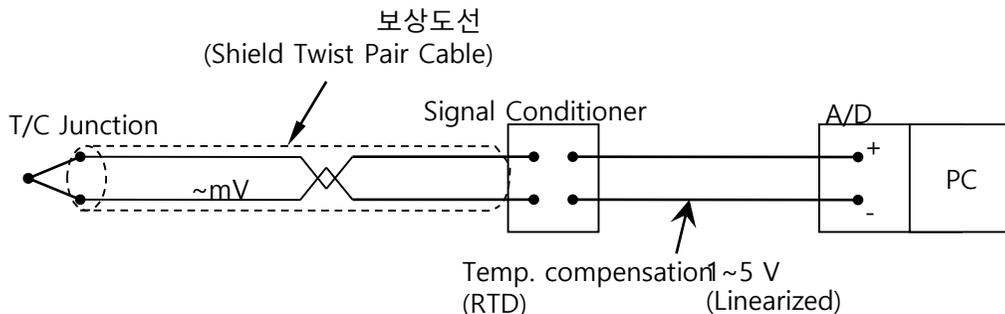
## ❖ Thermocouple (열전대, 열전쌍)



- ✓ Used widely.
- ✓ S/W required for the reference temp compensation and temp. Calculation.
- ✓ A/D I.O. board according to the type of TC



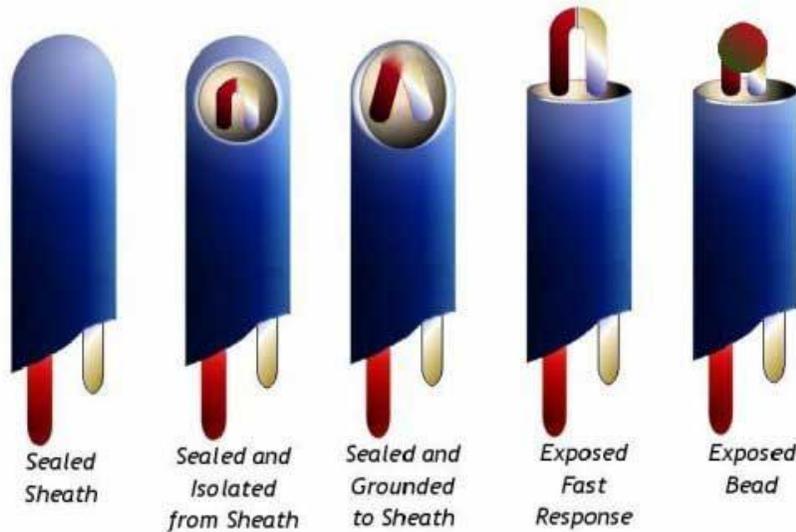
- ✓ Response time is fast
- ✓ Requires table for the temp. calculation.



- ✓ Requires signal conditioner according to TC type
- ✓ Linear relationship between signal and temperature.

# 온도 측정 방법

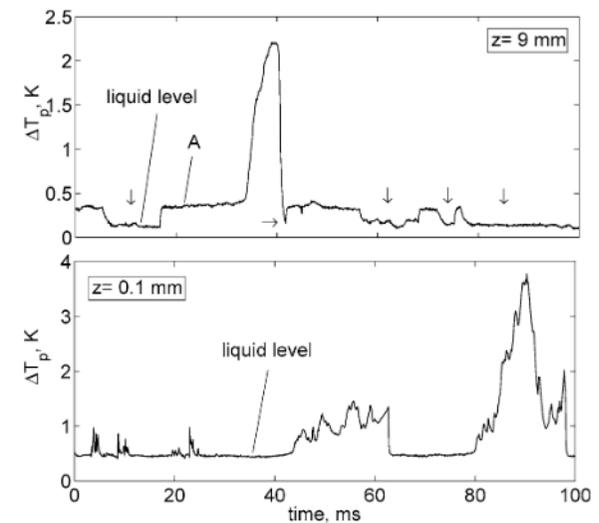
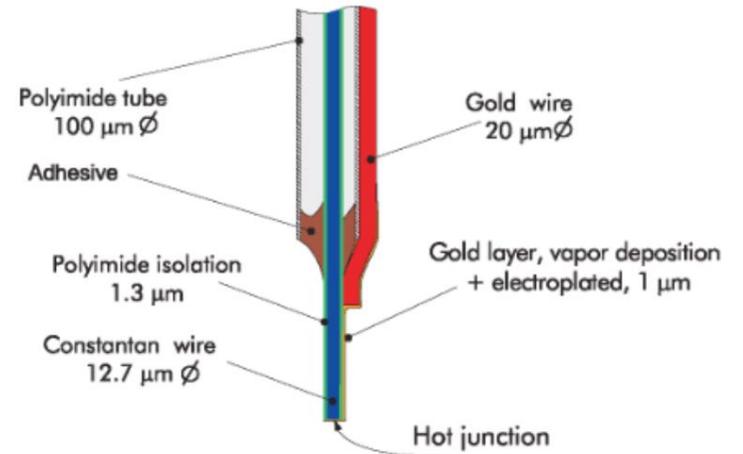
## ❖ Thermocouple (열전대, 열전쌍)



Thermocouple Sheath Options

Type	Noise	Response Time
Sealed/isolated	Good	Bad
Sealed/grounded	Bad	Good
Exposed	Bad	Very good

microthermocouple



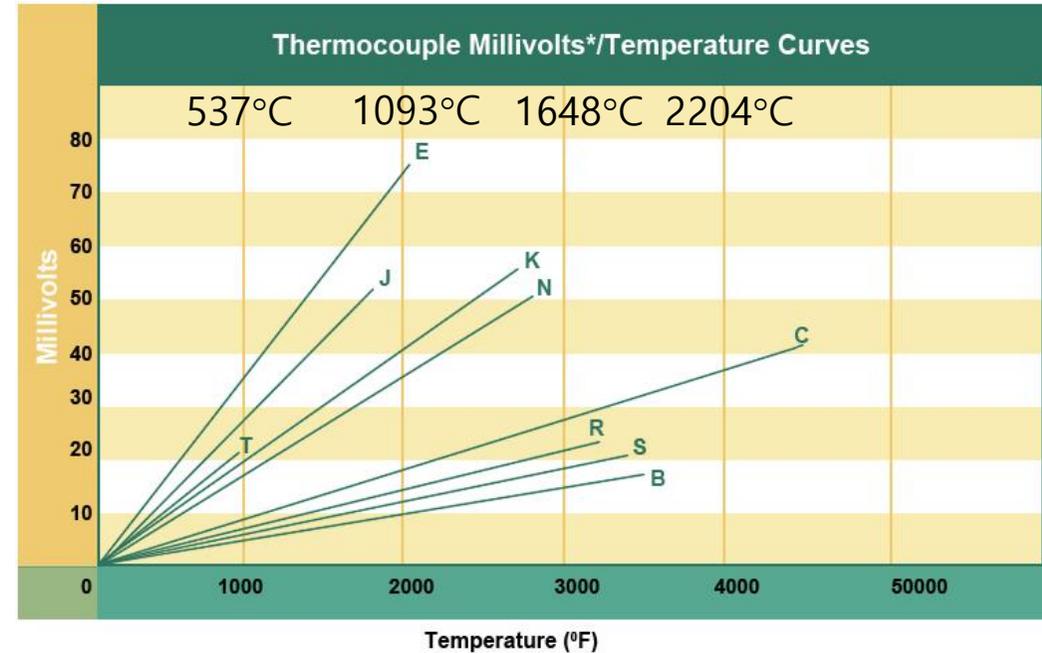
# 온도 측정 방법

## ❖ Thermocouple (열전대, 열전쌍)

### ✓ Type of TCs

- 열수력 실험 시, K type 또는 T type 열전대 사용

Standard Calibration		Material	Temp Range	Accuracy	Premium Grade	Accuracy
"J"	+	Iron	32 F to 1400 F	+/- 4 F or 0.75%	"JJ"	+/- 2 F or 0.4%
	-	Constantan				
"K"	+	Chromel	32 F to 2300 F	+/- 4 F or 0.75%	"KK"	+/- 2 F or 0.4%
	-	Alumel				
"T"	+	Copper	-320 F to 700 F	+/- 2 F or 0.75%	"TT"	+/- 1 F or 0.4%
	-	Constantan				
"E"	+	Chromel	32 F to 1600 F	+/- 3 F or 0.75%	"EE"	+/- 1.8 F or 0.4%
	-	Constantan				
"N"	+	Nicrosil	32 F to 2300 F	+/- 4 F or 0.75%	"NN"	+/- 4 F or 0.4%
	-	Nisil				



# 온도 측정 방법

## ❖ Thermocouple (열전대, 열전쌍)

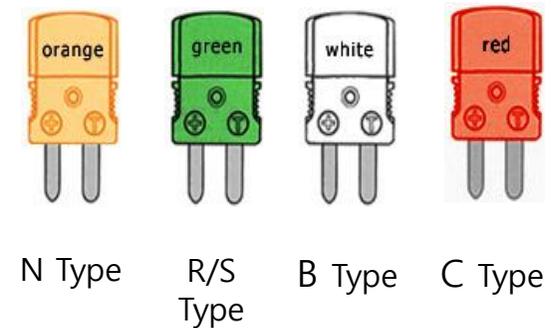
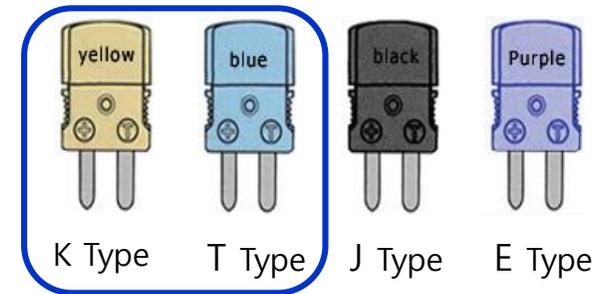
### ✓ TC extension wire (보상도선) and connector

Thermocouple and Extension Wire Color Codes

ASTM Code	ASTM T/C	ASTM Extension	UK BS 1843	Germany DIN 43710	Japan JIS C1610-1981	IEC 584-3
Type B						
Type E						
Type J						
Type K						
Type N						
Type R						
Type S						
Type T						

ANSI 칼라코드

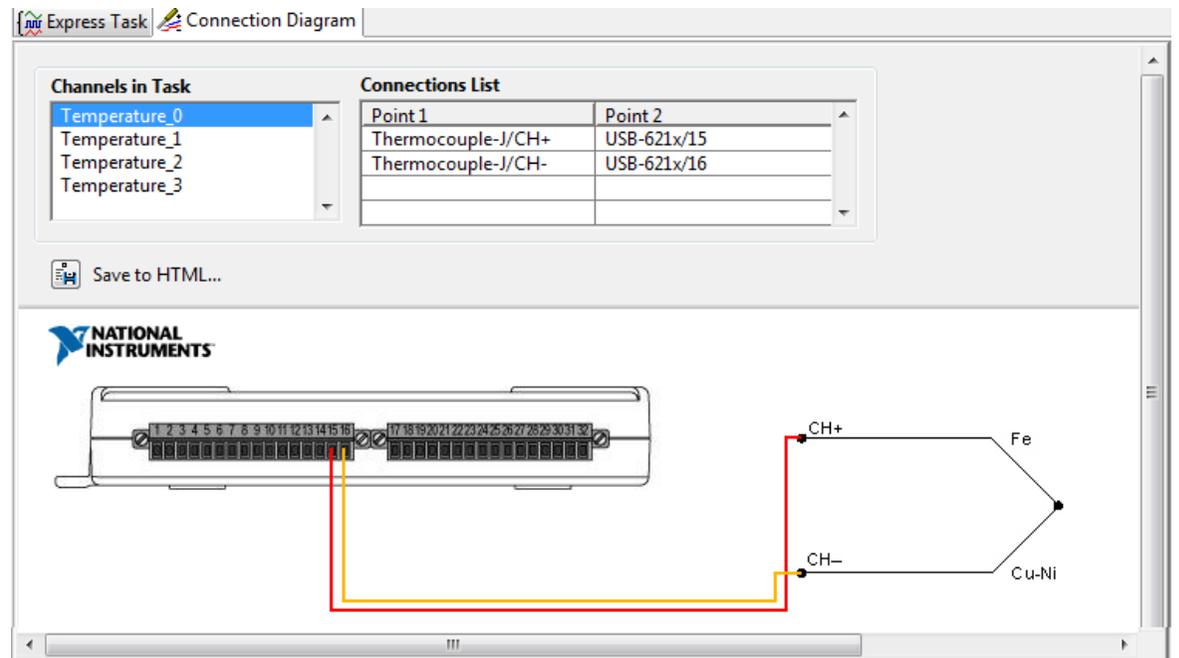
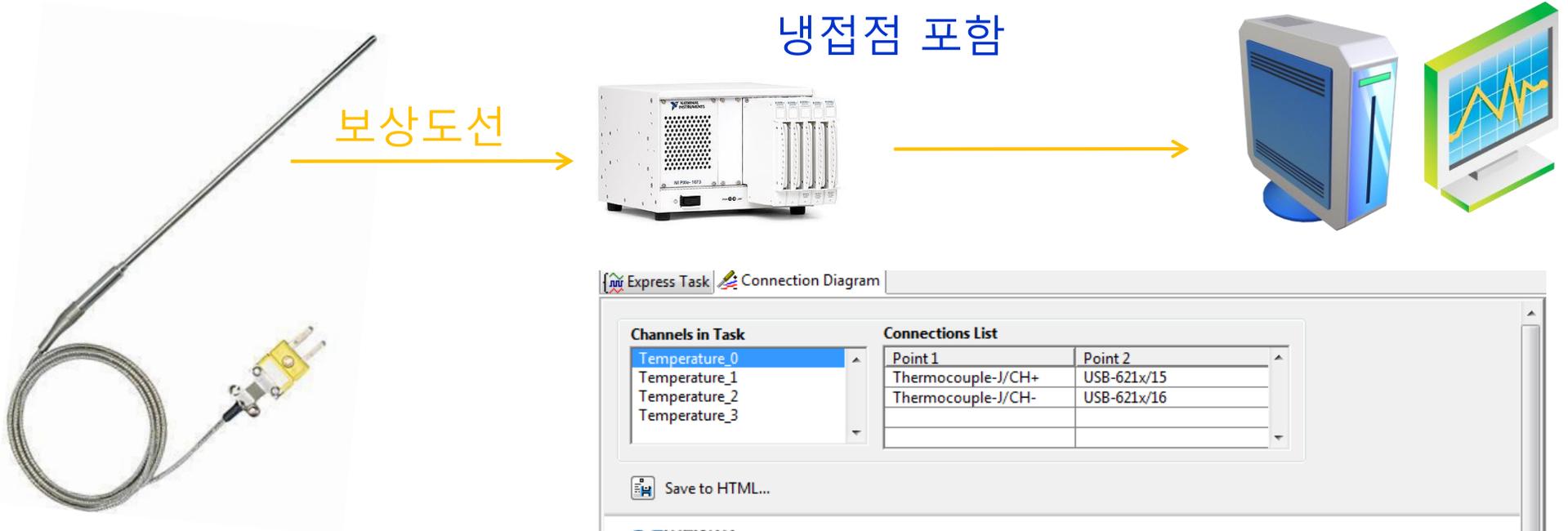
\* 열전대 타입을 칼라로 구별



# 온도 측정 방법

## ❖ Thermocouple (열전대, 열전쌍)

- ✓ 열전대를 이용한 측정 시스템 구성



# 온도 측정 방법

## ❖ RTD (측온저항계)

### ✓ 측정 원리

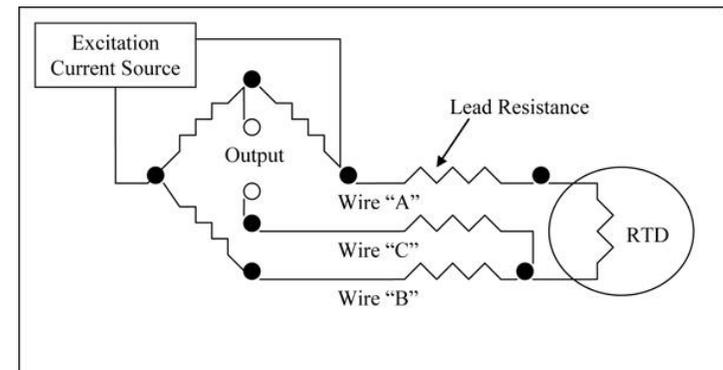
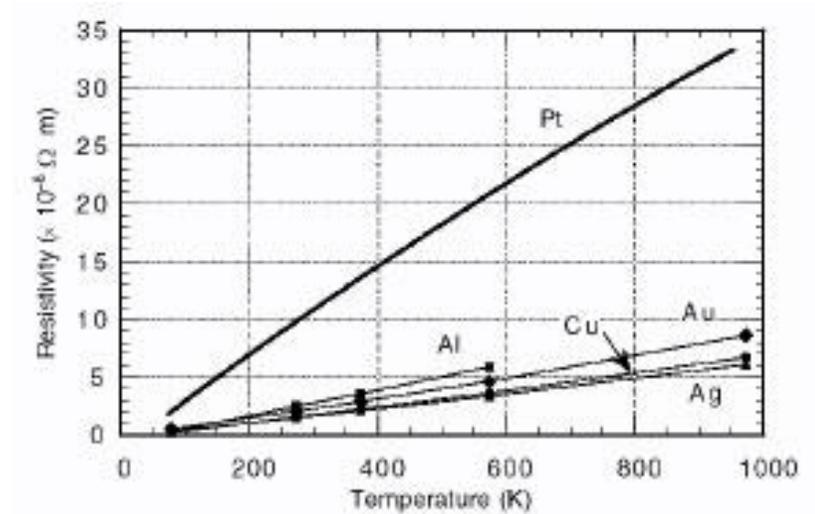
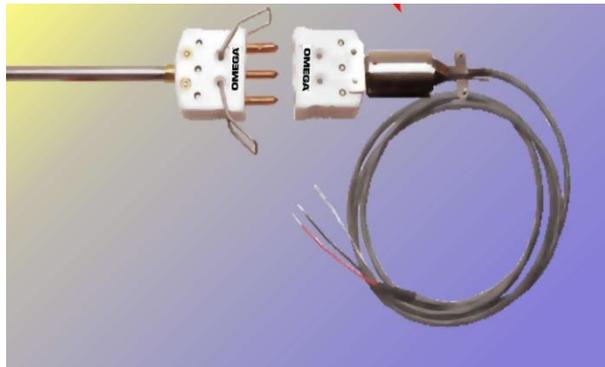
- 온도-저항 (R vs T) 관계를 이용
- Platinum (백금) 사용
  - -200 °C~ 500 °C

### ✓ 장점

- 정확도가 높음: 0.2 %~0.5 %

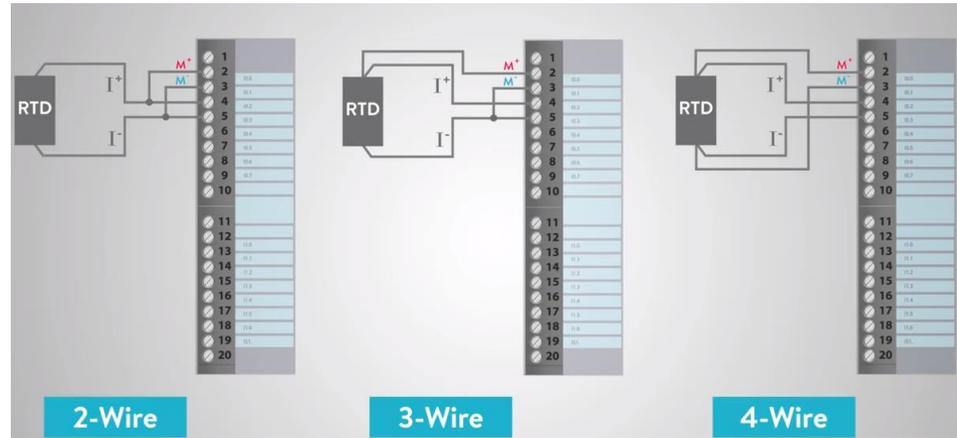
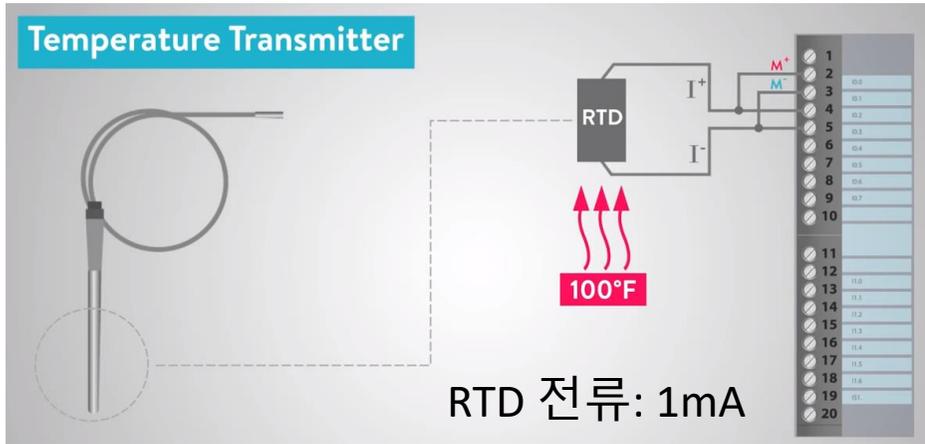
### ✓ 단점

- Slow response time
  - 같은 크기의 TC에 비해 10배 정도 느림



# 온도 측정 방법

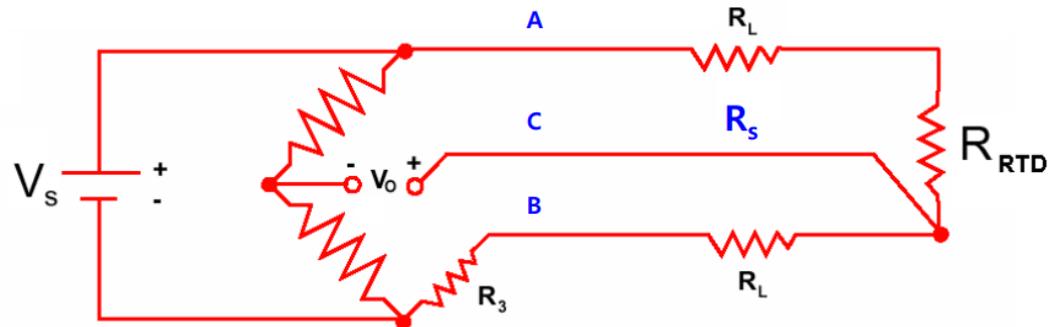
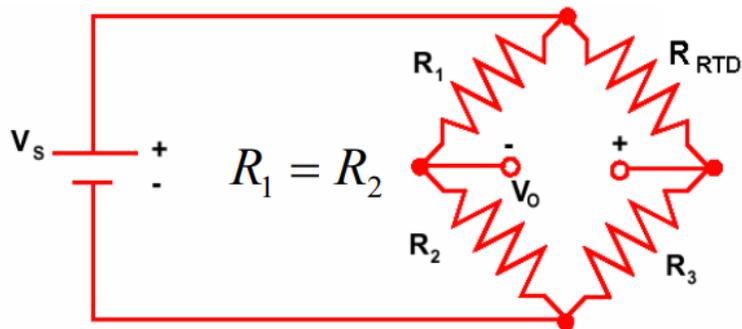
## ❖ RTD (측온저항계)



$$V_o = \frac{R_3}{R_3 + R_{RTD}} V_S - \frac{1}{2} V_S$$

$$R_{RTD} = R_3 \frac{V_S - 2V_o}{V_S + 2V_o}$$

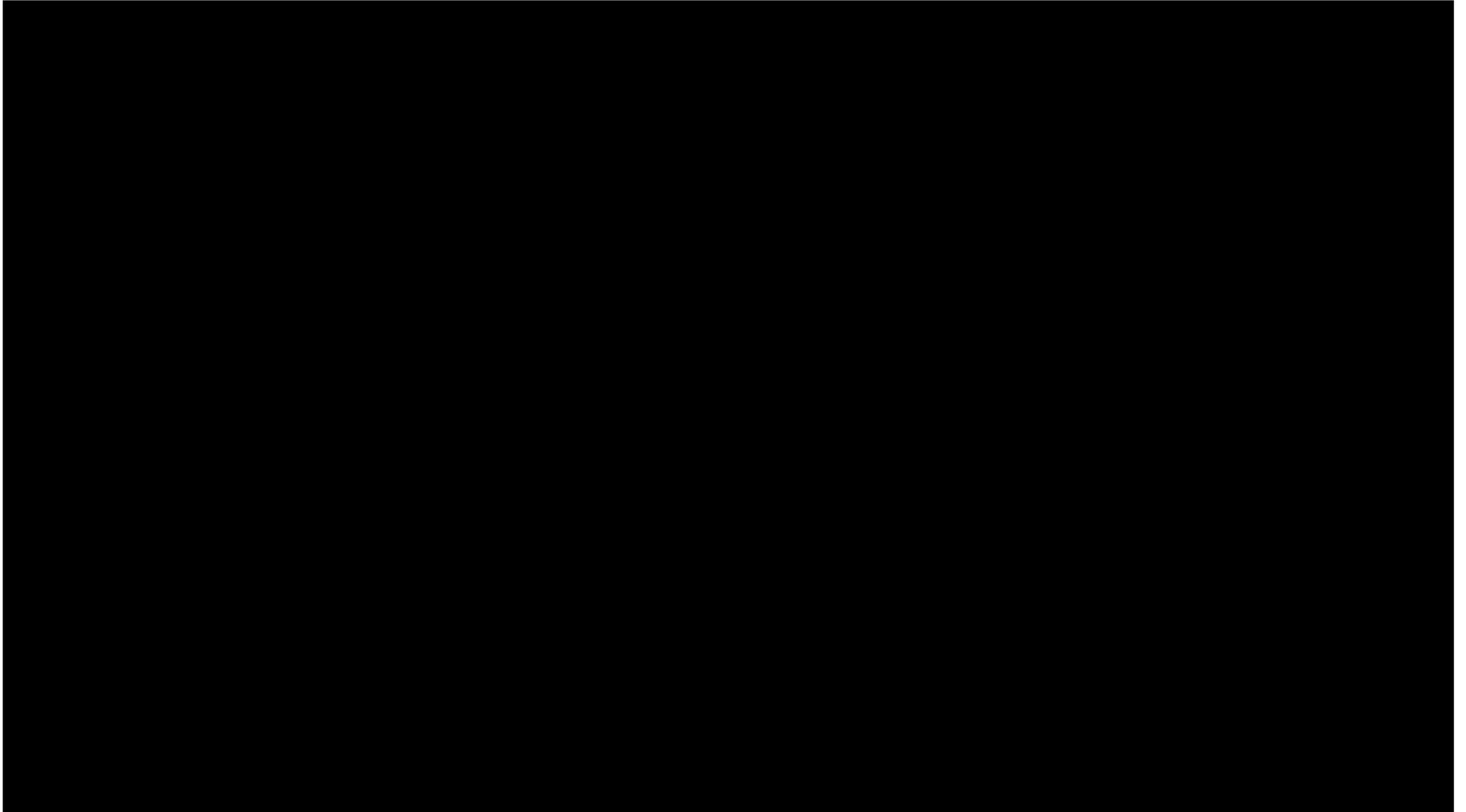
$$R_{RTD} = R_3 \frac{V_S - 2V_o}{V_S + 2V_o} - R_L \frac{4V_o}{V_S + 2V_o}$$



# 온도 측정 방법

## ❖ RTD (측온저항계)

[https://www.youtube.com/watch?v=4mQ3o1t4Ssg&ab\\_channel=RealPars](https://www.youtube.com/watch?v=4mQ3o1t4Ssg&ab_channel=RealPars)



# 온도 측정 방법

## ❖ RTD (측온저항계)

### ✓ Film RTD sensor

- RTD sensor on FPCB

