Set point $q$

$\sum$ $P$ $I$ $D$

Variable DC voltage source

Sense resistor

$R_s$

$V$

$\Delta E$

$E_{kn}$

Heater needle temperature sensor

Offset needle temperature sensor

2.5V

10 kΩ at 20°C

10 kΩ

V

2.5V

Nichrome heater wire

(a)

Heating and cooling DP model (Equation 2)

Signal processing SP and DP model (Section 2.2.2)

Dual probe (DP)

(b)

Sense needle with thermistor

Single probe (SP)

Heater needle with thermistor

Forward model (Equation 1)

Signal processing SP model (Equation 9)

Late-time SP model (Section 2.2.1)

Heat pulse probe (HPP)

Plastic body