Implexx Sap Flow Sensor
&
SDI-12 Parameter
Outputs Explained

C! Command

- **Total sap flow – Litres per Hour**

- Sap Flux Density Outer – $cm^3\ cm^{-2}\ hr^{-1}$

- Sap Flux Density Inner – $cm^3\ cm^{-2}\ hr^{-1}$

Dual Method Approach

- Alpha Outer

- Alpha Inner

Heat Ratio Method
Slow Rates of Flow Method

- Beta Outer

- Beta Inner

- Tmax Outer

Tmax Method

- Tmax Inner

Diagnostic variables that are critical for scientists!

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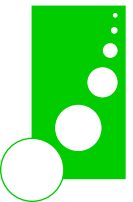
Sap Flow Parameters Explained

- Theory, methods and equations are published in Forster (2020), Tree Physiology, 40, 683-694.
- doi:10.1093/treephys/tpaa009

Tree Physiology 40, 683–694
doi:10.1093/treephys/tpaa009

Methods paper

The importance of conduction versus convection in heat pulse sap flow methods

Michael A. Forster[1,2,3]

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What is alpha?

- Alpha is the average temperature between 60 and 80 seconds after the heat pulse divided by the temperature prior to the heat pulse

5: Average Temp. Between 60 and 80 Seconds

Temperature

Time (seconds)

Downstream
Upstream

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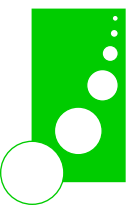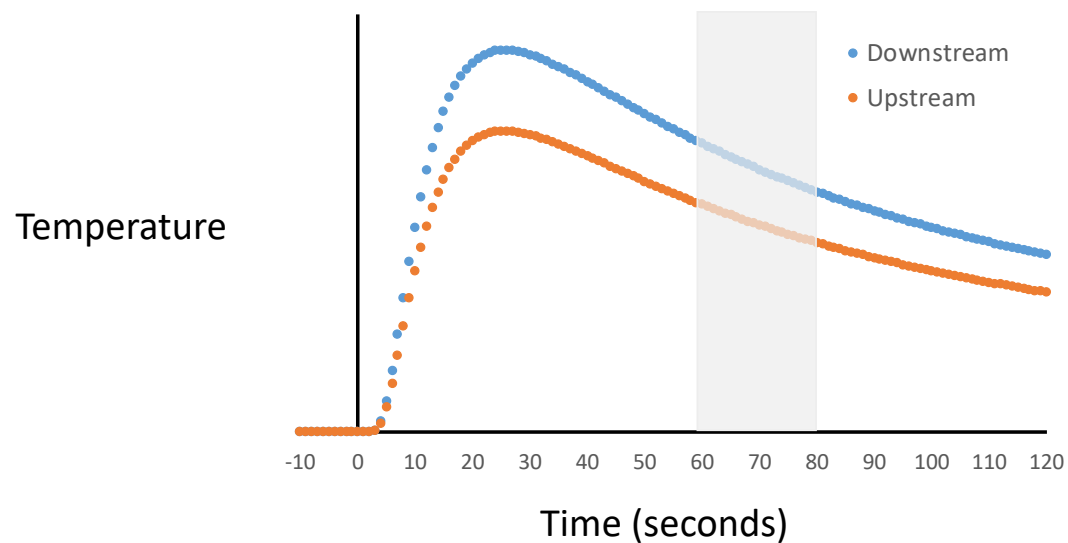
What is beta?

- Beta is the maximum temperature after the heat pulse divided by the temperature prior to the heat pulse

4: Maximum Temperature

Temperature

- Downstream
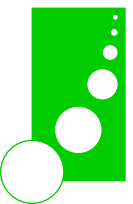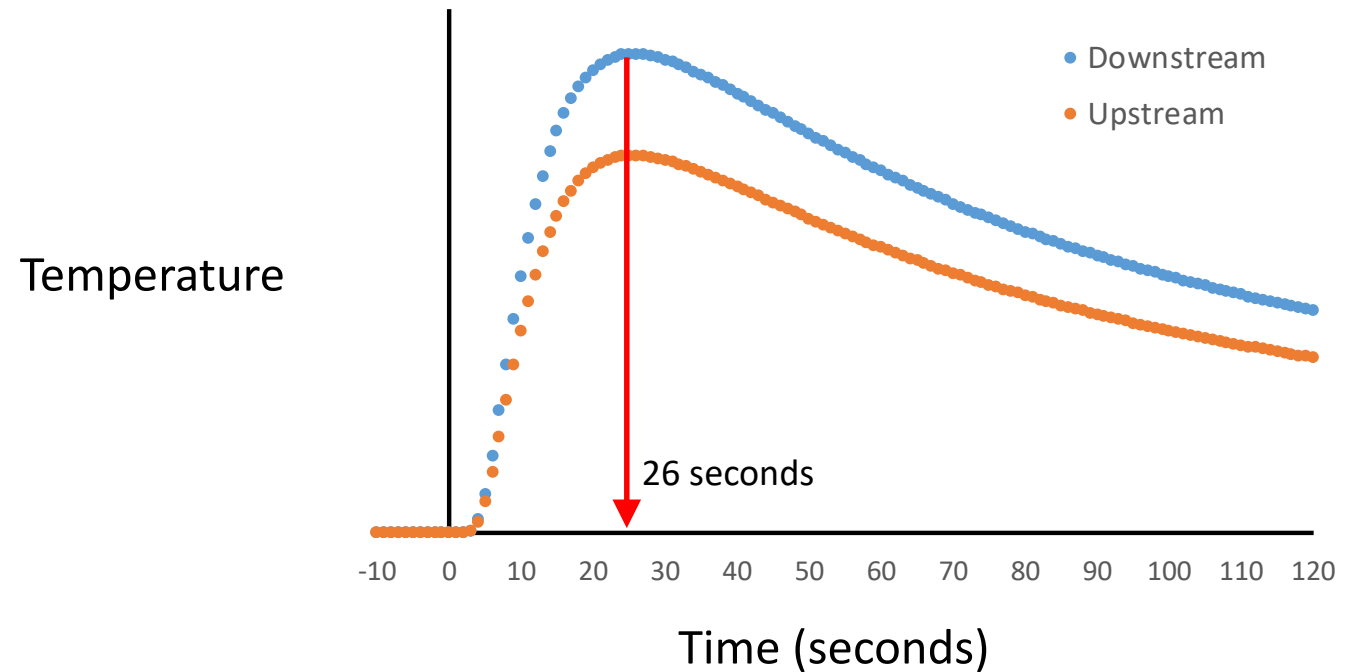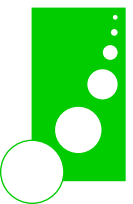- Upstream

Time (seconds)

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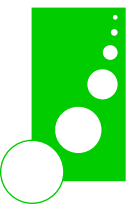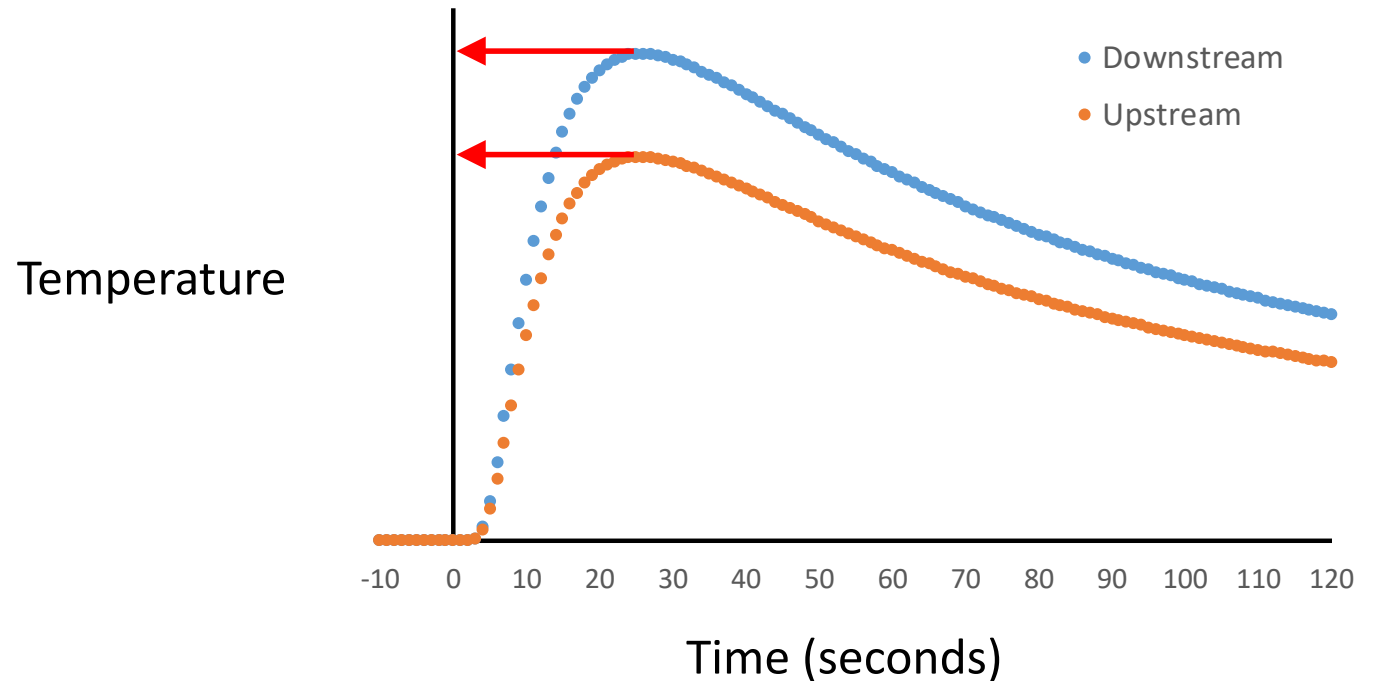
What is Tmax?

- Tmax is the time until the maximum temperature after the heat pulse

3: Time to Maximum Temperature

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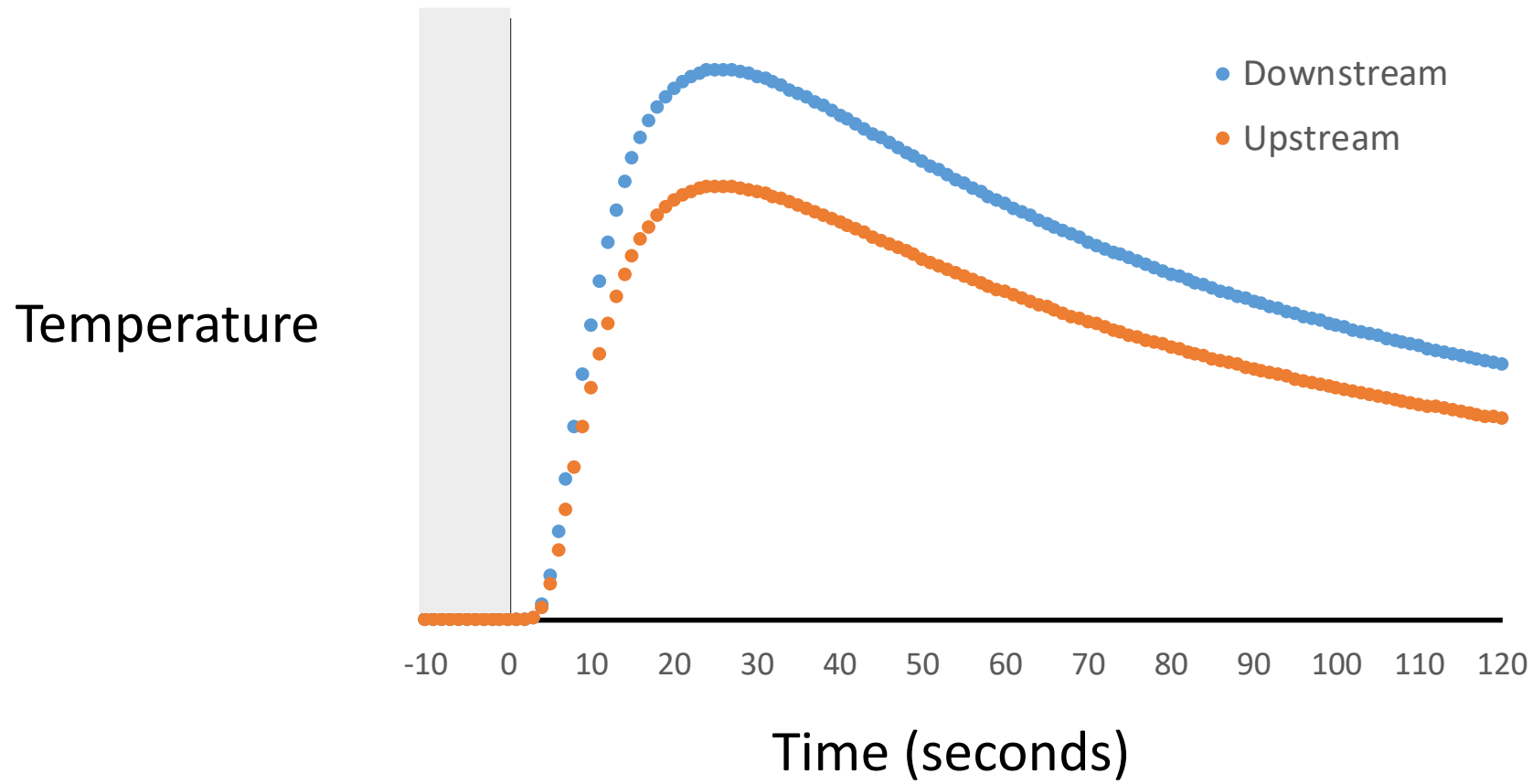Digital Environmental Sensing

C1! and C2! Commands

- Tds Pre – avg. temperature before heat pulse

- dTmax – maximum temperature after heat pulse

- Tds Post – avg. temperature 60 to 80 seconds after heat pulse

Downstream needle
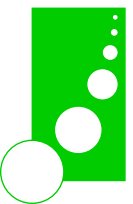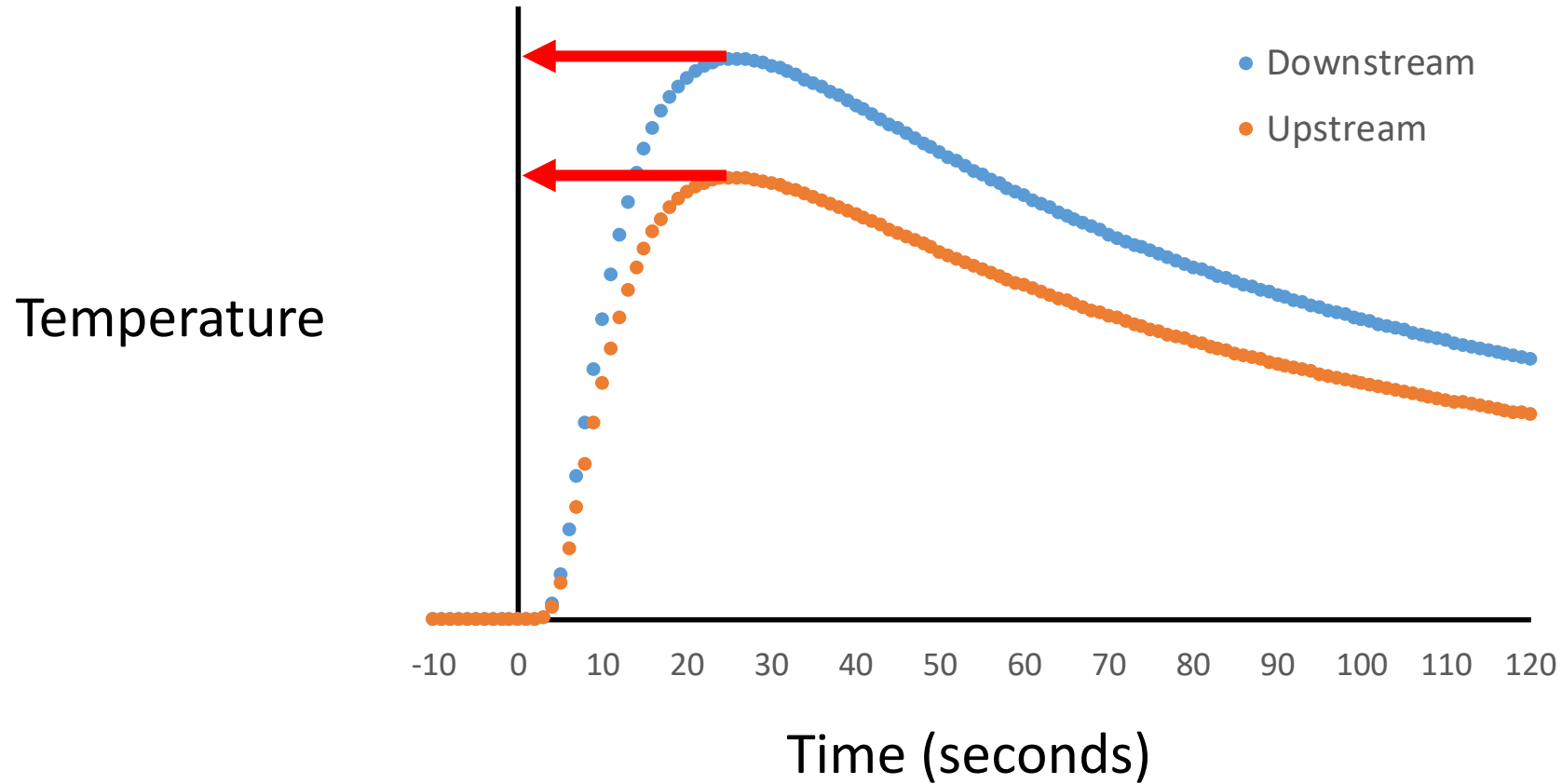
- Tus Pre – avg. temperature before heat pulse

- uTmax – maximum temperature after heat pulse

- Tus Post – avg. temperature 60 to 80 seconds after heat pulse

Upstream needle

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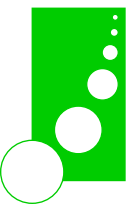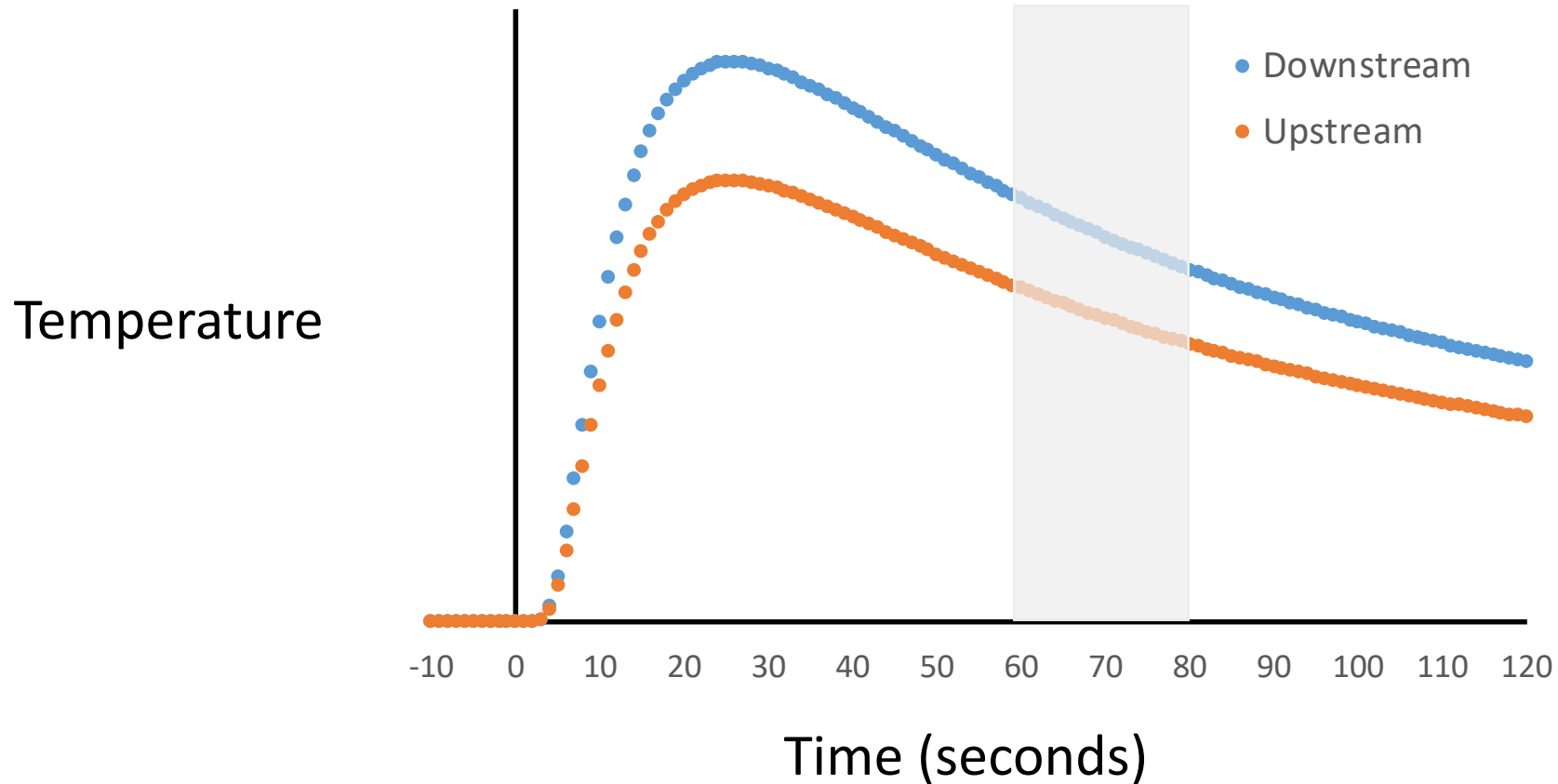### Digital Environmental Sensing

C1! and C2! -> Baseline Temperature

Temperature

Time (seconds)

Downstream

Upstream

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C1! and C2! -> Maximum Temperature

C1! and C2! -> Avg Temp. Between 60-80 Seconds

C3! Command – Stem Water Content

- Stem Water Content Outer – %
- Stem Water Content Inner – %

⎤ Use pre-dawn or 4am values only

- Volumetric Heat Capacity Outer
- Volumetric Heat Capacity Inner

⎤ How much heat is stored in stem (related to water & wood density)

- Pulse Energy

⎤ How much heat is released

- Pulse Time

⎤ Heat pulse duration (3 seconds)

⎤ Diagnostic variables

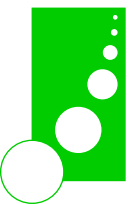**Implexx Sense**
Digital Environmental Sensing
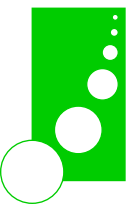
C4! Command

- Average Volts

- Average Current

- Minimum Volts

- Maximum Volts

- Diagnostic

Checking heater performance and efficiency
Diagnostic variables for the engineers!

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C5! Command

- Tmax upstream outer
- Tmax upstream inner

Time to maximum temperature in the upstream temperature needle

- Note: This command will very rarely be used. Perhaps a thermal physicist may be interested in this.

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C6! Command

- Current temperature downstream outer

- Current temperature upstream outer

- Current temperature downstream inner

- Current temperature upstream inner

- Note: Should never be used during a measurement.

- Note: Use this command for bench testing thermistors.

- Note: Ideal for checking if sensor is working without needing to fire a heat pulse.

Implexx Sense
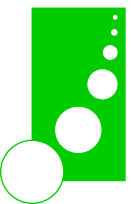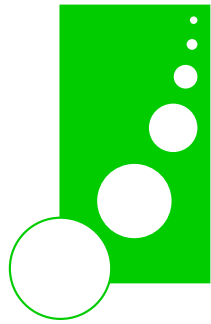Digital Environmental Sensing
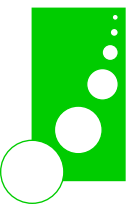
X! Commands – Changing Parameters

- All stem properties, measurement timing parameters and the thermal parameters for calculating heat capacity and water content can be reported and modified:

- aXmmm! Reports current value of parameter mmm

- aXmmm=value! Sets parameter mmm to new value

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X! Commands

- TDD   - trunk diameter in cm (default 10.0, float, allowed 0-300)

- BDD   - bark depth in cm (default 0.5, float, allowed 0-10)

- DDW - density of dry wood in g/cm3 (default 0.4, float, allowed 0.2-0.9) – see note below

- TDF   - thermal diffusivity in cm2/second (0.0020, float, allowed 0.001-0.004)

- BMD - baseline temperature measurement duration in seconds (default 10, integer, allowed 1-60)

- HTD   - heater duration in seconds (default 3.0, float, allowed 0.001-10)

- PMS   - post-heat temperature measurement start in seconds (60, integer, allowed 1-120)

- PMD - post-heat temperature measurement duration in seconds (20, integer, allowed 1-60)

- TMD - maximum temperature measurement duration in seconds (80, integer, allowed 1-200)

- CDW - specific heat capacity of dry wood in J/kg/K (default 1200, integer, allowed 800 to 2000)

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