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USER MANUAL

Heat Flow Experiment

Set Up and Configuration

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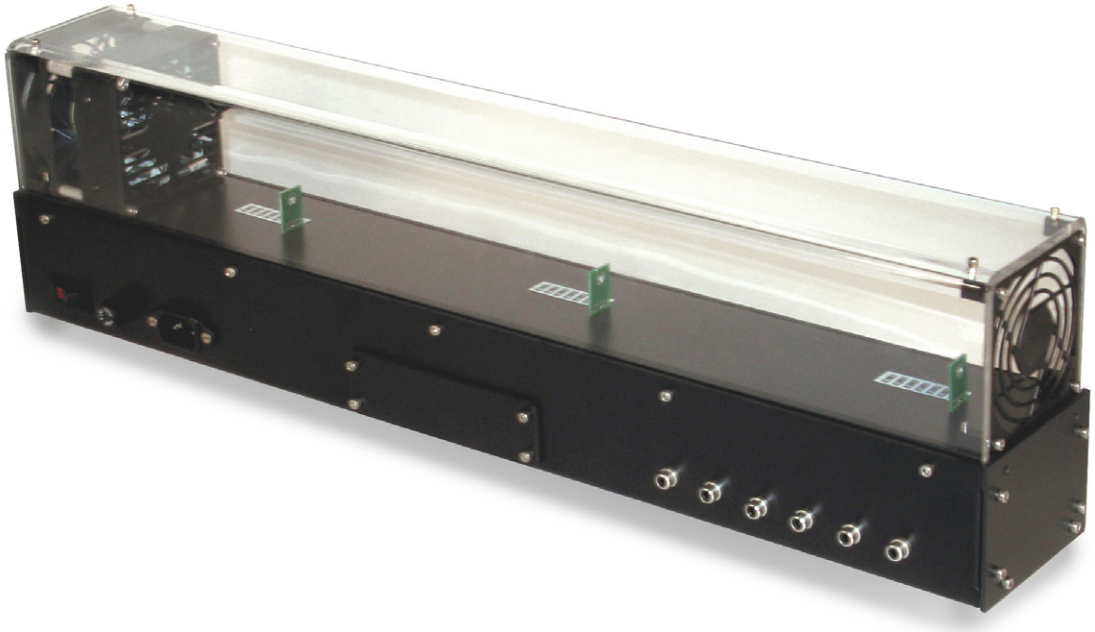

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Table of Contents

1. Introduction

The Quanser Heat Flow (HFE) experiment shown in Figure 1 is a process control plant. The 50 x 15 x 10 cm^3 system consist of a fiberglass chamber that is equipped with a coil-based heater and a blower at one end and three temperature sensors located equidistantly along the duct. The HFE has a built-in amplifier to deliver power to the heater and blower. The power delivered to the heater and blower are controlled using analog signals. There is a tachometer mounted on the blower to measure the fan speed. The three temperature sensors in the chamber are fast settling platinum transducers.

Figure 1: Quanser Heat Flow Experiment.

2. Heat Flow Components

The Heat Flow components are identified in Section 2.1. Some of the those components are then described in Section 2.2.

2.1. Component Nomenclature

The components of the Heat Flow plant are listed in Table 1 below and labeled in Figure 2 and Figure 3.

ID #	*Component*	*ID #*	*Component*
1	Base	10	Tmp One Connector
2	Fiberglass chamber	11	Temperature Sensor 1 Offset
3	Blower	12	Tmp Two Connector
4	Heater coil	13	Temperature Sensor 2 Offset
5	Temperature Sensor 1	14	Tmp Three Connector
6	Temperature Sensor 2	15	Temperature Sensor 3 Offset
7	Temperature Sensor 3	16	Fan Spd Connector
8	Power ON/OFF Switch	17	Fan Cmd Connector
9	Power Cable Connector	18	Heat Cmd Connector

Table 1: Smart Structure components.

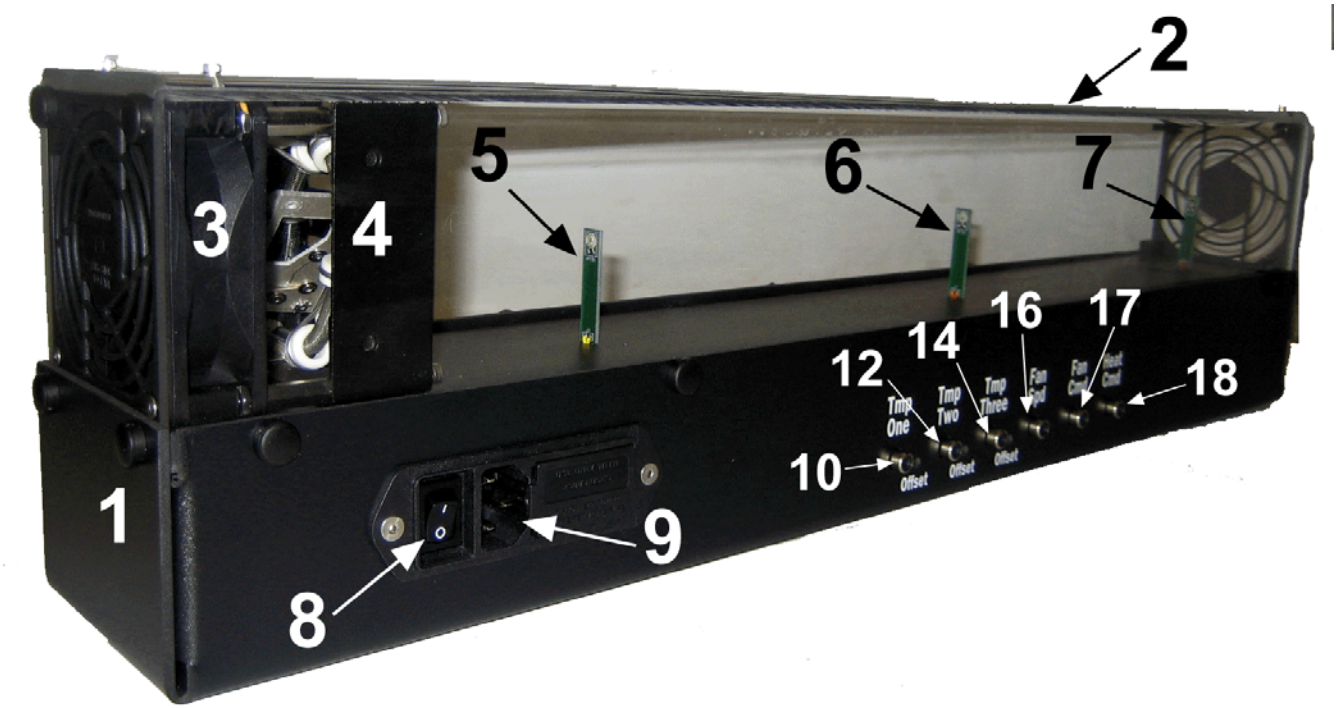


Figure 2: Heat Flow components.

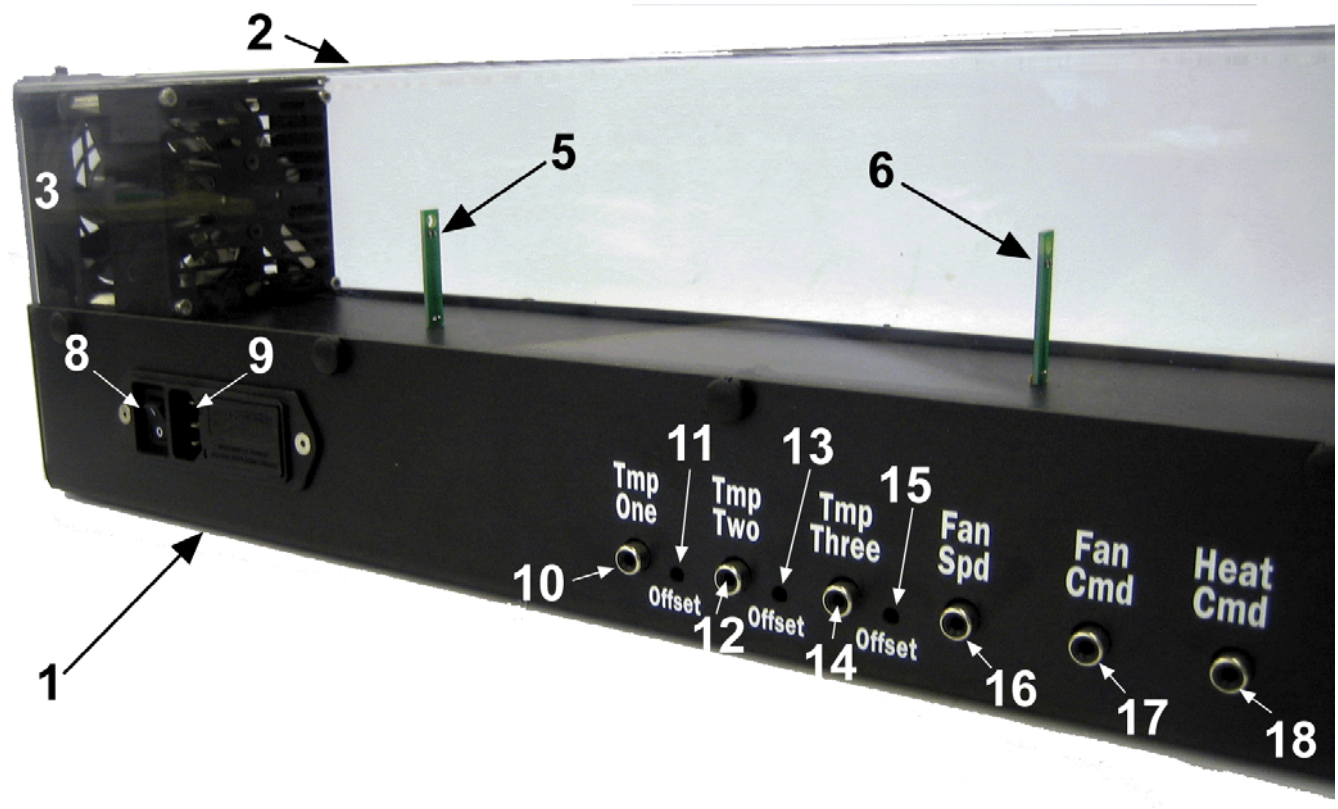


Figure 3: Other view of Heat Flow components.

2.2. Component Description

2.2.1. Temperature Sensors (Component #5, 6, and 7)

The Minco model **S101503 PF12** fast settling, platinum temperature transducers are used to measure the chamber air temperature. The sensor outputs a 0-5.0 V analog signal proportional to the temperature and its calibration gain is 20 °C/V. Sensor repeatability is at least ±0.1 °C. See Reference [5] for more details.

Sensor Calibration
This procedure describes how to calibrate the thermistor sensors on the Heat Flow to measure the correct temperature:

1. Turn ON the Heat Flow and let the blower run for at 2 minutes to ensure the temperature sensors are settled and any excess heat is flushed out. If the Heat Flow was recently ran, then you may extend this time.
2. Measure the ambient temperature with a reliable thermometer.
3. Using a voltmeter or digitally through software, measure the readings at the *Tmp One*, *Tmp Two*, and *Tmp Three* connectors. The voltage read should correspond to the ambient temperature. Recall that the calibration gain for the sensors is 20.0 °C/V. Therefore if the measured room temperature is 20 °C, then the Heat Flow sensor readings should all be 1.0 V. If the room temperature is 23.0 °C, then the readings should be 1.15 V.
4. If the temperature sensors do not match the ambient temperature then adjust the offset knobs.

2.2.2. Blower (Component #3)

The Heat Flow incorporates a NMB-MAT DC Axial Fan model **3110SB-04W-B40** for the blower, shown in Figure 2 with ID #3. As given in Table 2, below, its nominal airflow is 36 CFM and its rated speed is 2700 RPM. See Reference [3] for more details.

2.2.3. Tachometer

The tachometer installed measures the angular rate of the blower fan. It has a calibration gain of 1063 RPM / V.

2.2.4. Heater (Component #4)

The Axial Fan Heater model **AF20-400-120-XX10-3.1** used is a 400 W / 120 V heater. Using the on-board dimmer, the user can adjust the amount of regulated AC voltage powering the coil though the *Heat Cmd* analog signal. See Reference [2] for more details.

2.2.5. Chamber

The chamber of duct is made of solid Plexiglas and has a cross-sectional area of 0.0064 m^2.

3. Heat Flow Specifications

Table 2, below, lists and characterizes the main parameters associated with the Heat Flow.

Symbol	*Description*	*Value*	*Unit*
	Heat flow dimensions	50 x 15 x 10	cm
	Heat flow mass	0.5	kg
$V_{b,nom}$	Blower nominal input voltage.	6	V
B	Blower nominal airflow.	36	CFM
B_{SI}	Blower nominal airflow (in SI units).	1.02	m^3/min
W_s	Max wind speed.	159.4	m/min
$\omega_{b,max}$	Blower maximum speed	2700	RPM
$K_{tach,V2HZ}$	Tachometer calibration gain (rev/s).	17.73	Hz/V
K_{TACH}	Tachometer calibration gain (RPM).	1064	RPM/V
P_h	Heater maximum power (at 5.0 V)	400	W
K_{temp}	Temperature sensor calibration gain	20	°C / V
t_s	Temperature sensor settling time	4.0	s
A	Cross sectional area of chamber	0.0064	m^2
	Current power requirements (maximum current)	5	A
	Heatflow voltage power requirements	120 or 240	VAC

Table 2: Heat Flow system specifications.

CAUTION: **The voltage input for the Heatflow device is set for either a 120 VAC or 240 VAC input**. Make sure the correct AC voltage is used.

4. Wiring Procedure

The following is a listing of the hardware components used in this experiment:

- **Data Acquisition Board**: Quanser Q8-USB, QPID/QPIDe, National Instruments DAQ Device, or equivalent.
- **Process Control Plant**: Quanser Heat Flow speciality experiment.

The typical connections used for to connect the Heat Flow experiment to a data acquisition (DAQ) device is given in Table 3 and illustrated in Figure 4. The connection procedure is given below. **Note**: the DAQ device used in Figure 4 is generic. Make sure the analog input and output channels on your particular DAQ board match the diagram below.

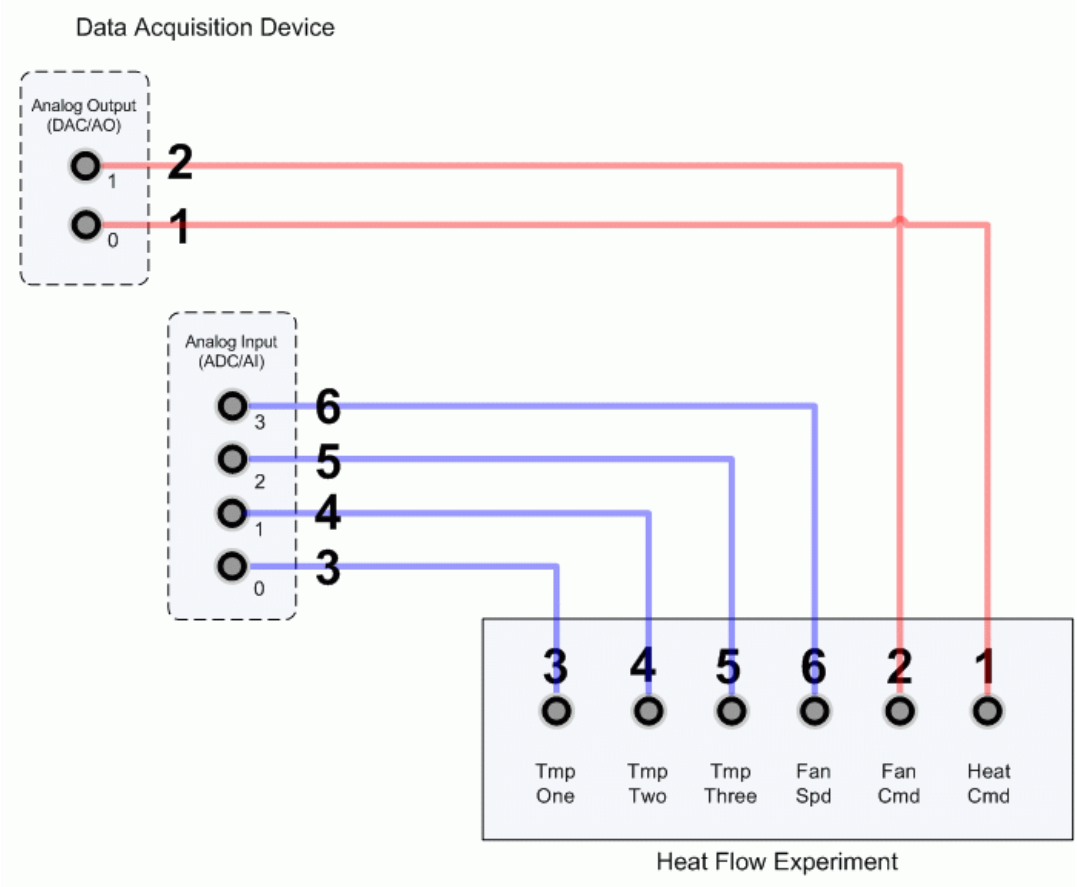


Figure 4: Connections between Heat Flow experiment and DAQ channels.

Cable #	*From*	*To*	*Signal*
1	Terminal Board: Analog Output #0	"Heat Cmd" connector on HFE	Heater voltage control signal.
2	Terminal Board: Analog Output #1	"Fan Cmd" connector on HFE	Blower voltage control signal.
3	Terminal Board: Analog Input #0	"Tmp One" connector on HFE	Temperature sensor 1 voltage measurement.
4	Terminal Board: Analog Input#1	"Tmp Two" connector on HFE	Temperature sensor 2 voltage measurement.
5	Terminal Board: Analog Input #2	"Tmp Three" connector on HFE	Temperature sensor 3 voltage measurement.
6	Terminal Board: Analog Input#3	"Fan Spd" connector on HFE	Fan speed measured by tachometer,

Table 3 Heat Flow system wiring summary.

Follow these steps to connect the Heat Flow system:

1. It is assumed that the data acquisition device has already been installed and tested (see the DAQ specific documentation for more information).
2. Make sure everything is powered off before making any of these connections. This includes turning off your PC and the Heat Flow.
3. Connect the RCA cable from the *Analog Output Channel #0* on the terminal board to the *Heat Cmd* Connector on the Heat Flow. See cable #1 shown in Figure 4. This carries the heater voltage control signal, V_h.
4. Connect the RCA cable from the *Analog Output Channel #1* on the terminal board to the *Fan Cmd* Connector on the Heat Flow. See cable #2 shown in Figure 4. This carries the blower voltage control signal, V_b.
5. Connect *Analog Input Channel #0* on the terminal board to the *Tmp One* Connector on the Heat Flow using an RCA cable, as shown by cable #3 in Figure 4. This carries the voltage signal proportional to the temperature at T_1, V_{T1}.
6. Connect *Analog Input Channel #1* on the terminal board to the *Tmp Two* Connector on the Heat Flow using an RCA cable, as shown by cable #4 in Figure 4. This carries the voltage signal proportional to the temperature at T_2, V_{T2}.
7. Connect *Analog Input Channel #2* on the terminal board to the *Tmp Three* Connector on the Heat Flow using an RCA cable, as shown by cable #5 in Figure 4. This carries the voltage signal proportional to the temperature at T_3, V_{T3}.
8. Connect *Analog Input Channel #3* on the terminal board to the *Fan Spd* Connector on the Heat Flow using an RCA cable. See cable #6 in Figure 4. This carries the voltage signal from the tachometer that measures the speed of the blower axial fan, ω_b.

5. Technical Support

To obtain support from Quanser, go to http://www.quanser.com/ and click on the *Tech Support* link. Fill in the form with all the requested software and hardware information as well as a description of the problem encountered. Also, make sure your e-mail address and telephone number are included. Submit the form and a technical support person will contact you.

Note: Depending on the situation, a support contract may be required to obtain technical support.

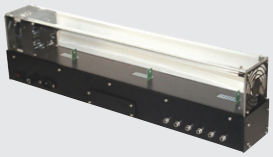
6. References

[1] Data Acquisition Device User Manual.

[2] Farnam Custom Products. *Farnam Heaters*.
[3] NMB-MAT. *FBA08A Fan*.
[4] Velleman. *K8064 Light Dimmer Manual*.
[5] Minco. Ts103A_11 Temp Sensors.

Process control plants for teaching and research

Heat Flow Experiment



Magnetic Levitation

Coupled Tanks

Industrial Mechatronic Drives Unit (IMDU)

IMDU Web Winding

IMDU Multi DOF Torsion

Quanser experimental plants can emulate complex mechatronic systems. With their precision , robust and open architecture design, they present highly suitable and affordable options for study and research of control-related challenges encountered in process control, such as fluid level control, temperature control and web winding. For more information please contact info@quanser.com

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