PHENOSYS
Technology for Behaviour Analysis

Virtual Reality - Jet Ball

TFT Surround Monitor
200 mm Ball for Mice

Manual for users

Version 1.0

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Safety instructions

- Before setting up the Jet Ball system, please read all the documentation that comes with the package carefully.
- To prevent fire or shock hazard, never expose the product to moisture.
- Never try to open any of the components of the product including the electrical enclosure. Dangerous voltages may result in serious physical injury.
- Before using the product, make sure all cables are connected correctly and the power cables are not damaged.
- Slots and openings on the back or on the top of the electrical enclosure, the computer, and the monitors are provided for ventilation. Do not block these slots.
- Do not overload the outlet strip. Overloading can result in fire or electric shock.
- Avoid dust, humidity, and temperature extremes.
- Unplug the unit during lightning storm or if it will not be used for a long period of time. This will protect the product from damage due to power surges.
- If you encounter any technical problems with the product, please contact **PhenoSys**.

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1. INTRODUCTION

The Jet Ball is a novel virtual reality experimental system for mice and rats. It is based on an air supported spherical treadmill (tracksphere) allowing a restrained animal to navigate in a virtual space.
Virtual Reality (VR) provides a perfectly controllable experimental environment and can be used for investigating brain function underlying navigation, cognition, learning, and memory.
Restrained animals can be examined with electrophysiological and optogenetic methods while the animal performs simple or complex behaviours.

1.1. Package Contents

Quantity	Content
1	TFT Surround Monitor (with cable loom)
1	Ball Holder for 200 mm ball (for mice) with X/Y motion sensor and retractable operant device with peristaltic pump (with cable loom)
2	200 mm balls
1	Movable rack with electrical enclosure, monitor, keyboard and computer mouse, outlet strip, pressure regulator and flow meter (with cable loom)
1	Computer
1	Tool set (only outside of Europe)

1.2. Components

The Virtual Reality-Jet Ball set-up consists of two sub-units, the Jet Ball Unit (Fig. 1) and its Control Unit (Fig. 2).

The Jet Ball Unit includes the ball with Ball Holder and operant device (see Fig. 3 for details), the TFT Surround Monitor (Fig. 1), and relevant accessories and optional peripheral systems, such as speakers.

The Control Unit consists of a movable rack with the computer, electrical enclosure, and pressure regulator/flow meter (Fig. 2).

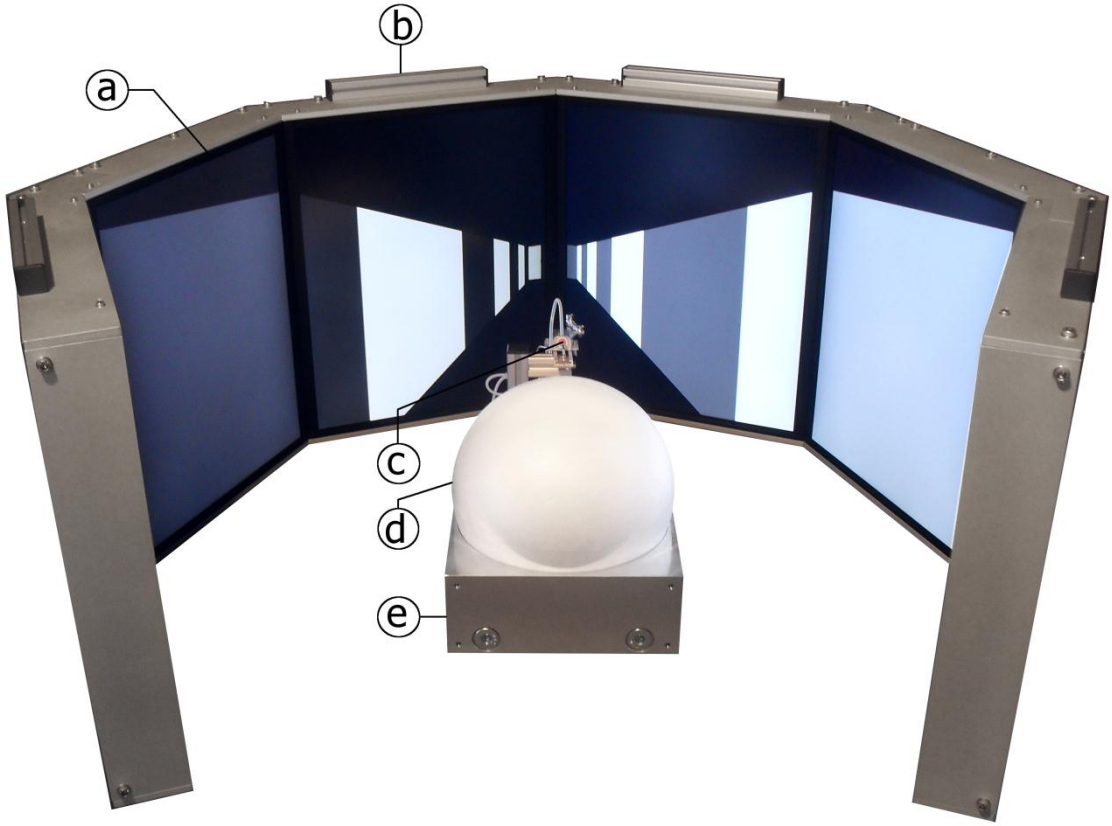


Fig. 1: Jet Ball Unit of the Virtual Reality – Jet Ball

a: TFT Surround Monitor with virtual reality scene
b: Holder for speaker (optional)
c: Retractable operant device
d: Ball
e: Ball Holder

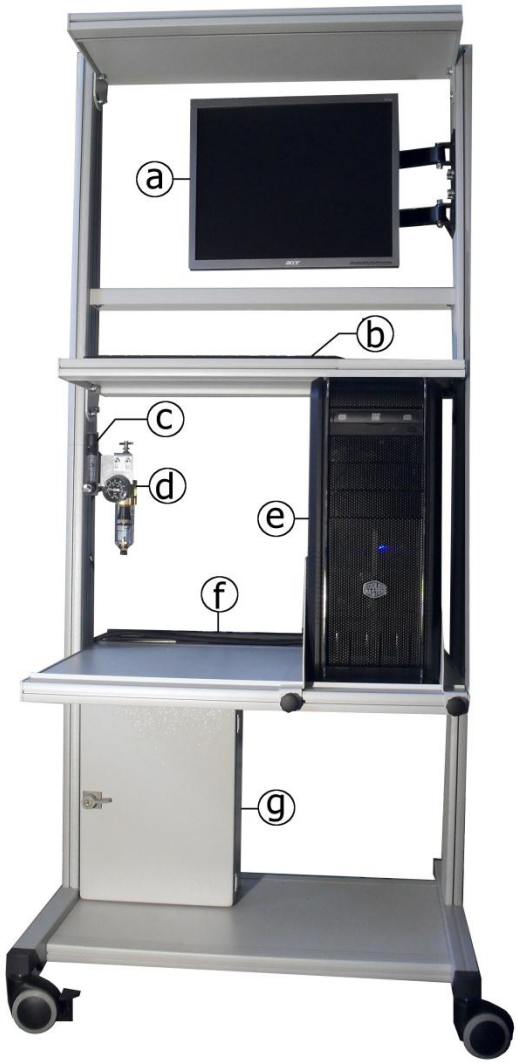


Fig. 2: Control Unit of the Virtual Reality – Jet Ball

a: Monitor
b: Keyboard and computer mouse
c: Flow meter
d: Pressure regulator
e: Computer with 2 bookends
f: Outlet strip
g: Electrical enclosure

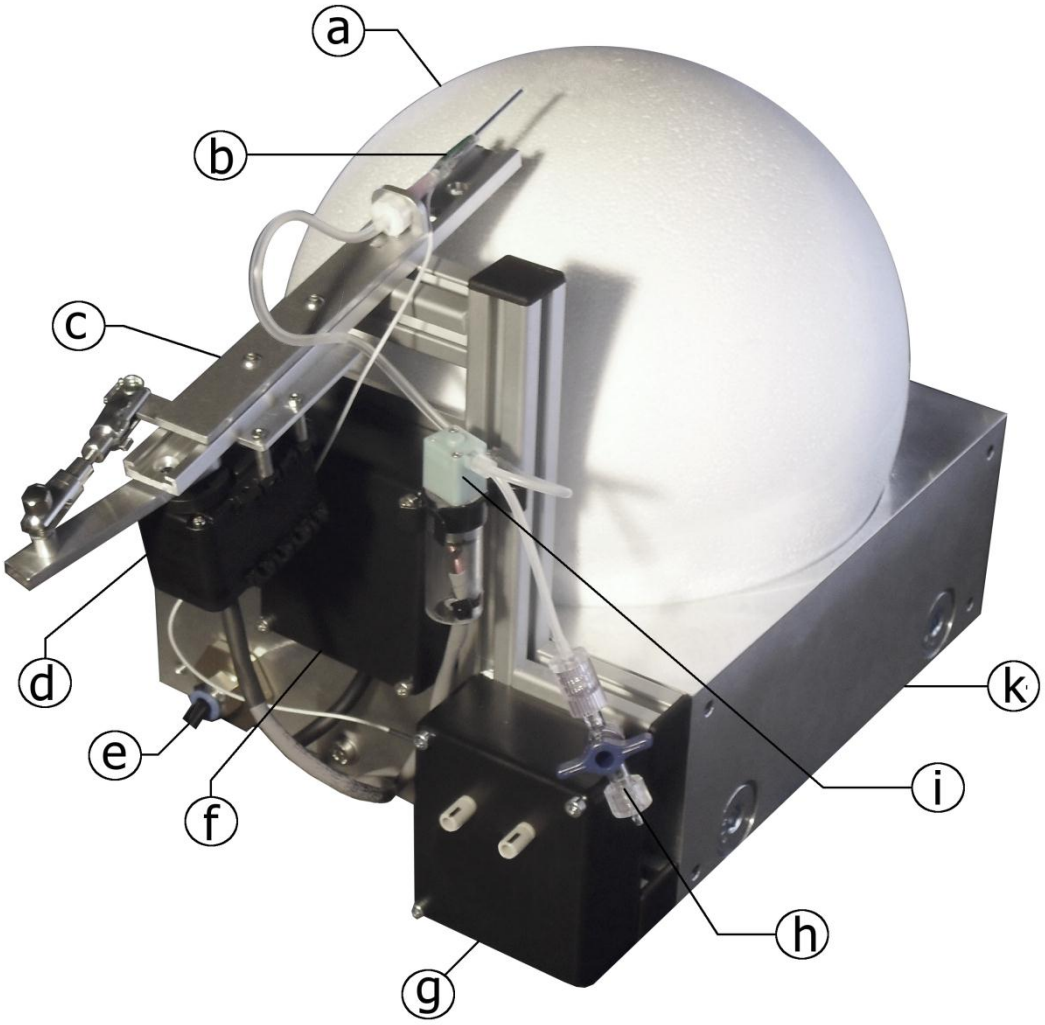


Fig. 3: Retractable operant device of the Virtual Reality – Jet Ball

a: Ball
b: Lick sensor with capillary tube
c: Retractable applicator
d: Servo motor
e: Connector to compressed air supply
f: X/Y motion sensor
g: Lick sensor controller
h: Connector to liquid reward container
i: Peristaltic pump
k: Ball Holder

2. ASSEMBLY OF HARDWARE

- Place the TFT Surround Monitor on a stable table with the Ball Holder in the middle, its operant device pointing towards the center of the surround monitor (see Fig. 1). The distance to the movable rack is limited by the ~ 3.5 m cable of the TFT Surround Monitor.
- Remove the protective sheets from the backside of the TFT Surround Monitor and the six monitors.
- Place the computer on the lower shelf of the movable rack flanked by the bookends (see Fig. 2).
- Do not shine bright illumination onto the Jet Ball Unit.

1. To install the Jet Ball experimental system, first connect the TFT Surround Monitor to the Control Unit:

    a. Fix the end of the protective hose of the TFT Surround Monitor with the help of the large hose clip at the rear of the movable rack (see Fig. 4).

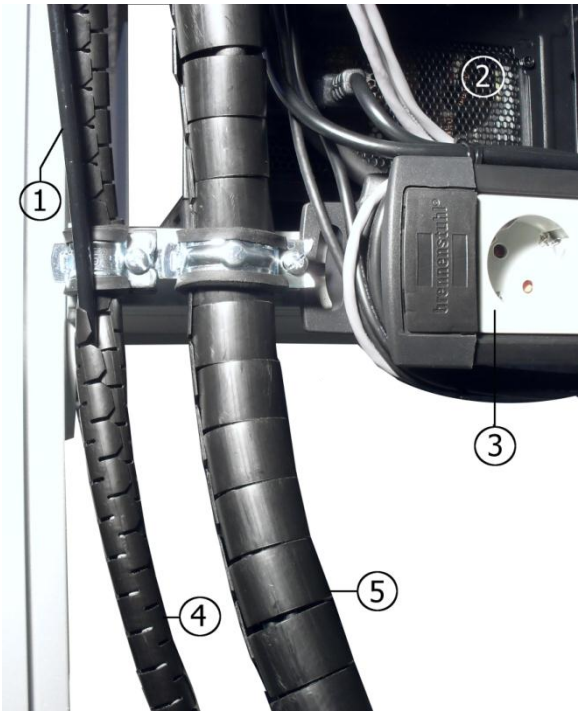


Fig. 4: Fixing the protective hoses at the Control Unit

1: Compressed air tube to flow meter
2: Computer
3: Outlet strip
4: Protective hose to connect the Ball Holder
5: Protective hose to connect the TFT Surround Monitor

b. Connect the cable socket of the TFT Surround Monitor to the power plug on the rear of the electrical enclosure (see Fig. 5). Turn the cable socket clockwise until the security switch snaps into place. To unplug, pull the security switch and turn the cable socket counter-clockwise.

Fig. 5: Plug of the electrical enclosure (left) and cable socket of the TFT Surround Monitor (right).

c. Connect the six signal connectors of the TFT Surround Monitor to the respective outputs of the video cards of the computer as labelled: Monitor 1, Monitor 2, Monitor 3, Monitor 4, Monitor 5, and Monitor 6.

2. To assemble the retractable operant device after shipment:

a. Remove the adhesive film (a)

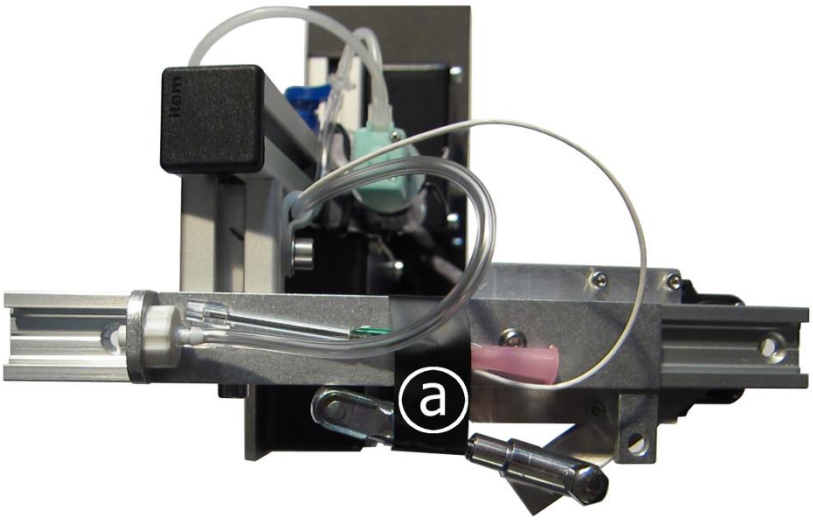


Fig. 1: Operant device after shipment; a: Adhesive film

b. Put the hollow needle on the connector of the feeder with the lick sensor (green) pointing downwards.

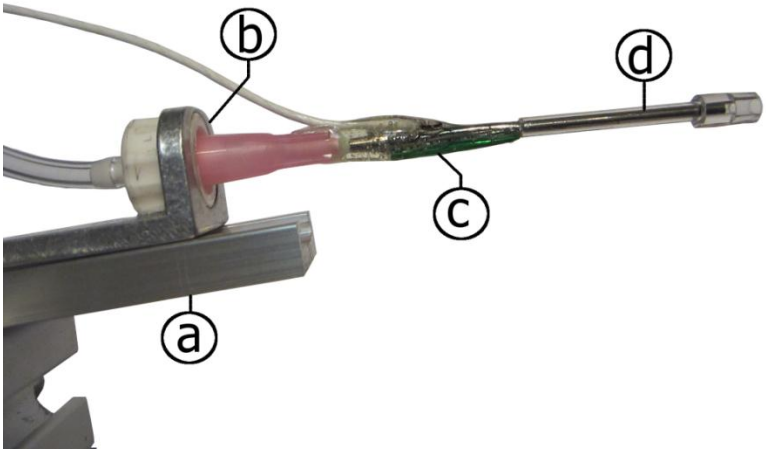


Fig. 2: Assembling the lick sensor

a: Guide rail of the operant device
b: Fixing hole for the needle connector
c: Lick sensor
d: Metallic capillary tube of the lick sensor with plastic coating

c. Fix the retractable applicator of the operant device:
   - Remove the metallic clamp from the angle.
   - Connect the angle with the clamp to the retractable applicator.
   - Fix the clamp on the angle.

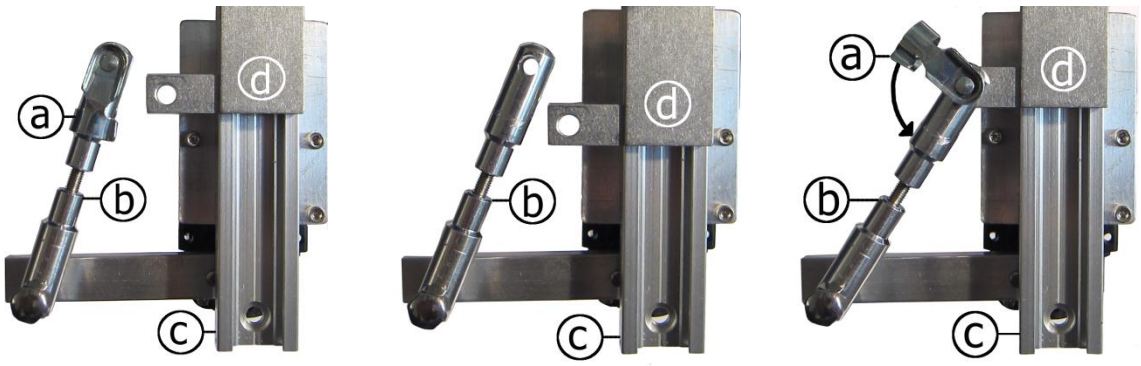


Fig. 3: Fixing the retractable applicator of the operant device

a: Metallic clamp
b: Angle
c: Guide rail
d: Retractable applicator

3. Connect the Ball Holder to the Control Unit:

   a. Fix the end of the protective hose of the Ball Holder with the help of the small hose clip at the movable rack of the Control Unit. The compressed air tube **must not be fixed** within the hose clip (see Fig. 4).

   b. Connect the compressed air tube of the Ball Holder to the flow meter (see Fig. 6). Use the cable duct to place the compressed air tube.

> **Note**
> To unplug the compressed air tube, push the blue locking device of the Push-in fitting (see Fig. 6b).

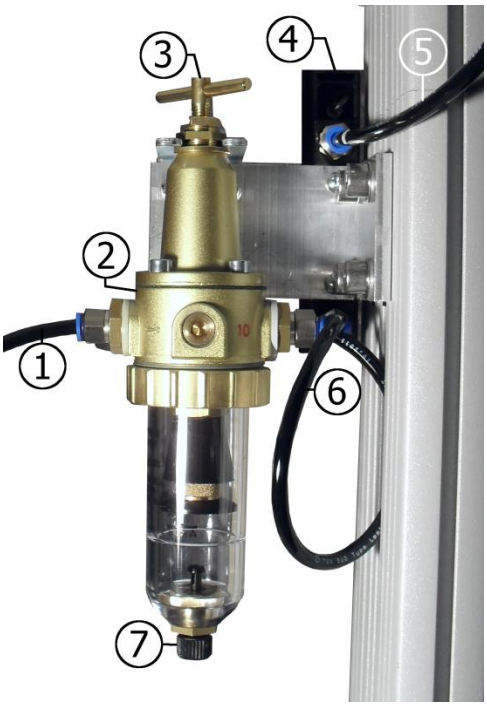


Fig. 6a: Rear view of the pressure regulator and the flow meter including the compressed air tubes.

1: Compressed air tube to compressed air supply
2: Pressure regulator
3: Valve of the pressure regulator
4: Flow meter
5: Compressed air tube to Ball Holder
6: Compressed air tube between pressure regulator and flow meter
7: Release valve (to remove condensed water)

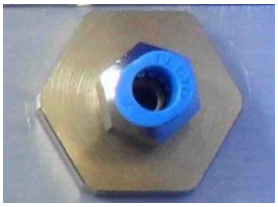


Fig. 6b: Push-in fitting for the connection of a compressed air tube at the Ball Holder.

c. Connect the cable connectors of the lick sensor, the servo motor, and the pump to the respective panel plugs on the rear of the electrical enclosure (Fig. 7). It is recommended to use the side of the outlet strip to fix the cables.

Fig. 7: Panel plug with 5, 3, or 2 pins (left) and the respective female cable connector 5P, 3P, or 2P (right) to connect the lick sensor, the servo motor, and the valve of the operant unit, respectively.

d. Connect the USB plug of the X/Y motion sensor to a USB receptacle on the rear side of the computer.

4. Connect the Jet Ball to the compressed air supply:
   Connect the compressed air supply tube to the air pressure regulator of the Control Unit equipped with a 40 µm filter and fitted with a 6 mm threaded union (Fig. 6).

5. Connect the two USB cables of the electrical enclosure belonging to the peristaltic pump/lick sensor (one cable) and the servo motor to USB receptacles on the backside of the computer.

6. Connect the computer monitor via the VGA cable with the computer. Connect the keyboard and the computer mouse to USB receptacles on the backside of the computer.

7. Connect the tube of the retractable applicator to the container or bottle with the liquid reward (not supplied). We recommend that you place a glass beaker or conical flask on the experimental table behind the Ball Holder.

8. Finally, connect the power cord of the Control Unit to the AC outlet.

3. STARTING THE JET BALL: STEP-BY-STEP

1. Preparation of the operant device: Fill the bottle that supplies the feeder with the reward liquid, e.g. sugar water.

2. Place the ball in the deepening of the Ball Holder.

3. Compressed air supply: Open the valve of the pressure regulator (recommended 2, max. 4 bar). Adjust the flow rate of the air with the valve of the flow meter to 20 l/min (max. 30 l/min). Move the ball with your hand to check if the ball is floating.

4. Consecutively, turn on the 5 rocker switches of the outlet strip on the backside of the Control Unit with a pause of at least five seconds between each rocker switch. (Usually only 3 power sockets are used by the Jet Ball.)

5. Turn on the computer of the Control Unit. Be sure that the switch of the computer on the backside is in the position "ON". Wait until the computer has booted up completely.

> **Note**
> The Control Monitor of the movable rack is the main monitor of the computer. However, the cursor may be absent because it can be positioned on one of the monitors of the TFT Surround Monitor. In this case, move the computer mouse sideways until the cursor appears on the Control Monitor.

6. Double-click the folder "*PhenoSoft VR*" on the desktop of the computer. Then, double-click the application *PhenoSoft VR*. In the folder "PhenoSoft VR\Data" that opens afterwards, choose the XML configuration file for the experiment you want to run (e.g. *sample*; see *4. Using the software PhenoSoft VR* for details).

> **Note**
> To load the virtual reality may take some time. Please do not proceed before the respective virtual reality scene is displayed on the TFT Surround Monitor.

7. Open the folder "*PhenoSoft Control"* on the desktop of the computer and double-click the application *PhenoSoft Control*. Click on the control button "Open", open the folder "configs", and load an appropriate Excel configuration file (e.g. *sample;* see *5. Using the software PhenoSoft Control* for details). If you want to change the parameters of the configuration file or learn how to create an experimental set-up, see *5.1. The Excel configuration file of PhenoSoft Control* for details.

> **Important note**
> When using the Jet Ball with its virtual reality environment, you always need to start the program *PhenoSoft VR* first, BEFORE running the software *PhenoSoft Control* to control the Jet Ball itself.

8. Check the functionality of the operant device by clicking on the trigger field “Pump1” to activate the peristaltic pump of the feeder and “Motor1” to retract or extend the retractable operant device. Gently tip on the top of the retractable operant device to activate the lick sensor: the “LS1” field will turn green (see *5.3. The **Control** screen of PhenoSoft Control*).

9. Head-fix the animal on the ball and adjust the operant device (see *6. The retractable operant device* for details on how to adjust the liquid reward system).

> **Attention!**
> - The handling, preparation, and head fixation of the animal must be performed according to the manual of the manufacturer of the head fixation device.
> - Fix the animal while the operant device is fully **extended** to prevent injuries of the animal!
> - Ensure that the animal is able to drink if the operant device is extended.

10. Run the experiment (see *5.1. The Excel configuration file of PhenoSoft Control* for details on how to define different experimental routines).

11. Quit the experiment by clicking on the control button “Quit” of *PhenoSoft Control*. There is no separate option to save data as the **log file** is automatically saved (see *5.7. The experimental data of PhenoSoft Control* for details).

3.1. Shutting down the Jet Ball

The Jet Ball is designed for permanent use and can be left turned-on for extended periods. To shut-down the system:

1. Remove the liquid from the tube system of the operant device.
2. Close *PhenoSoft Control*, press “Esc”, and close *PhenoSoft VR*.
3. Shut down the computer.
4. Turn off the 5 rocker switches of the outlet strip on the backside of the Control Unit.
5. Turn off the compressed air supply to the system.

4. USING THE SOFTWARE *PHENOSOFT VR*

PhenoSoft VR controls the computer-simulated environment displayed on the TFT Surround Monitor. The parameters that define the virtual reality can be adjusted in an XML configuration file (see Fig. 8). This configuration file allows you to design the size, shape, and number of rooms of the virtual reality environment as well as the size, colors, and textures of the walls and it may include the definition of additional virtual objects.


```
<?xml version="1.0" encoding="UTF-8"?>
<graph mode="OneOnOne" windowed="true" frameAngle="-4" distortion="false">
    <!-- texture for ground floor -->
    <floorTexture val="black.png" />
    <wallHeight val="200"/>
    <edgeWidth val="375"/>
    <skySphereTexture val="gradient.png"/>
    <!-- the VR starts on this node -->
    <startNode id="n1"/>
    <!-- a cross-way/room with id and coordinates -->
    <node id="n0" x="0" y="0" texture="gray_gray.png"/>
    <node id="n1" x="1100" y="0" texture="gray_gray.png"/>
    <node id="n2" x="-1100" y="0" texture="gray_gray.png"/>

    <edge source="n0" target="n1">
        <Wall1>
            <Texture path="schachbrett.png" tileX="1" tileY="1"/>
            <Texture path="schachbrett.png" tileX="1" tileY="1"/>
            <Texture path="schachbrett.png" tileX="1" tileY="1"/>
            <Texture path="schachbrett.png" tileX="1" tileY="1"/>
        </Wall1>
        <Wall2>
            <Texture path="gray_gray.png" tileX="1" tileY="1"/>
            <Texture path="gray_gray.png" tileX="1" tileY="1"/>
            <Texture path="gray_gray_rect.png" tileX="1" tileY="1"/>
            <Texture path="gray_gray.png" tileX="1" tileY="1"/>
        </Wall2>
    </edge>
    <edge source="n0" target="n2">
        <Wall1>
            <Texture path="gray_gray.png" tileX="1" tileY="1"/>
            <Texture path="gray_gray_with_circle.png" tileX="1" tileY="1"/>
            <Texture path="gray_gray.png" tileX="1" tileY="1"/>
            <Texture path="gray_gray.png" tileX="1" tileY="1"/>
        </Wall1>
        <Wall2>
            <Texture path="schachbrett_rect.png" tileX="1" tileY="1"/>
            <Texture path="schachbrett.png" tileX="1" tileY="1"/>
            <Texture path="schachbrett.png" tileX="1" tileY="1"/>
            <Texture path="schachbrett.png" tileX="1" tileY="1"/>
        </Wall2>
    </edge>
</graph>
```

Fig. 8: XML configuration file of the software *PhenoSoft VR*.

4.1. Editing the XML configuration file

Below you find explanations for the different parameters of the XML configuration file.

The root node is called **graph** and the following attributes are possible:

1. **displays**: This attribute defines the TFT monitors that display the virtual reality: 3, 2, 1, 8, 7, 6.
2. **frameAngle**: An integer value to compensate for that part of the visual scene that is blocked from view by the external frames around each single monitor. This feature allows for “smooth” movement of the virtual scene across multiple monitors.
3. **distortion**: A boolean value that turns on/off spatial distortion.
4. **windowed**: A boolean value that defines whether the virtual reality is displayed in full screen mode.
5. **minDistToWall**: This value defines the minimum distance that will be kept to the virtual walls. 2*minDistToWall has to be lower than **edgeWidth** (see below).

The root node can contain the following nodes:

1. **floorTexture**: File name of the image for the floor.
2. **wallHeight**: The standard height of the walls.
3. **skySphereTexture**: This value defines the texture of the sky above the walls.
4. **startNode**: The room where a virtual reality experiment will start.
5. **node**: The definitions for single rooms:
    a. **id**: Name (label) of the room. This label must occur only once, which is important for the definition of corridors.
    b. **x**: X-coordinate of the room.
    c. **y**: Y-coordinate of the room.
    d. **texture**: Texture of the walls of the room.

    For each room up to six pictures can be defined. These pictures will be displayed on the walls around the room.

    w1Img to **w8Img**:

    1. **name**: The name (label) of a picture. This name must occur only once. This name defines whether the picture will be visible or invisible later on.
    2. **visible**: This parameter defines whether the picture is visible during the start of the virtual reality experiment.
    3. **texture**: Texture of the picture.
6. **edge**: Definition of a corridor.
    a. **source**: Name of the first room.
    b. **target**: Name of the second room.
    c. **height**: Height of the corridor walls.
    d. **Wall1**: Node for the definition of the wall on the right-hand side of the corridor.
        i. **height**: Height of the wall on the right-hand side.
        ii. **Texture**: With this node a wall can be separated in several walls of equal length:
            1. **path**: Texture for this section of the wall.
            2. **tileX**: This value defines how often the texture will be displayed horizontally on the wall.
            3. **tileY**: This value defines how often the texture will be displayed vertically on the wall.
            4. **height**: Height of this section of the wall.
    e. **Wall2**: Node for the definition of the wall on the left-hand side of the corridor. The definition of the wall is similar to **Wall1**.

7. **object**: With this node 3D objects can be displayed in a room.
    a. **x**: X-coordinate of the object.
    b. **y**: Y-coordinate of the object.
    c. **name**: Name of the object. This name must occur only once.
    d. **mesh**: Name of the file that defines the object. The object has to be defined in the DirectX-format. The names of the textures of the object are defined in this file and therefore, will be uploaded automatically.
    e. **scale**: This parameter defines the size of the object.

Notes

1. All required textures as well as definitions of objects and their textures for the virtual reality need to be archived in the directory "Data" as separate image files such as PNG, JPEG, or BMP.

2. During test runs of the configuration and constructing process pressing the "**Ctrl+Alt+F**"-buttons will enable a program mode that allows you to navigate freely through the virtual reality with the arrow keys of the keyboard. Press "**Ctrl+Alt+F**" to exit this mode. Please do not enter into this program mode while running an experiment!

5. USING THE SOFTWARE *PHENOSOFT CONTROL*

The Jet Ball and its relevant appliances are controlled by the software *PhenoSoft Control*. *PhenoSoft Control* also records the acquired data in a **log file** (see *5.7. The experimental data of PhenoSoft Control*). The parameters to control the hardware and to record data can be adjusted in an Excel configuration file (see *5.1. The Excel configuration file of PhenoSoft Control* for details).

Important note
When using the Jet Ball with its virtual reality environment, you always need to start the program *PhenoSoft VR* first, **BEFORE** running the software *PhenoSoft Control* to control the Jet Ball itself.

After opening *PhenoSoft Control* you will see the *PhenoSoft Control* **Control** screen with its five control buttons: **Control**, **Logs**, **Charts**, **Open**, and **Quit** (see Fig. 9).

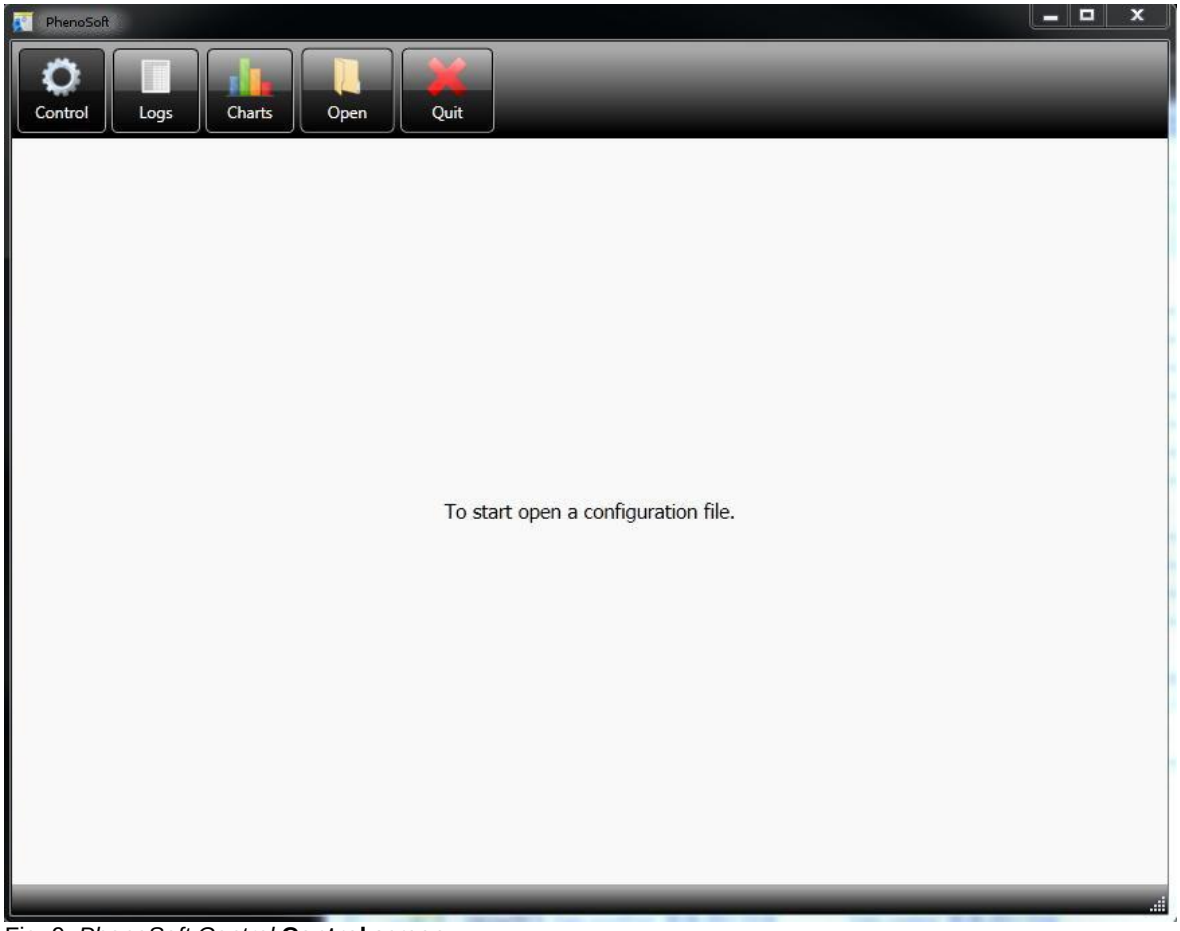


Fig. 9: *PhenoSoft Control* **Control** screen.

5.1. The Excel configuration file of *PhenoSoft Control*

The control button "**Open**" allows you to load the configuration file that defines the experimental routines to run the Jet Ball and its accessories.

Most parameters in the configuration file are on their default values to allow the general functioning of the Jet Ball. These settings are optimized and normally do not need to be changed. However, some values are specific to individual experiments.

Open the Excel configuration file. The file consists of two sheets: "Table 1" and "IO" (see Fig. 10). Sheet "IO" defines the hardware configuration and must not be changed except otherwise mentioned (e.g.: 6.1. Positioning the operant device).

	A	B	C	D
1	**Configuration**	[comments]		
2	configFile	name of configuration file to be loaded	Sample.xlsx!IO	
3	dataPrefix	prefix for data filename	Sample	
4	save	save configurations with each run	false	
5	CSVcolumnDelimiter		;	
6	dataSuffix	suffix for data filename		
7	dataFilePath	directory results files; default = start directory		
8	configFilePath	directory configuration files; default = start directory		
9				
10				
11	**AirCompensation**			
12	label		AirComp	
13	invertMove		true	
14	invertRotate		false	
15	pointsIn180		35	
16	vrRotation		112	
17	vrRotationOnStart		338	
18	mode		None	
19	pathFinder		PathPos	
20	intervall		10	
21	vr		VR	
22				
23				
24	**RfidCondition**	Konfiguration der Tränken		
25	label		**CondMod1**	
26	triggerSensor		LS1	
27	posX		0	
28	posY		0	
29	reinforce1		Pump1,0,100,true,0	
30				
31				
32				
33				
34	**Individual**			
35	label		**Ind1**	
36	rfid		0415C48D15	
37	defInd		true	
38	expPath		Sample.xaml	
39	expInput		Comp,AirComp,AirCompensation	
40	expInput		CondMod,CondMod1,CondMod	
41	expInput		motor,Motor1,Door	
42	expInput		VR,VR,Vr	
43	expInput		Is,LS1,DigIn	
44				
45				
46	**ConstantOF**	Definition konstanter Ausgabefunktionen		
47	label		**constOut**	
48	indLabel		Ind1	
49	output		200	
50	outputOffset		0	
51	minTime		PT0S	
52	reward		positive	
53	moduleLabel		CondMod1	
54				

Fig. 10: Table 1 of the Excel Configuration file.

Below you find explanations for the parameters of “Table 1” of the Excel configuration file you may change:

Configuration
configFile: Name of the hardware configuration file to be loaded (IO).
dataPrefix: Prefix of the **log file** to be saved automatically.
Individual
expPath: Name of the *PhenoSoft Schedule* file to be loaded (see **Note** below).

> **Note**
> The program *PhenoSoft Schedule* is a graphical way of creating your experimental schedule by using flow charts. The resulting schedule is saved as an XAML file (see *5.2. PhenoSoft Schedule*).

ConstantOF
output: Quantity of liquid reward at the operant device defined as time in milliseconds the peristaltic pump will be activated (minimum value: 200 [ms]).

After editing the configuration file, save it within the subfolder “configs”.

5.2. *PhenoSoft Schedule*

The program *PhenoSoft Schedule* is a graphical way of creating your experimental schedule using flow charts (see Fig. 11). To create a new schedule, click “File” and “New”. Use the icons on the left side to define your experimental routine and save the file within the subfolder “configs”. Detailed information is available in the manual “*PhenoSoft Schedule*”.

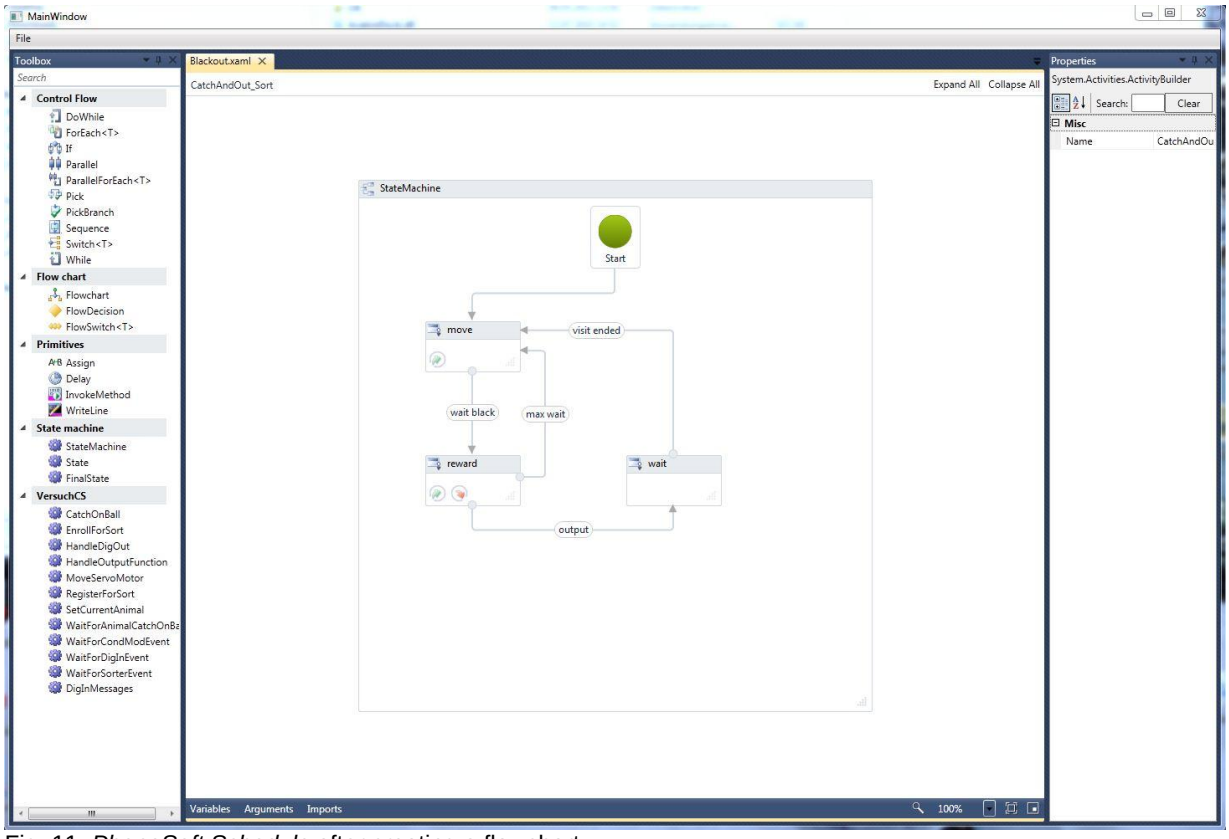


Fig. 11: *PhenoSoft Schedule* after creating a flowchart.

5.3. The **Control** screen of *PhenoSoft Control*

After loading a configuration file, the *PhenoSoft Control* **Control** screen shows icons with all relevant devices for the respective experimental set-up of the Jet Ball and its accessories as defined in the configuration file (see Fig. 12).

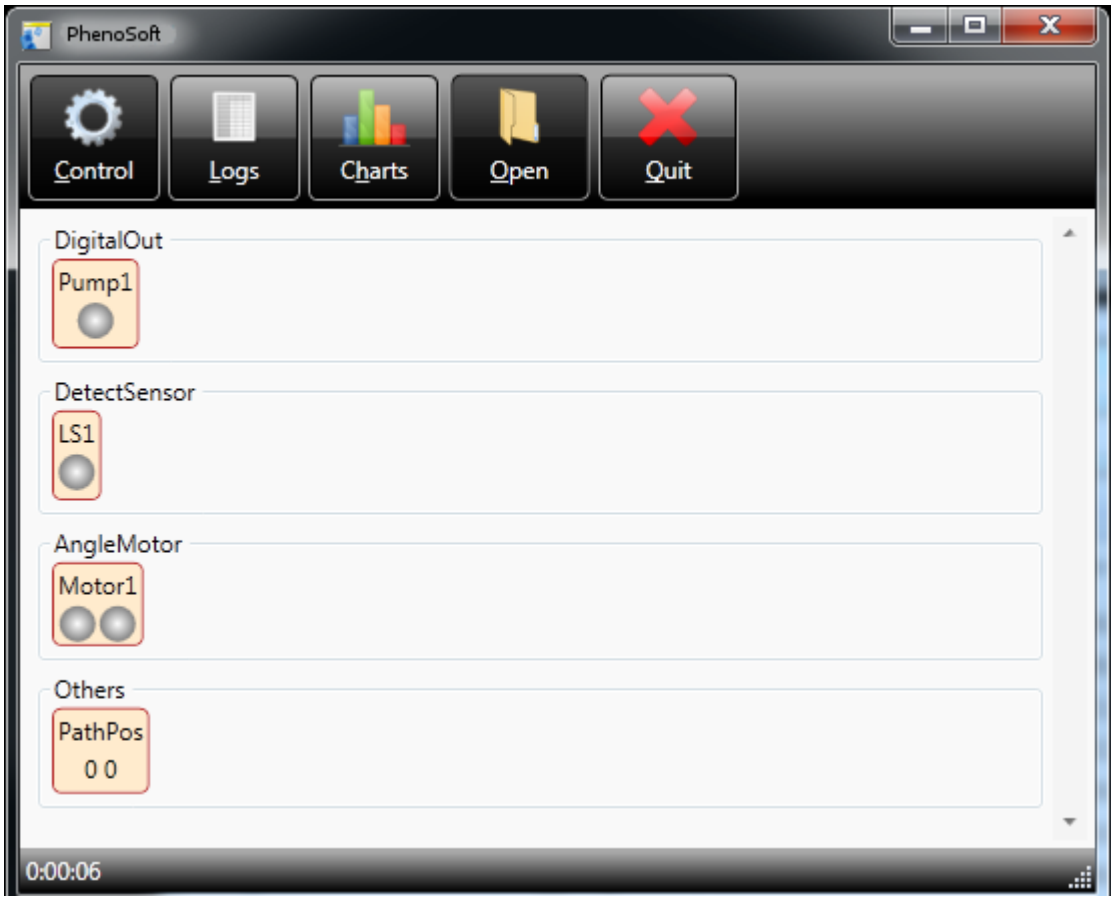


Fig. 12: *PhenoSoft Control* **Control** screen after loading a configuration file.

The icons signal the current state of single system functions. They also permit to control each component manually. An active component turns red or green. Click on an icon to manually activate/deactivate the selected component. This option is not active while running an experimental schedule.

Note
You can always switch to this **Control** screen by clicking the control button "**Control**" while running *PhenoSoft Control*.

For the basic set-up of the Jet Ball the **Control** screen will show the following icons (Fig. 12):

1. **Digital Out.** Peristaltic pump of the operant device. Click on “Pump1” to activate the pump to provide a single reward. The trigger field turns red.

2. **DetectSensor**. The trigger field represents the lick sensor (LS1) of the retractable operant device. Tip on top of the operant device to activate the lick sensor. The trigger field turns green.

3. **AngleMotor**. The two trigger fields “Motor1” show whether the drinking spout is in forward position or retracted. Clicking on one of the two trigger buttons will change position between forward and retracted.

4. **Others**. PathPos is the position of the animal within the virtual reality environment.

5.4. The **Logs** screen of *PhenoSoft Control*

Clicking the control button “**Logs**” will show the *PhenoSoft Control* **Logs** screen (see Fig. 13). On this screen you can follow data acquisition in real-time. The first column shows date and time. The other columns show various parameters as defined in the configuration file for each respective experiment, such as the amount of liquid reward (reinforce1value; see table below for a list of possible parameters).

> **Note**
> The second and the third column are only relevant when working with transponder-tagged animals.

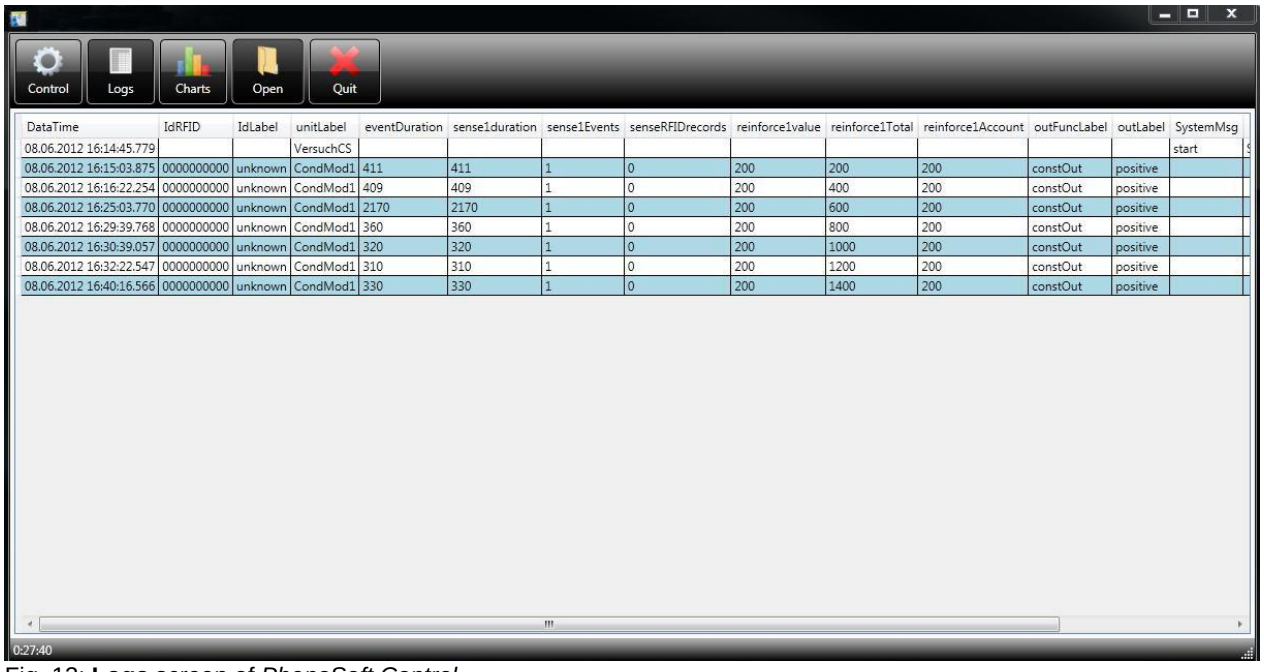


Fig. 13: **Logs** screen of *PhenoSoft Control.*

Table 2: Possible parameters displayed in the **Logs** table. The actual parameters are dependent on their respective definition in the configuration file.

UnitLabel	Location of event
EventDuration	Duration of event in milliseconds [ms]
Sense1duration	Duration of triggering the lick sensor [ms]
Sense1Events	Number of separate licks during lick sequence
Reinforcevalue	Amount of reward given as duration of pump activation [ms]
Reinforce1Total	Total amount of liquid rewards received by the animal
OutFuncLabel	Name as defined in the configuration file
OutLabel	Positive reward (the other label is: negative reward)
SystemMsg	General messages from the system or from the experimental schedule
MsgValue1, MsgValue2, MsgValue3	Message values

5.5. The **Charts** screen of *PhenoSoft Control*

The control button "**Charts**" is only relevant when working with more than one operant device.

5.6. Closing *PhenoSoft Control*

The control button "**Quit**" will close the program.

> **Note**
> The program will continuously write the recorded data to a **log file**. Therefore, there is no button to save data. The **log file** will be automatically saved in the subfolder "configs" in the folder of *PhenoSoft Control* (e.g. C:\Desktop\PhenoSoftControl\configs\logs-12.2.12).

5.7. The experimental data of *PhenoSoft Control*

The *PhenoSoft Control* **log file** containing the experimental data is written in a CSV format and is automatically saved in the "configs" folder of *PhenoSoft Control* (e.g. Logs-12.05.08, see Fig. 14).

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	DateTime	IdRFID	IdLabel	unitLabel	eventDuration	sense1duration	sense1Event	senseRFIDrecords	reinforce1value	reinforce1Total	reinforce1Account	outFuncLabel	outLabel
2	13.06.2012 15:41:40,595			VersuchCS									
3	13.06.2012 15:41:54,206	0	unknown	CondMod1	470	470	1	0	200	200	200	constOut	positive
4	13.06.2012 15:42:08,746	0	unknown	CondMod1	370	370	1	0	200	400	200	constOut	positive
5	13.06.2012 15:42:23,406	0	unknown	CondMod1	720	720	1	0	200	600	200	constOut	positive
6	13.06.2012 15:42:52,023	0	unknown	CondMod1	1000	1000	1	0	200	800	200	constOut	positive
7	13.06.2012 15:43:11,403	0	unknown	CondMod1	440	440	1	0	200	1000	200	constOut	positive
8	13.06.2012 15:43:26,973	0	unknown	CondMod1	390	390	1	0	200	1200	200	constOut	positive
9	13.06.2012 15:43:39,112	0	unknown	CondMod1	381	381	1	0	200	1400	200	constOut	positive
10	13.06.2012 15:43:47,399			VersuchCS									
11													
12													
13													
14													

Fig. 14: The *PhenoSoft Control* **log file** viewed as Excel spreadsheet.

The **log file** gives date and time encoded as serial date-time in the first column (ddddd.tttttt). The integer portion of the number, ddddd, represents the number of days since 1900-Jan-0. The integer portion of the number, tttttt, represents the fractional portion of a 24 hour day. With the Excel format cell function the serial date-time can be simply converted to show a regular date and time format, for example dd.mm.yyyy hh.mm.ss. All other recorded parameters, such as quantity of feeder visits are then simply listed with the corresponding time stamp in the respective spreadsheet columns.

Note
As long as the **log file** of the same day is opened, the program *PhenoSoft Control* cannot continue to write data to this file. However, the program memorises recorded data while not being able to write to the **log file** and will append the recorded data to the **log file** as soon as it is closed again.

A second **log file** contains the time-stamped positions (X, Y) of the animal in the virtual reality environment.

6. THE RETRACTABLE OPERANT DEVICE OF THE JET BALL

As defined in the reward routine in the Excel configuration file (see *5.1. The Excel configuration file of PhenoSoft Control*), the operant device will extend to be presented to the animal. The movement of the operant device is triggered, for example, when the animal reaches a defined landmark within the virtual reality. The system then waits for a licking response by the animal and will then activate the peristaltic pump to deliver a reward. The lick sensor detects any slight vibration of the feeder tube as caused by the licking animal.

6.1. Positioning the operant device

To adjust the height (see Fig. 15 “1”), the angle “2”, and the distance “3” of the operant device to the ball loosen the respective screw with a 3 mm hex key.

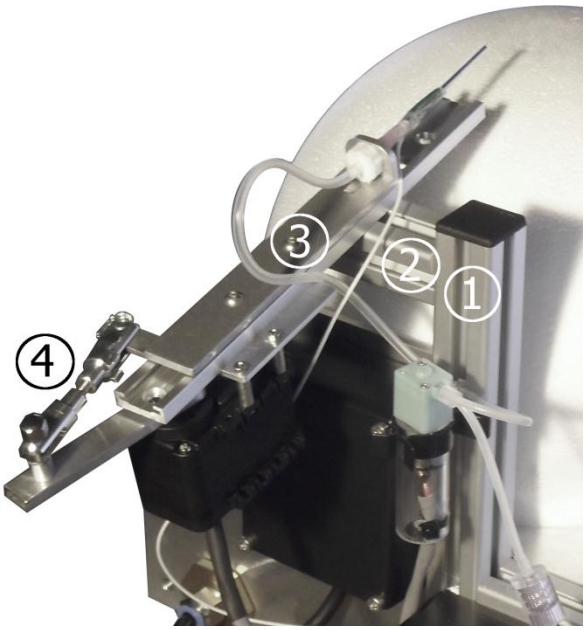


Fig. 15: Adjusting the position of the operant device.

1: Height
2: Angle
3: Distance
4: Position of the licking spout

To change the position of the licking spout of the operant device (retracted or extended; see Fig 15 “4”):

1. Click on “Open” on the *PhenoSoft Control* **Control** screen and load the Excel configuration file “Hardware”.

2. Right-click on the trigger field “Motor1” and vary the angle. The range is from 50 to 500. Write down the final angle values.

3. Open the configuration file (see *5.1. The Excel configuration file of PhenoSoft Control* for details). In the “IO” sheet enter for the parameters “openAngle” and “closeAngle” the determined angle values (see Fig. 16). The two values must be in the range from 50 (openAngle) to 500 (closeAngle).

13				
14	**AngleMotor**			
15	label		Motor1	
16	channel		dynMot1	
17	openAngle		50	
18	closeAngle		500	
19	showInGui		true	
20				
21				

Fig. 16: “AngleMotor” of Table “IO” of the Excel configuration file.

4. Confirm the changed parameters by starting *PhenoSoft Control* and clicking on the icon “AngleMotor” trigger buttons.

Attention!
You can seriously harm the animal if the retractable operant device is not adjusted correctly. Make sure that the operant device in its “forward” position **does not interfere** with the position of the animal.

6.2. Adjusting the lick sensor

Adjust the sensitivity of the lick sensor with “Gain” and “Sens.” of the lick sensor controller (see Fig. 17). “Gain” regulates the intensity of the signal, “Sens.” the sensitivity of the signal. It is recommended that the bars of the two pins are pointing upwards.

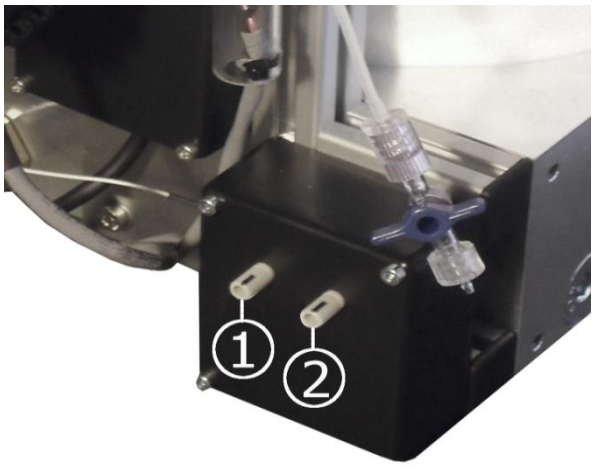


Fig. 17: Lick Sensor Controller

1: Pin “Gain”
2: Pin “Sens.”

6.3. Calibration of the reward quantity

The quantity of a single liquid reward is determined in the configuration file as time (in milliseconds) the pump of the feeder is activated. To calibrate the reward quantity produced we recommend using a graduated glass pipette for 100 or 200 µl total volume. With this you can measure the volume of a liquid reward droplet. Alternatively, you can pump multiple rewards onto an electronic balance as described below.

To automatically pump multiple rewards:

1. Click on “Open” on the *PhenoSoft Control* **Control** screen and load the configuration file “Hardware”. Right-click on the trigger file “Pump1” to define the following parameters:
    a. “High”: Duration of pump activity (must be at least 200 ms).
    b. “Low”: Time interval before pump can be reactivated (recommended: 100 ms).
    c. “Count”: Number of cycles the pump will be activated (recommended: 10)

2. Hold a glass test tube under the feeder to collect all reward liquid that is released.

3. Start the calibration procedure with *PhenoSoft Control* similar to starting an experimental trial.

4. Gently touch the lick sensor to activate the pump.

5. Weigh the test tube and divide the added weight by the number of pump events.

6. Repeat this procedure several times for higher accuracy.

Note
The calibration has to be repeated when changing the components of the tube system or the kind of liquid reward (for example concentrated milk instead of sugar water).

7. MAINTENANCE OF THE JET BALL

Cleaning of the different components of the Jet Ball:

Tube system and container with reward liquid	• Clean the liquid reward container regularly, e.g. every second day. • When the operant device is not used for more than two days, release all liquid from the tubes and have a disinfecting cleaning fluid (e.g. 70% alcohol) flow through the tube for e.g. 10 minutes. • Before using the operant system again rinse the tube system with plenty of water. • The tube to the liquid reward container should be replaced at regular intervals. We recommend disposable IV line tubes with a luer lock ending (where you cut off the second luer lock) as are available in various lengths from medical/hospital product suppliers.
Compressed air tubes	The compressed air tubes should be replaced at regular intervals. We recommend 6 mm OD, 4 mm ID, e.g. PUN-6x1. Possible supplier: http://www.festo.com/net/startpage/ (order number 159665)
Ball Holder, aluminium base	Use a solution containing a mild detergent or alcohol. Be sure to clear the reservoir at the bottom of the Ball Holder from dirt and urine.
Retractable operant device and lick sensor	Use soft cloth soaked with water. Be careful not to damage the lick sensor.
X/Y motion sensor	Control at regular intervals if the opening of the sensor is dust-free. Remove dust with a small brush.
Ball	• Clean the ball of the Jet Ball Unit with a solution containing a mild detergent or alcohol. • The balls should be replaced at regular intervals. Balls must have a 200 mm diameter (mice) consisting of two hollow halves. Please contact **PhenoSys** for a list of possible suppliers.
Pressure regulator	Remove the condensed water within the pressure regulator at regular intervals. For this, open the release valve at the bottom of the regulator (see Fig. 6a).

TFT Surround Monitor	Clean the surface of the TFT Surround Monitor with an alcohol free glass cleaner and soft cloth. If you have to disinfect the surface of the monitor, use a solution containing quaternary ammonium (e. g. Destix MK75 from Kleinmann GmbH).

8. TECHNICAL SPECIFICATIONS

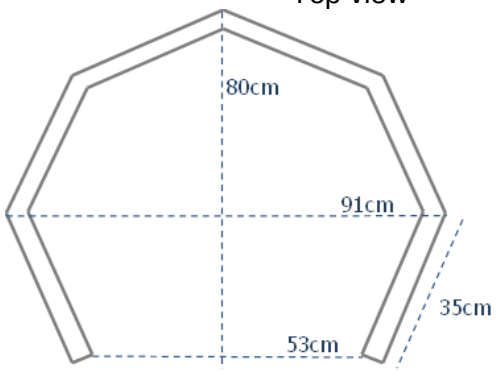
Version	TFT Surround Monitor
Power input voltage	100-240 V AC
Power consumption	850 W (maximal), 500 W (typical)

TFT Surround Monitor

270°, in octagonal arrangement with six TFT sub-units

Height: 41 cm
Weight: 29.9 kg

Top view



Power consumption TFT surround monitor	210 W

TFT sub-unit

Diagonal	17.0“
Active area	337.92 (H) x 270.336 (V) mm
Resolution – display	1280 x 1024 pixel
Resolution – controller	640 x 480 – 1280 x 1024 pixel
Pixel pitch	0.264 (H) × 0.264 (V) mm
Pixel arrangement	RGB vertical stripe
Display colours	16.2 Mio.
Display mode	Normally White
Brightness	300 cd/m²
Contrast ratio	700:1
Viewing angle	hor.: 80° / 80°, ver.: 80° / 80°
Response time	8 ms
H-Sync.	31.5 – 80 KHz
V-Sync.	60 – 75 Hz
Power input voltage	12V DC
Power consumption TFT sub-unit	35 W
Dimension	358.5 x 296.5 x 27 mm

Ball

Diameter	200 mm (for mice)
Material	Polystyrene

Lick sensor

Material (outer cover)	Polyvinyl chloride

Ball Holder (without operant device)	
Length	20 cm
Width	20 cm
Height	8 cm
Height with ball (without air flow)	21 cm
Weight	5.5 kg
Material	Aluminium
Sound pressure level	50-55 dBA (1 cm distance from the ball)
Flow meter	
Flow range	4-50 l/min
Pressure	6.9 bar (maximal)
X/Y motion sensor (tracking)	
Resolution	200-5700 dpi
Max. acceleration	30G
Max. speed	Up to 4.19 m/second
Peristaltic pump	
Typical flow rate	0.45 ml/min
Movable rack	
Width	78 cm
Depth	78 cm
Height	178 cm
Computer	
Power consumption	600 W (maximal)
Delay of data transfer to external interface	1-5 ms
Interval of position reports of the animal	10 ms

Electrical power supply and safety:

- Computer and electrical enclosure: All electrically conductive parts with 230V connection are connected with the protective bonding circuit of the electric connection by a safety plug (in accordance with protection class I to EN 61140).
- TFT Surround Monitor and Ball Holder: safety extra-low voltage (according to protection class III to DIN EN 61140).

9. EXTERNAL INTERFACE

The NI-USB 6501 of the Jet Ball allows the transmission of 16 TTL digital signals to the ITC-18 Data Acquisition Interface (Table 3):

- Output: Port 1 and 2 of the NI-USB (Jet Ball)
- Input: Digital I/O of the ITC-18 (see Fig. 18)

Table 3: Rear Panel Connector PIN Assignments.

Pin	Top Connector	NI-USB Interface	Bottom Connector	NI-USB Interface	Pin	Top & Bottom Connector
1	Ground	Ground	no connection	Ground	2	Ground
3	TTL input bit 8	P2.0	TTL input bit 0	P1.0	4	Ground
5	TTL input bit 9	P2.1	TTL input bit 1	P1.1	6	Ground
7	TTL input bit 10	P2.2	TTL input bit 2	P1.2	8	Ground
9	TTL input bit 11	P2.3	TTL input bit 3	P1.3	10	Ground
11	TTL input bit 12	P2.4	TTL input bit 4	P1.4	12	Ground
13	TTL input bit 13	P2.5	TTL input bit 5	P1.5	14	Ground
15	TTL input bit 14	P2.6	TTL input bit 6	P1.6	16	Ground
17	TTL input bit 15	P2.7	TTL input bit 7	P1.7	18	Ground
...						

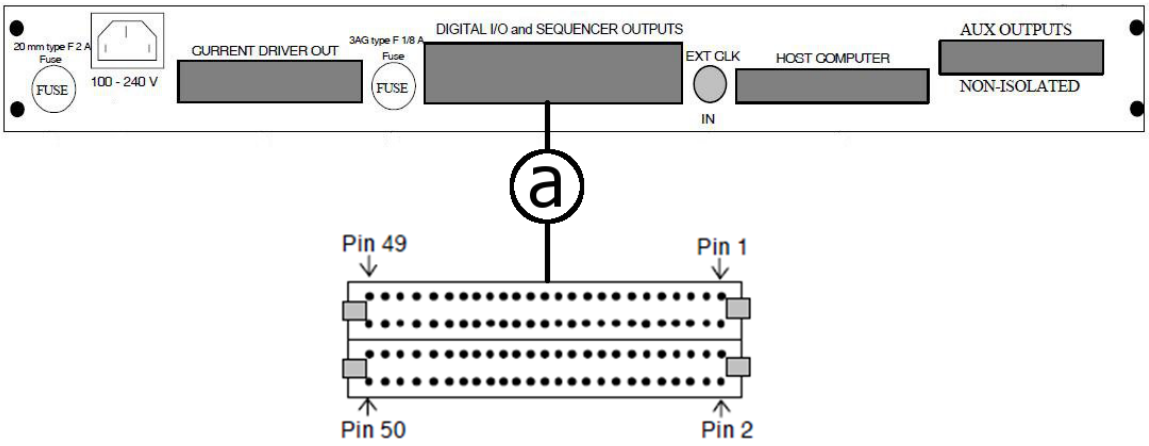


Fig. 18: Rear panel controls of the ITC-18 Data Acquisition Interface.

a: DIGITAL I/O and SEQUENCE OUTPUTS: Dual 50 pin IDC connector. 16 Digital input lines with individual grounds, 16 Digital output lines with individual grounds (Channel 0), 16 Digital output lines with individual grounds (Channel 1) and 7 sequencer outputs with individual grounds. Please note that the absolute maximum voltage range for the digital inputs is -0.5 volts to +5.5 volts. Do not exceed this range or damage can result to the input circuitry.

Connect the 2 cables of the NI-USB (Jet Ball) to the DIGITAL I/O of the ITC-18 Data Acquisition Interface (Fig. 19).

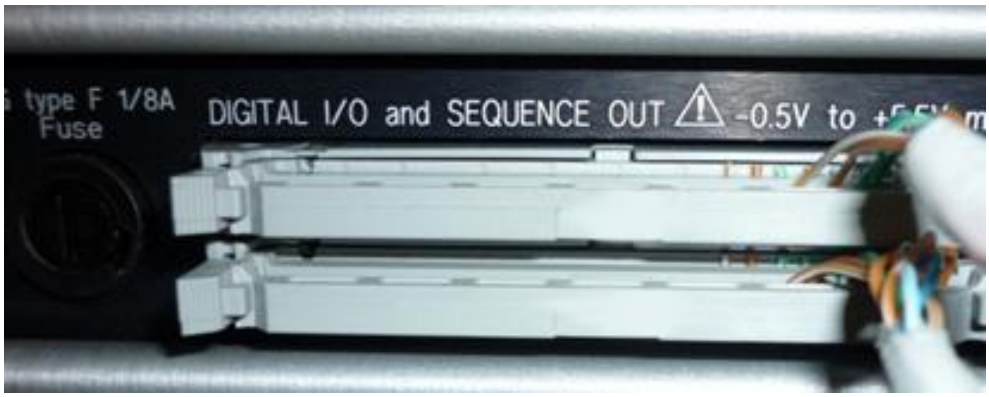


Fig. 19: Connection of the NI-USB 6501 to the ITC-18.

10. TECHNICAL SUPPORT

To obtain technical assistance, please contact us by email, phone, or web:

info@phenosys.com
+49-(0)30-54858831
www.phenosys.com

PhenoSys GmbH
Droysenstrasse 8
10629 Berlin
Germany

11. WARRANTY

ONE-YEAR-WARRANTY

Except as otherwise stated herein or in an order acknowledgment delivered to Buyer, Seller warrants to Buyer that the Product shall be free of defects in materials and workmanship. **The product is covered by a One-Year-Warranty.**

Seller makes no warranty regarding the model life of components. Buyer shall notify Seller in writing promptly (and in no case later than thirty (30) days after discovery) of the failure of any component of the product to conform to the warranty set forth above; shall describe in commercially reasonable detail in such notice the symptoms associated with such failure; and shall provide to Seller the opportunity to inspect such Products as installed, if possible. The notice must be received by Seller during the Warranty Period for such product, unless otherwise directed in writing by the Seller. Seller shall correct failure by, at Seller's options, either (i) modifying or repairing the Product or (ii) replacing the Product. Such modification, repair, or replacement and the return shipment of the Product with minimum insurance to Buyer shall be at Seller's expense. Buyer shall bear the risk of loss or damage in transit, and may insure the Product. Buyer shall reimburse Seller for transportation cost incurred for Product returned but not found by Seller to be defective. Modification or repair, of Products may, at Seller's option, take place either at Seller's facilities or at Buyer's premises. If Seller is unable to modify, repair, or replace a Product to conform to the warranty set forth above, then Seller shall, at Seller's option, either refund to Buyer or credit to Buyer's account the purchase price of the Product less depreciation calculated on a straight-line basis over Seller's stated Warranty Period.

THESE REMEDIES SHALL BE THE BUYER'S EXCLUSIVE REMEDIES FOR BREACH OF WARRANTY. SELLER GRANTS NO OTHER WARRANTIES, EXPRESS OR IMPLIED BY STATUTE OR OTHERWISE, REGARDING THE PRODUCTS, THEIR FITNESS FOR ANY PURPOSE, THEIR QUALITY, THEIR MERCHANTABILITY, THEIR NONINFRINGEMENT, OR OTHERWISE. NO EMPLOYEE OF SELLER OR ANY OTHER PARTY IS AUTHORIZED TO MAKE ANY WARRANTY FOR THE GOODS OTHER THAN THE WARRANTY SET FORTH HEREIN. SELLER'S LIABILITY UNDER THE WARRANTY SHALL BE LIMITED TO A REFUND OF THE PURCHASE PRICE OF THE PRODUCT. IN NO EVENT SHALL SELLER BE LIABLE FOR THE COST OF PROCUREMENT OR INSTALLATION OF SUBSTITUTE GOODS BY BUYER OR FOR ANY SPECIAL, CONSEQUENTIAL, INDIRECT, OR INCIDENTAL DAMAGES.

Buyer assumes the risk and agrees to indemnify Seller against and hold Seller harmless from all liability relating to (i) assessing the suitability for Buyer's intended use of the Products and of any system design or drawing and (ii) determining the compliance of Buyer's use of the Products with applicable laws, regulations, codes, and standards. Buyer retains and accepts full responsibility for all warranty and other claims relating to or arising from Buyer's products, which include or incorporate Products or components manufactured or supplied by Seller. Buyer is solely responsible for any and all representations and warranties regarding the Products made or authorized by Buyer. Buyer will indemnify Seller and hold Seller harmless from any liability, claims, loss, cost, or expenses (including reasonable attorney's fees) attributable to Buyer's products or representations or warranties concerning same.

12. NOTES