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Operations Manual for the NO_vA Power Distribution System

The elements of the power distribution system operate with very high voltage and current which can cause serious injury or death if handled improperly. Please read the separate manuals for detailed information!

1 Content

1	Content	2
2	Overview	3
3	Low Voltage Power Supplies	4
3.1	General Remarks	4
3.2	Direct Control of the Power Supply	5
3.3	Command Line Control	5
3.4	Control via Labview	6
3.5	Control via MuseControl	6
4	Breaker Panel	7
5	High Voltage Power Supplies	8
5.1	General remarks	8
5.2	Command Line Control	9
5.3	Control via Labview	9
6	Command Line Control	10
7	Power Distribution Box	13

2 Overview

The NOvA power distribution system (PDS) supplies power to four different electronic components used in the readout: front-end boards (FEBs), avalanche photodiodes (APDs), thermoelectric coolers (TECs), and data concentrator modules (DCMs). The power distribution system consists of the low voltage power supplies and the breaker panel, the high voltage power supply, the power distribution boxes that fan out the power to the FEBs, APDs, TECs, and DCMs, and the power cables and their cable trays. A schematic is shown in Figure 1. The next sections of the manual describe how the components of the power distribution system can be controlled and monitored.

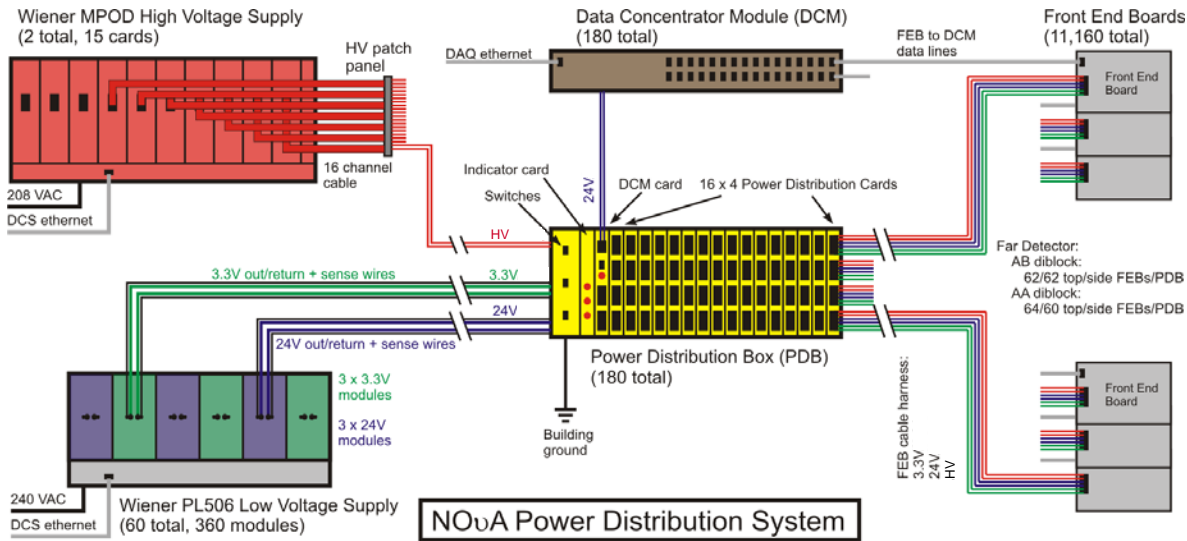


Figure 1

Layout of the Power Distribution System.

Each power distribution box feeds 3.5V (FEB), 24V (TEC), and high voltage (APD) via a single cable to a maximum of 66 front-end boards, and 24V via a single cable to the nearby data concentrator module. The APD voltage to the power distribution boxes is provided by Wiener MPOD cards situated in a Wiener mainframe. The FEB, TE cooler, and DCM power are provided by Wiener PL506 power supplies. The channel counts are for the NOvA Far Detector only.

3 Low Voltage Power Supplies

3.1 General Remarks

The low voltages needed by the FEBs (3.5V), DCMs (24V), and TE coolers (24V), are provided by the Wiener PL506 Power Supply System. Each power supply has three 3.5V channels and three 24V channels, so that it can serve 3 power distribution boxes (PDBs), while each PDB gets fed by one 3.5V and 24V channel each. These power distribution boxes distribute the power to the FEBs, TECs, and DCMs. There are currently two low voltage power supplies installed, which are both located at relay rack 1 (see Table 1).

PDB location		LV power supply			
Diblock	Position on diblock	Relay rack	Position in relay rack	IP address	Channel numbers
1	1 (top)	1	1 (top)	http://131.225.198.230	u0 ... 3.5V u1 ... 24V
1	2 (side – upper row)	1	1 (top)	http://131.225.198.230	u2 ... 3.5V u3 ... 24V
1	3 (side – lower row)	1	1 (top)	http://131.225.198.230	u4 ... 3.5V u5 ... 24V
2	1 (top)	1	2 (bottom)	http://131.225.198.231	u0 ... 3.5V u1 ... 24V
2	2 (side – upper row)	1	2 (bottom)	http://131.225.198.231	u2 ... 3.5V u3 ... 24V
2	3 (side – lower row)	1	2 (bottom)	http://131.225.198.231	u4 ... 3.5V u5 ... 24V
3	1 (top)	2	1 (top)	http://131.225.198.232	u0 ... 3.5V u1 ... 24V
3	2 (side – upper row)	2	1 (top)	http://131.225.198.232	u2 ... 3.5V u3 ... 24V
3	3 (side – lower row)	2	1 (top)	http://131.225.198.232	u4 ... 3.5V u5 ... 24V
Muon Catcher	1 (top)	2	2 (bottom)	http://131.225.198.233	u0 ... 3.5V u1 ... 24V
Muon Catcher	2 (side – upper row)	2	2 (bottom)	http://131.225.198.233	u2 ... 3.5V u3 ... 24V

Table 1

Low Voltage Power Supply chart

The measured sense voltage and the current can be monitored at the display at the frontpanel of the power supply. The status of each channel of the low voltage power supplies can also be monitored at a web browser at the addresses listed in the table above.

For safety reasons, whenever something needs to be done at the power cables, the plug at the front panel should be pulled to disconnect the power supply **AFTER** everything is turned off.

3.2 Direct Control of the Power Supply

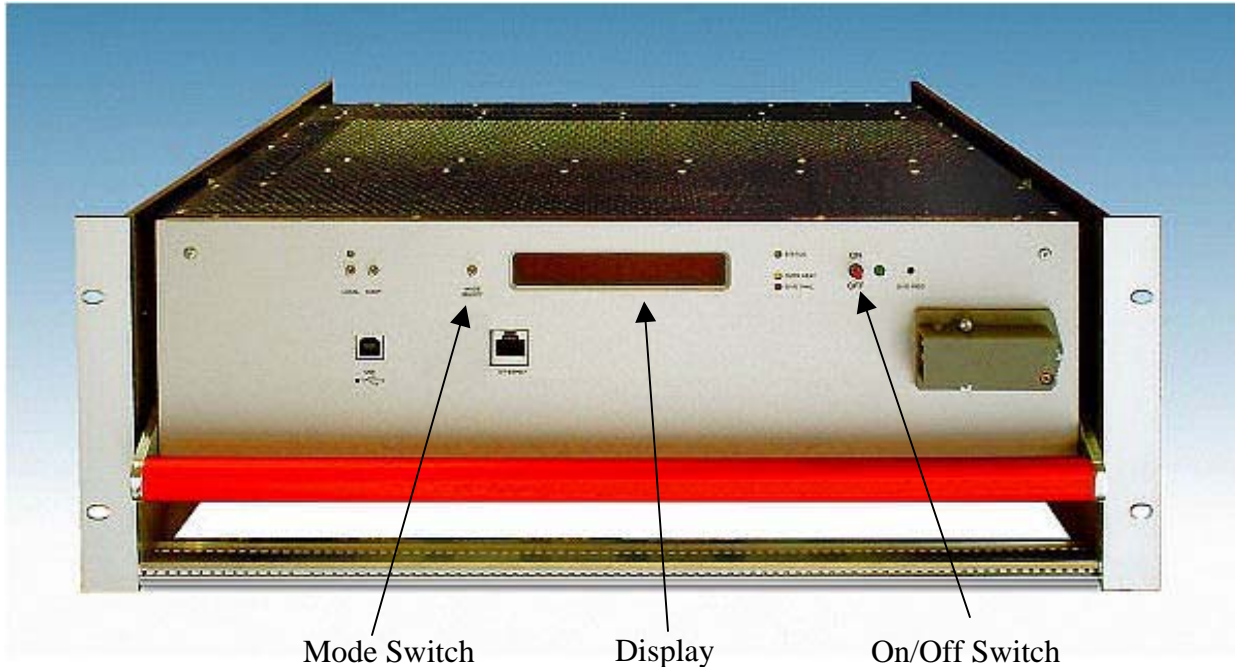


Figure 2
Wiener PL506 Low Voltage Power Supply

The power supply can be turned on at on/off switch at the front panel of the power supply by pushing the switch up (see Figure 2) and holding it for a second. Once the power supply is on, individual channels can be selected with the mode switch. The selected channel is shown in the display. A particular channel can be turned on or off by pushing the on/off switch up or down. To turn off the entire power supply, the on/off switch needs to be pushed down and held for a second.

The sense voltage and current of the selected channel is shown at the display at the frontpanel.

3.3 Command Line Control

The LV power supply can be controlled via command line access (with snmp) from a computer running a Linux operating system. See chapter 6 for details.

The following values (Table 2) are set for the 3.5V channels (u0, u2, u4) on all LV power supplies:

Option	Value
outputVoltage	3.5 V
outputCurrent	100.0 A
outputVoltageRiseRate	1.0 V/s
outputVoltageFallRate	100.0 V/s
outputSupervisionBehavior	17749 (turn off channel in the event of the following failures: outputFailureMinSenseVoltage, outputFailureMaxSenseVoltage, outputFailureMaxTerminalVoltage, outputFailureMaxCurrent, outputFailureMaxTemperature, outputFailureMaxPower, outputFailureTimeout
outputSupervisionMinSenseVoltage	3.1 V

outputSupervisionMaxSenseVoltage	4.0 V
outputSupervisionMaxTerminalVoltage	5.0 V
outputSupervisionMaxCurrent	100.0 A
outputSupervisionMaxPower	600.0 W

Table 2

Settings for the 3.5V channels (u0, u2, u4) of all low voltage power supplies.

The following values (Table 3) are set for the 24V channels (u1, u3, u5) on all LV power supplies:

Option	Value
outputVoltage	24.0 V
outputCurrent	23.0 A
outputVoltageRiseRate	5.0 V/s
outputVoltageFallRate	100 V/s
outputSupervisionBehavior	17749 (turn off channel in the event of the following failures: outputFailureMinSenseVoltage, outputFailureMaxSenseVoltage, outputFailureMaxTerminalVoltage, outputFailureMaxCurrent, outputFailureMaxTemperature, outputFailureMaxPower, outputFailureTimeout)
outputSupervisionMinSenseVoltage	22.8V
outputSupervisionMaxSenseVoltage	25.2V
outputSupervisionMaxTerminalVoltage	27.0 V
outputSupervisionMaxCurrent	23.0 A
outputSupervisionMaxPower	550.0 W

Table 3

Settings for the 24V channels (u1, u3, u5) of all low voltage power supplies.

3.4 Control via Labview

[...]

3.5 Control via MuseControl

[...]

4 Breaker Panel

The power cables connecting the power supply with the PDBs are protected by breakers which are located in breaker panels at the back of the relay rack. These breakers trip in the case of an overcurrent. They are used **ONLY** to protect the cables, and **NOT** to turn off the power to the PDBs (as convenient as it may seem). Switching the breakers off while the sense cables are still connected, may cause the sense cable fuses to blow. Therefore, **DO NOT** use the breakers to turn off the power – use the on/off switch at the power supply instead.

5 High Voltage Power Supplies

5.1 General remarks

The high voltage needed by the APD is provided by the Wiener MPOD HV-EX high voltage power supplies system mainframes using ISEG EHS F6-05x 156-F floating 16-channel cards. A multiconductor cable takes the 16 HV channels from each ISEG card to a nearby patch panel, and tri-axial cables go from the patch panel to the PDBs. Each Wiener HV channel feeds a single PDB. The HV power supply is installed at relay rack 2 (see Table 4).

PDB location		HV power supply channel
Diblock	Position on diblock	
1	1 (top)	u400
1	2 (side – upper row)	u401
1	3 (side – lower row)	u402
2	1 (top)	u403
2	2 (side – upper row)	u404
2	3 (side – lower row)	u405
3	1 (top)	u406
3	2 (side – upper row)	u407
3	3 (side – lower row)	u408
Muon Catcher	1 (top)	u409
Muon Catcher	2 (side – upper row)	u410

*Table 4
High Voltage Power Supply chart*

The HV power supply does not have a front panel control, except and on/off switch at the mainframe. Individual channels can be controlled remotely only.

If a particular PDB needs to be supplied with high voltage, the HV switch at the PDB needs to be on **BEFORE** the HV is turned on at the power supply. Turning the switch at the PDB on after the HV has been turned on at the power supply, may lead to an overcurrent fault at the power supply. If one wants to turn off the high voltage for a particular PDB, it needs to be done **at the power supply first**. Turning off the HV switch at the PDB while the HV is still on, may lead to an overcurrent fault at the power supply.

The output voltage and current can be monitored of each channel of the high voltage power supply can be monitored at a web browser at <http://131.225.198.243>.

For safety reasons, whenever something needs to be done at the power cables, the plug at the front panel should be pulled to disconnect the power supply **AFTER** everything is turned off.

5.2 Command Line Control

The HV power supply can be controlled via command line access (with snmp) from a computer running a Linux operating system. See chapter 6 for details.

The following values (Table 5) are set for the channels of the HV power supplies:

Option	Value
outputVoltage	425.0 V
outputCurrent	0.015 A
outputVoltageRiseRate	5.0 V/s
outputVoltageFallRate	5.0 V/s
outputSupervisionBehavior	0 (ignore all failures)
outputSupervisionMinSenseVoltage	nan
outputSupervisionMaxSenseVoltage	nan
outputSupervisionMaxTerminalVoltage	nan
outputSupervisionMaxCurrent	nan
outputSupervisionMaxPower	nan

Table 5

Settings for the channels of all high voltage power supplies.

5.3 Control via Labview

[...]

6 Command Line Control

Both power supplies can be controlled via command line access from a computer running a Linux operating system.

One needs to have NetSNMP installed to communicate with the power supply. The file WIENER-CRATE-MIB.txt (which can be found at http://www.iseg-hv.com/download.php/979/file_url_en/WIENER-CRATE-MIB.txt) is needed as well. At the computer at the NOvA surface building, this file is located at /home/nova. In the section below, one can find a list of commands which can be used to control the power supply.¹ The option -m +./WIENER-CRATE-MIB.txt assumes that the commands are executed from the same location as the MIB file, i.e. at /home/nova. If the MIB is located somewhere else (e.g. if run from your own laptop), the path to the file needs to be changed accordingly. If the MIB is moved to /usr/share/snmp/mibs/, then the option -m +WIENER-CRATE-MIB can be used.

To check whether the crate is on or off:

```
snmpget -v 2c -m +./WIENER-CRATE-MIB.txt -c public 131.225.198.243 sysMainSwitch.0
```

To turn the crate on:

```
snmpset -v 2c -m +./WIENER-CRATE-MIB.txt -c public 131.225.198.243 sysMainSwitch.0 i 1
```

To turn the crate off:

```
snmpset -v 2c -m +./WIENER-CRATE-MIB.txt -c public 131.225.198.243 sysMainSwitch.0 i 0
```

To return a list of possible HV channels:

```
snmpwalk -v 2c -m +./WIENER-CRATE-MIB.txt -c public 131.225.198.243 outputName
```

To return the set voltages of all HV channels:

```
snmpwalk -v 2c -m +./WIENER-CRATE-MIB.txt -c public 131.225.198.243 outputVoltage
```

To return the set voltages of one HV channel (e.g. u400 – first channel in slot 4):

```
snmpget -v 2c -m +./WIENER-CRATE-MIB.txt -c public 131.225.198.243 outputVoltage.u400
```

To set the set voltages for HV channel u400 to 450V:

```
snmpset -v 2c -m +./WIENER-CRATE-MIB.txt -c guru 131.225.198.243 outputVoltage.u400 F 450
```

To turn on HV channel u400:

```
snmpset -v 2c -m +./WIENER-CRATE-MIB.txt -c guru 131.225.198.243 outputSwitch.u400 i 1
```

To turn off HV channel u400:

```
snmpset -v 2c -m +./WIENER-CRATE-MIB.txt -c guru 131.225.198.243 outputSwitch.u400 i 0
```

To clear all events for HV channel u400 (e.g. after power supply has blocked the channel after an overcurrent fault):

```
snmpset -v 2c -m +./WIENER-CRATE-MIB.txt -c guru 131.225.198.243 outputSwitch.u400 i 10
```

¹ From MPOD HV& LV Power Supply System – Technical Manual, 20. November 2009, Version 1.02

The general pattern for these and other commands is

snmpget -v 2c -m +./WIENER-CRATE-MIB.txt -c guru 131.225.198.243 \$name.\$index
to read a value from the crate for one particular channel

snmpwalk -v 2c -m +./WIENER-CRATE-MIB.txt -c guru 131.225.198.243 \$name
to read the values from the crate for all channel, and

snmpset -v 2c -m +./WIENER-CRATE-MIB.txt -c guru 131.225.198.243 \$name.\$index \$format \$value
to set a particular value for one particular channel

with \$name the name of the value to be read or set (see list below)
 \$index the index of the particular channel (e.g. u400)
 \$format the format of the value to be set (see list below)
 \$value the value to be set

See Table 6 for a list of options. A complete list can be found in the MIB file.

\$name	\$format	Access	Comments
outputVoltage	F	R/W	Set voltage
outputCurrent	F	R/W	Current limit
outputMeasurementSenseVoltage		R	Actual voltage
outputMeasurementTerminalVoltage		R	Actual voltage
outputMeasurementCurrent		R	Actual current
outputSwitch	I	R/W	Turns channels on/off \$value = 0: off \$value = 1: on \$value = 10 clear events
outputVoltageRiseRate	F	R/W	Channel ramp up rate
outputVoltageFallRate	F	R/W	Channel ramp down rate
outputStatus		R	Channel status info
outputSupervisionBehavior	I	R/W	Behavior of the channel or crate after a failure occurred. \$value is the decimal value of the combination of the bits explained in Table 7.
outputSupervisionMinSenseVoltage	F	R/W	Minimum sense voltage ²
outputSupervisionMaxSenseVoltage	F	R/W	Maximum sense voltage ²
outputSupervisionMaxTerminalVoltage	F	R/W	Maximum terminal voltage ²
outputSupervisionMaxCurrent	F	R/W	Maximum current ²

Table 6

Possible Options for the snmp commands for the WIENER Power Supplies.³

² The behavior of the channel or crate in the event that the condition set by this value is not met is set by outputSupervisionBehavior.

³ Information are taken from the WIENER MIB file.

Bit Fields	Used for setting the behavior of the channel/crate in the event of the following failure (returned by outputStatus)
0 and 1	outputFailureMinSenseVoltage (this failure is ignored if the channel is ramping up)
2 and 3	outputFailureMaxSenseVoltage
4 and 5	outputFailureMaxTerminalVoltage
6 and 7	outputFailureMaxCurrent
8 and 9	outputFailureMaxTemperature
10 and 11	outputFailureMaxPower
12 and 13	outputFailureInhibit
14 and 15	outputFailureTimeout

Table 7

Bit fields used by outputSupervisionBehavior for setting the behavior of the channel/crate in the event of a failure (e.g. returned by outputStatus).⁴ The bit field pairs can be set to values between 0 and 3, where

0 means ignore this failure

1 means turn off the channel

2 means turn off all channels with the same group number (for an ISEG HV power supply: turn off the channel via emergencyOff)

3 means turn off the crate (for an ISEG HV power supply: turn off the entire board via emergencyOff)

An example: If one wants to have the channel turned off (1), if terminal voltage is too high, and turn off the entire power supply (3) if the current is too high, and ignore all other failures (0), then the bits 4 and 5 are set to 0 1 (=1), the bits 6 and 7 are set to 1 1 (=3), and all other bit are left at 0 0 (=0). The combination of all 16 bits will look like

15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	0	0	0	0	0	1	1	0	1	0	0	0	0

The decimal value of 0000000011010000 is 208, which is used as \$value for outputSupervisionBehavior.

⁴ Information are taken from the WIENER MIB file.

7 Power Distribution Box

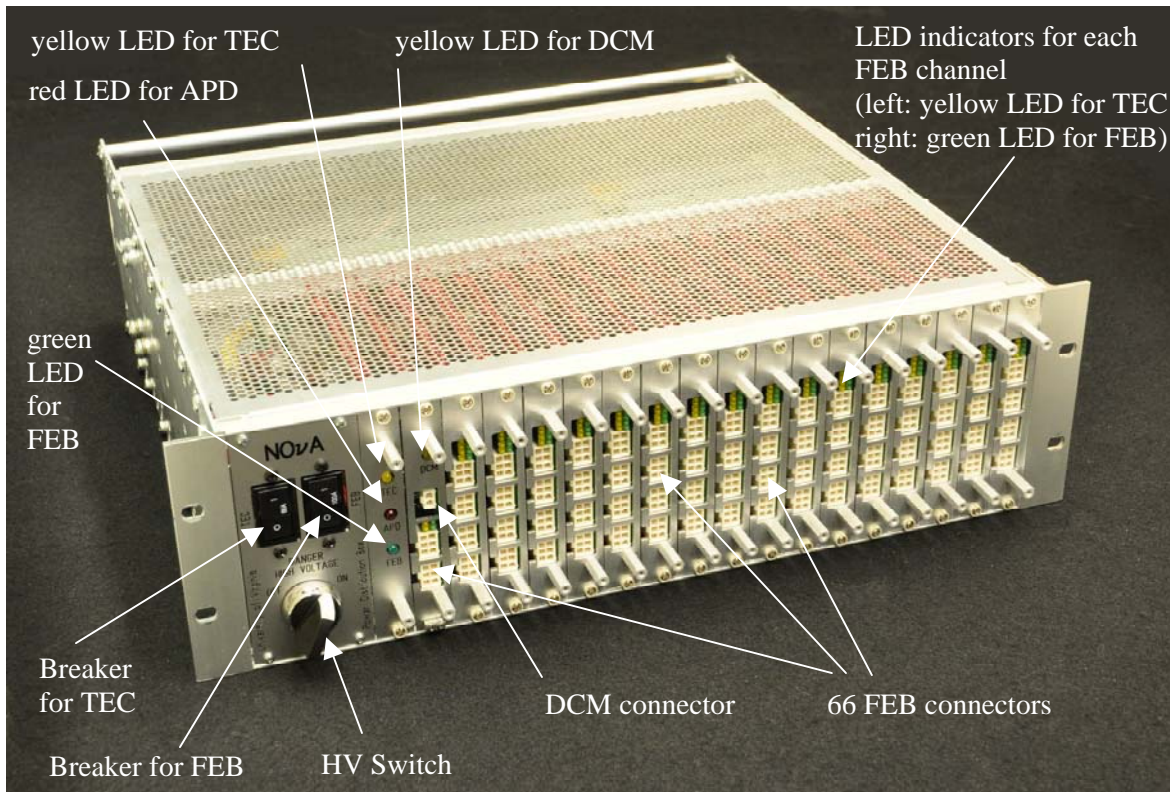


Figure 3
Power Distribution Box

The power distribution box receives power from low voltage and high voltage power supplies. Its function is to distribute this power to the FEBs, TECs, DCMs, and APDs installed at the detector. The frontpanels have LED indicators for the FEB (for the entire PDB and for each individual channel), the TEC (for the entire PDB and for each individual channel), the APD (for the entire PDB, but not for individual channels) and the DCM.

The HV switch and LV breaker switches are only a safety precaution to make sure that there is no high voltage / high current provided while the switches are “off”. The switches should **NOT** be used to turn on/off the power while the power supplies are on (and provide power to this PDB). Turning the HV and LV on/off needs to be done at the power supplies. Turning off the FEBs (3.5V) and TECs (24V) through the circuit breaker switches does not interrupt the DCM power; no switch is available to turn off DCM power at the PDB.

If an FEB, DCM or Indicator card needs to be replaced, the power supplies must be **turned off** first. In order to take the card out of the slot, all cables connected to this card need to be unplugged, and the captive screws on top and bottom of the card need to be loosened. The old card can be taken out by pulling on the two standoff screws. After the new card is pushed into the slot, the captive screws need to be tightened, and the cables can be plugged in.