Power Module X4

Features

- Space for 4 N-type MOSFET channels.
- 3V3 MCU direct on/off – With the right MOSFET, only one resistor is needed for controlling it.
- Default on with pull-up resistor – Hard wire how a high signal shall act.
- Default off with pull-down resistor – Hard wire how a high signal shall act.
- 1xV Totem-Pole Switching – For controlling the MOSFETs with voltage higher than the MCU can deliver.
- Parallel Drive / Group Switching – For paralleling the MOSFETs.
- Optional Power Extension – To back feed power to the MCU with a DC-DC converter
- Extension Board Connectors – For adding IC controller for the MOSFETs.
- Double Sided Ground Plane – For less noise emissions.

General Description

You can make various standard N-Type MOSFET circuits based on this PCB. It is hence not fixed to be used with one N-Type MOSFET circuit only, and you can add components according to your circuit.

With the PCB board you can build electronics for real applications, next to extending a potential test circuit from a breadboard.
The PCB gives you a more reliable and stable circuit than a breadboard, lasting long time without wires dropping off or wire connections failing, as often with breadboards.

Technical Specification	
MOSFET Type	N
Channels	4
Rails	+Vcc Ground 1xV xV

Use cases / Features

3V3 MCU Direct On/Off

Use case: Straight ahead drive the MOSFETs from 3.3V or 5V via a resistor. With the right MOSFET, like for instance FQP30N06L, only one resistor is needed for controlling the MOSFETs with 3.3 V.

Component List	
MOSFET	FQP30N06L
R21	10 Ω

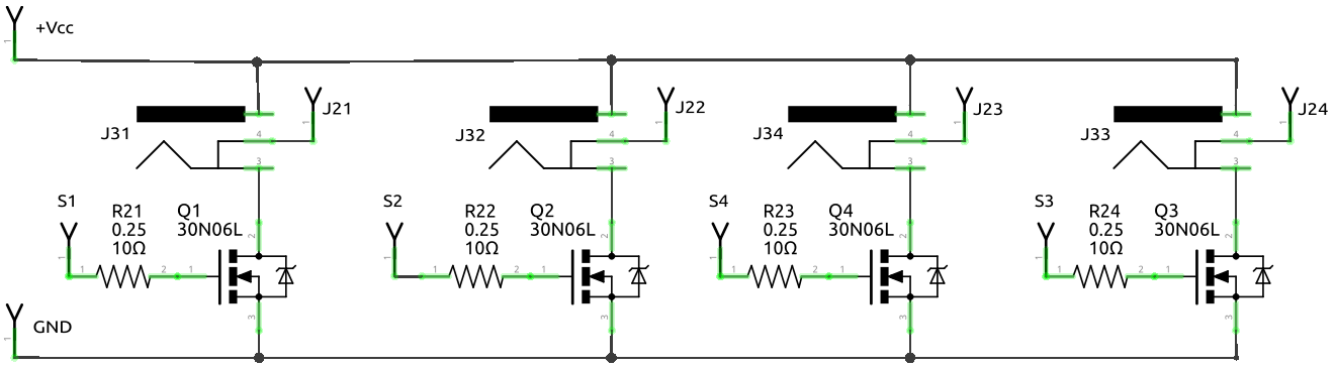

Fig. 1: 3V3 MCU Direct On/Off. Schematics for all 4 channels.

Default On with Pull-Up Resistor

Use case: You want the MOSFETs to be ON by default, until a signal changes that.

Using the schema to the right, makes it possible to drive the MOSFETs with a higher voltage than a MCU maybe can deliver.

Components List	
J1	Connect the one end of R1 here, instead of to GND
J21	Connect the one end of R21 here
J31	Power Jack
Q1	FET N-Channel like FQP30N06L
Q2	TRANSISTOR_NPN
R1	10kΩ Resistor
R21	1kΩ Resistor
S1	Generic header

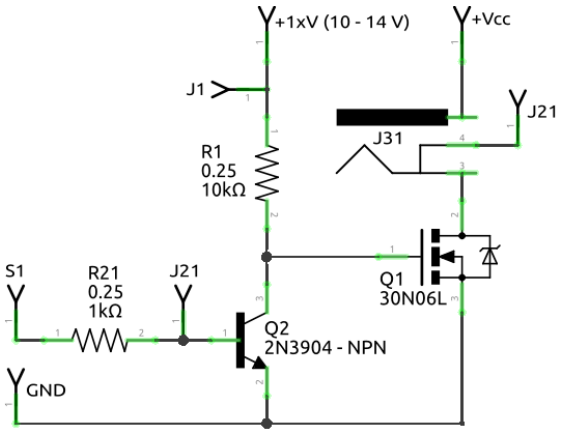

Fig. 2: Default On with Pull-Up Resistor

Default Off with Pull-Down Resistor

Use case: You want the MOSFETs to be OFF by default, until a signal changes that.

Using the schema to the right, makes it possible to drive the MOSFETs with a higher voltage than a MCU maybe can deliver.

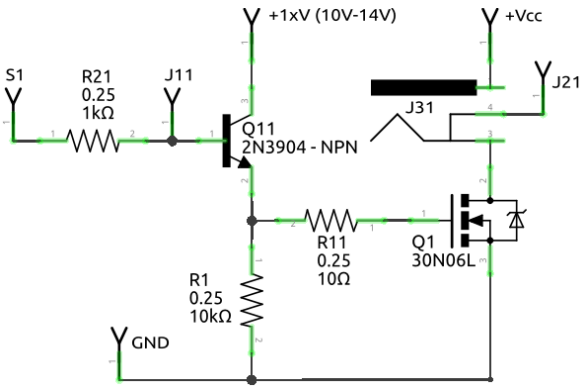

Fig. 3: Default Off with Pull-Down Resistor

Component List		
Reference	Qty.	Value
J11	n/a	Connect one end of R21 here.
J31	1	Power Jack
Q1	1	MOSFET N-Channel like FQP30N06L
Q11	1	NPN-Transistor
R1	1	10kΩ Resistor
R11	1	10Ω Resistor
R21	1	1kΩ Resistor

1xV Totem-Pole Switching

Use case: For switching the MOSFETs harder and faster at higher frequencies. This is needed if you want to switch the MOSFETs consistently with higher frequencies. Pulling the gate of the MOSFET down with a transistor is for instance fastener than letting it bleed off through a resistor. The higher voltage on the gate ensures faster switching, and hence lower switching loses in the MOSFET because of the Miller Effect.

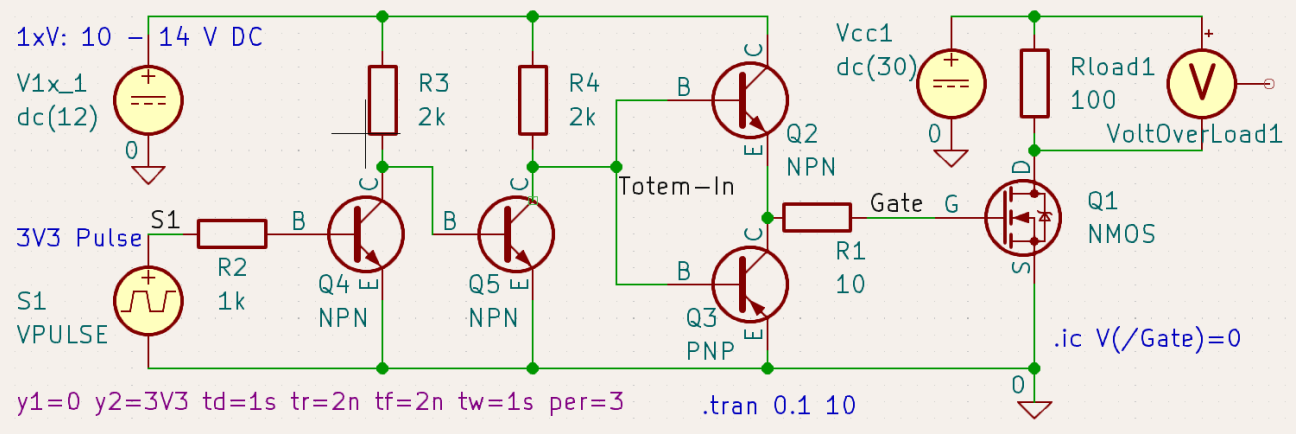

Fig. 4: Schema for 1xV Totem-Pole Switching, drawn in Spice, KiCad

Remember, if you use inductive loads, like a motor, don't forget to add a diode reversed over the load. D11 to D14 on the PCB is the place for that.

A 39K resistor could be added from the base of Q4 down to ground in Fig. 4, just to be sure the transistor turns off, should no signal be available.

Component List		
Reference	Qty	Value
Q1	1	NMOS
Q2, Q4, Q5	3	NPN
Q3	1	PNP
R1	1	10
R2	1	1k
R3, R4	2	2k
Rload1	1	Some Load

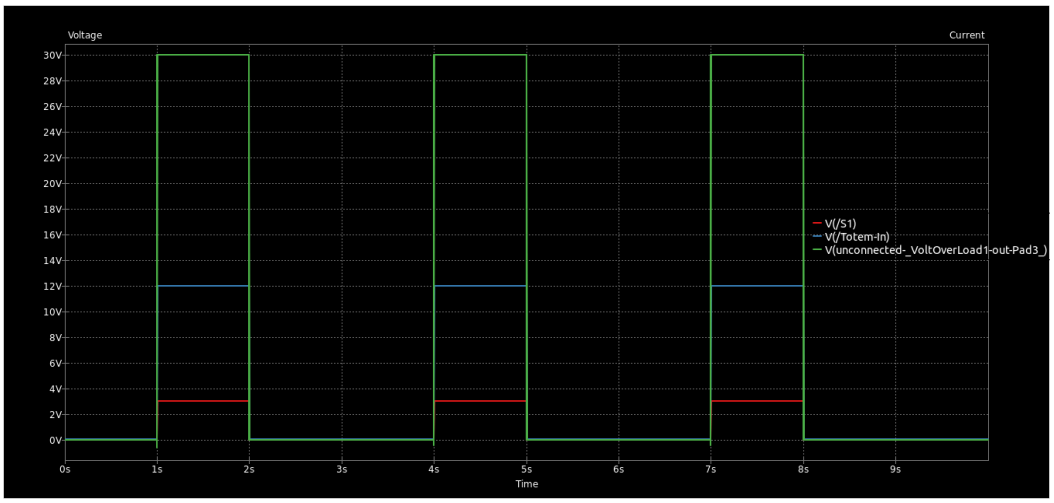

Fig. 5: Spice Simulation in KiCad for 1xV Totem-Pole Switching

Parallel Drive / Group Switching

Use case: Should you want to divide a load over more than one MOSFET, can you combine the signals driving the MOSFETs into one. This would be done by shorting R61 to R64, together with J65 and J66, according to the number of channels you want to drive in parallel. All four channels could at the end be driven via J67.

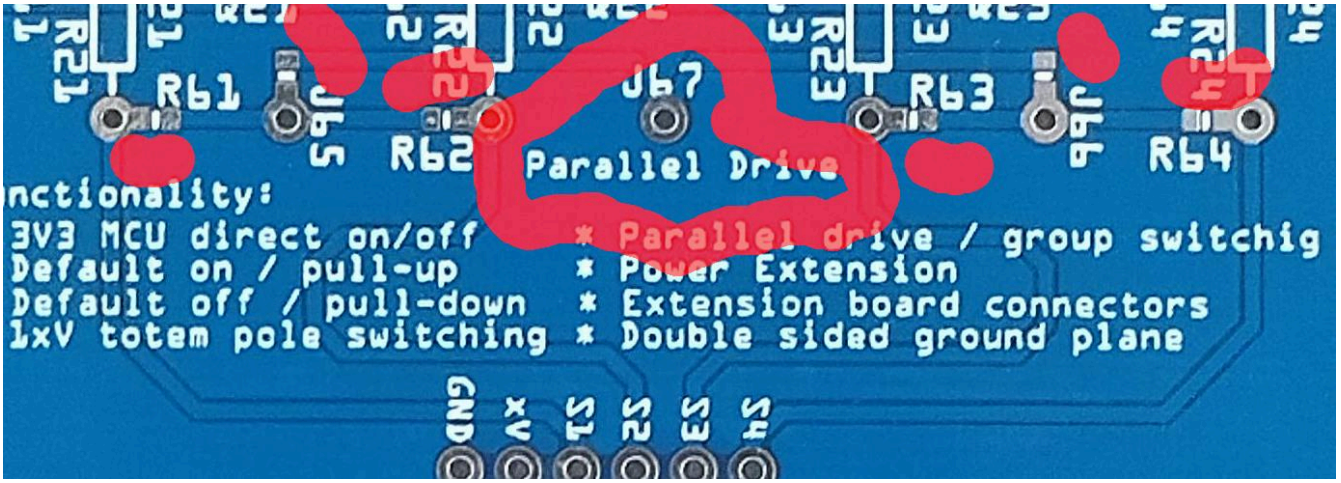

Fig. 6: R61-R64 J65-J66 and J67 marked by red.

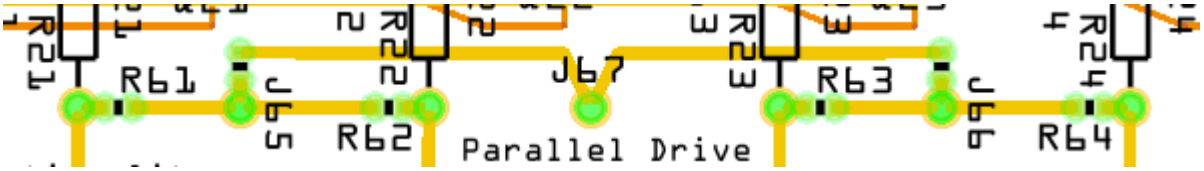

Fig. 7: The option for driving the MOSFETs in parallel, by shorting R31-R64, and J65-J66.

MCU Signal Connector

At the center, bottom of the PCB, you will find the MCU SIgnal Connector. This assembles the four signals controlling the MOSFETs into one connector, together with ground, and optionally a backfeed of 3.3V or 5V to the MCU, or other form of controlling unit.

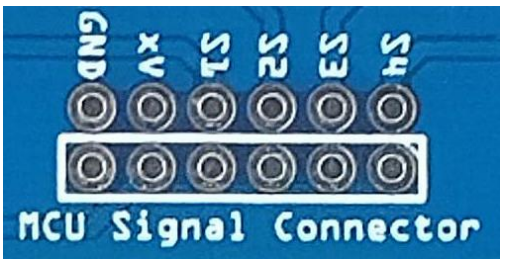

Fig. 8: MCU Signal Connector

Power Extension

Use cases:

1.) You want to power the switching of the MOSFETs with another voltage than +Vcc or the signal from the MCU.
2.) You want to use the power from +Vcc to backfeed via a DC-DC converter into the MCU or other unit driving the signal for switching the MOSFETs,

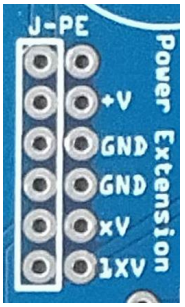

Fig. 9: The Power Extension

The Power Extension header will be you friend in that case. It allows you to add DC/DC converters that transforms +Vcc down to something in between 10V and 14V for driving the MOSFETs, and 3.3V or 5V for the MCU. All that could be on a little PCB just stuck into this header.

The pin labeled 1xV is for the 10 to 14V, or any voltage you choose really, for hard switching the MOSFETs.

The pin labeled xV is for something below 10V, for instance 5V in case of an Arduino, or 3.3V in case of an ESP32.

You decide if you want to put something here.

Extension Connectors

Use case: Some may want gate driver ICs for switching the MOSFETs. The Extension Connectors gives you the option to build your own extension board based on such ICs. So even if the Power Module PCB is starting out with space for transistors, it is possible to excel later on with gate driver ICs.

So why not implementing gate driver ICs right on the Power Module PCB? - Because there exist a ton of different gate driver ICs. And there exists a ton of different MOSFETs. Some may combine well, others bad. As the space was left anyway, the option for a connector was build in here. - See it as an extra.

The headers EC-West and EC-East are mainly for fixing an added gate driver board. They are not fixed in how to be used in any way.

The headers from the two Extension Connectors fit in 2.54mm grid distance to the MCU Signal Connector and the Power Extension. In version 7 of the Power Module board, you will also have fitting headers next to R21 - R24, with ground next by.

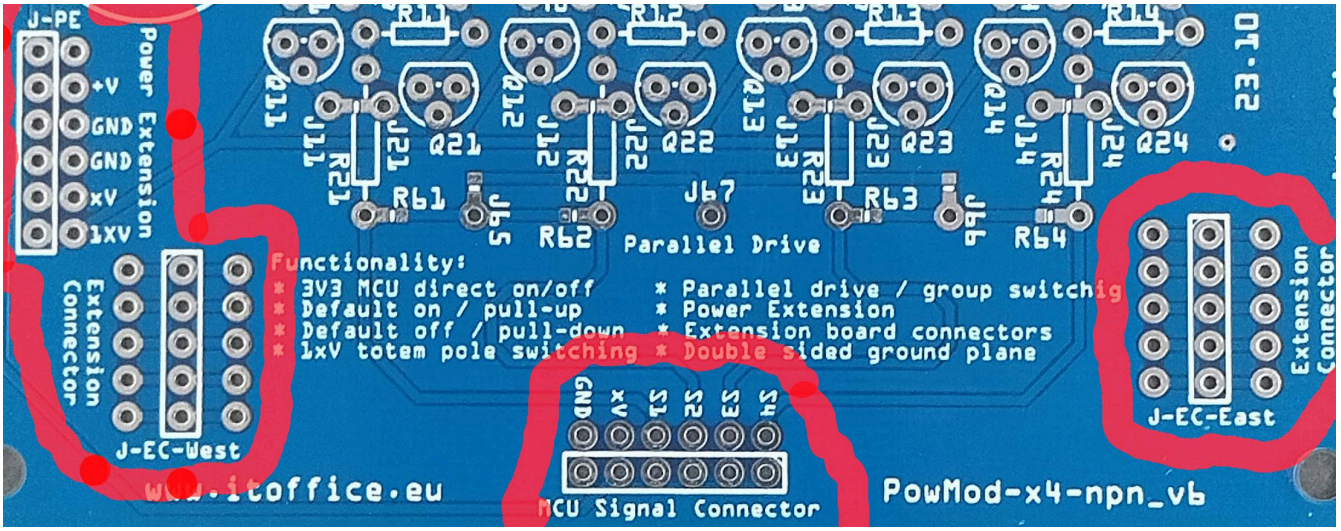

Fig. 10: The option to add gate driver ICs. Version 6 depicted.

Appendix - Component Overview

All component labels ending on 1, belong to channel 1. Vice versa with channel 2, 3 and 4. Other endings occur but are not fixed in belonging. For instance C11 belongs to channel one, while R14 belongs to channel 4. While C15 does not belong to a specific channel.

For the most basic usage, only the MOSFET and a resistor for the gate is necessary for each channel you want to use, next to something feeding into to this/these resistor(s).

The following list is sorted by Necessity, then Use Case, then Component Label.

MOSFET Channel	Component Label	Component Type	Necessty	Use Case
1	Q1	Basic FET N-Channel	Necessary	Any Use case
2	Q2	Basic FET N-Channel	Necessary	Any Use case
3	Q3	Basic FET N-Channel	Necessary	Any Use case
4	Q4	Basic FET N-Channel	Necessary	Any Use case
1	R21	Resistor	Necessary	Any Use case
2	R22	Resistor	Necessary	Any Use case
3	R23	Resistor	Necessary	Any Use case
4	R24	Resistor	Necessary	Any Use case
General	J30	Power Jack	Optional	Power Supply Input
1	C11	Capacitor Polarized	Optional	Decoupling for MOSFET supply
2	C12	Capacitor Polarized	Optional	Decoupling for MOSFET supply
3	C13	Capacitor Polarized	Optional	Decoupling for MOSFET supply
4	C14	Capacitor Polarized	Optional	Decoupling for MOSFET supply
1	C1	Capacitor	Optional	Decoupling for Transistor
2	C2	Capacitor	Optional	Decoupling for Transistor
3	C3	Capacitor	Optional	Decoupling for Transistor
4	C4	Capacitor	Optional	Decoupling for Transistor
General	C10	Capacitor Polarized	Optional	Decoupling from the Power Supply
General	C15	Capacitor Polarized	Optional	Decoupling from the Power Supply
1	J11	Optional hole for resistor R21	Optional	Default Off
2	J12	Optional hole for resistor R22	Optional	Default Off
3	J13	Optional hole for resistor R23	Optional	Default Off
4	J14	Optional hole for resistor R24	Optional	Default Off
1	R1	Resistor	Optional	Default Off / Default On
2	R2	Resistor	Optional	Default Off / Default On
3	R3	Resistor	Optional	Default Off / Default On
4	R4	Resistor	Optional	Default Off / Default On
1	Q11	Transistor	Optional	Default Off / 1xV Totem-Pole Switching
2	Q12	Transistor	Optional	Default Off / 1xV Totem-Pole Switching
3	Q13	Transistor	Optional	Default Off / 1xV Totem-Pole Switching
4	Q14	Transistor	Optional	Default Off / 1xV Totem-Pole Switching
1	R11	Resistor or Shorted	Optional	Default Off / 1xV Totem-Pole Switching

2	R12	Resistor or Shorted	Optional	Default Off / 1xV Totem-Pole Switching
3	R13	Resistor or Shorted	Optional	Default Off / 1xV Totem-Pole Switching
4	R14	Resistor or Shorted	Optional	Default Off / 1xV Totem-Pole Switching
1	J1	Optional hole for resistor R1	Optional	Default On
2	J2	Optional hole for resistor R2	Optional	Default On
3	J3	Optional hole for resistor R3	Optional	Default On
4	J4	Optional hole for resistor R4	Optional	Default On
1	J21	Optional hole for resistor R21	Optional	Default On
2	J22	Optional hole for resistor R22	Optional	Default On
3	J23	Optional hole for resistor R23	Optional	Default On
4	J24	Optional hole for resistor R24	Optional	Default On
1	Q21	Transistor	Optional	Default On / 1xV Totem-Pole Switching
2	Q22	Transistor	Optional	Default On / 1xV Totem-Pole Switching
3	Q23	Transistor	Optional	Default On / 1xV Totem-Pole Switching
4	Q24	Transistor	Optional	Default On / 1xV Totem-Pole Switching
1	D11	Rectifier Diode	Optional	Flywheel Diode for Inductive Loads
2	D12	Rectifier Diode	Optional	Flywheel Diode for Inductive Loads
3	D13	Rectifier Diode	Optional	Flywheel Diode for Inductive Loads
4	D14	Rectifier Diode	Optional	Flywheel Diode for Inductive Loads
Paral. Drive	J65	Generic header	Optional	Parallel Drive
Paral. Drive	J66	Generic header	Optional	Parallel Drive
Paral. Drive	J67	Generic header	Optional	Parallel Drive
1	R61	Shorted	Optional	Parallel Drive
2	R62	Shorted	Optional	Parallel Drive
3	R63	Shorted	Optional	Parallel Drive
4	R64	Shorted	Optional	Parallel Drive
Paral. Drive	R65	Shorted	Optional	Parallel Drive
Paral. Drive	R66	Shorted	Optional	Parallel Drive
1	J31	Power Jack	Optional	Power Output
2	J32	Power Jack	Optional	Power Output
3	J33	Power Jack	Optional	Power Output
4	J34	Power Jack	Optional	Power Output
1	D1	Zener Diode	Optional	Spike Voltage Protection
2	D2	Zener Diode	Optional	Spike Voltage Protection
3	D3	Zener Diode	Optional	Spike Voltage Protection
4	D4	Zener Diode	Optional	Spike Voltage Protection

Appendix - Components for a single MOSFET channel

The following list is sorted by Necessity, then Component Label.

MOSFET Channel	Component Label	Component Type	Necessty	Use Case
1	Q1	Basic FET N-Channel	Necessary	Any Use case
1	R21	Resistor	Necessary	Any Use case
1	C1	Capacitor	Optional	Decoupling for Transistor
1	C11	Capacitor Polarized	Optional	Decoupling for MOSFET supply
1	D1	Zener Diode	Optional	Spike Voltage Protection
1	D11	Rectifier Diode	Optional	Flywheel Diode for Inductive Loads
1	J1	Optional hole for resistor R1	Optional	Default On
1	J11	Optional hole for resistor R21	Optional	Default Off
1	J21	Optional hole for resistor R21	Optional	Default On
1	J31	Power Jack	Optional	Power Output
1	Q11	Transistor	Optional	Default Off / 1xV Totem-Pole Switching
1	Q21	Transistor	Optional	Default On / 1xV Totem-Pole Switching
1	R1	Resistor	Optional	Default Off / Default On
1	R11	Resistor or Shorted	Optional	Default Off / 1xV Totem-Pole Switching
General	J30	Power Jack	Optional	Power Supply Input
General	C10	Capacitor Polarized	Optional	Decoupling from the Power Supply
General	C15	Capacitor Polarized	Optional	Decoupling from the Power Supply