

PAD-L/PAD-LP series

REGULATED DC POWER SUPPLY (CV·CC)



High Capacity, Multiple Models, High Performance, High Reliability Power Supply Series
PAD-LP Series Has a Dedicated Ageing Function

Outline

The PAD-L Series are high performance and high reliability variable DC regulated power supplies used in all fields, from research and development and quality control to manufacturing plants.

This series is made up of a two excellent regulators: thyristor preregulator and power transistor series regulator. Therefore, it combines the high level of performance featured by the series input type with the low power supply harmonic distortion and efficient output characteristic featured by choke input phase control.

On the other hand, reliability and safety, which are important factors in power supply equipment, are ensured by the extensive use of parts that are stringently inspected beginning from the design stage and mounting know-how accumulated over many years. All models also have various safety functions, including an overvoltage protector (OVP).

The "LP" Series is also available which is provided with high speed OVP function and various status signals suitable for system use.

Features

- Improved power factor at low output voltages
Choke input circuit reduces the input apparent current and improves the power factor.
- Low AC input voltage waveform distortion
Choke input circuit reduces the harmonic component in the input current and minimizes line interference.
- Excellent temperature coefficient
Stringent selection of the parts used, circuit improvements, and forced-air cooling provide a 50 ppm/°C low-temperature drift and excellent ageing drift.
- Fast transient response
Since the wideband differential amplifier has a stable frequency-gain and phase characteristic and a loop gain up to a high frequency, its output impedance is low and it can amply respond to sudden changes.
- Low ripple noise voltage
Both effective value and peak value are low.
- Various safety functions
Overvoltage protector (OVP), overheating protection circuit, and other highly reliable safety functions are provided.

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Two big features of choke input system

■ **Low harmonic distortion factor minimizes the affect on other devices**
 Recently, the problem of harmonic distortion of commercial power supplies, which are the power source for electric products, has been closely examined from the sociological standpoint. Harmonic distortion is also said to be a factor in the growth of inverter type rotation control equipment and the popularity of electric devices with a capacitor input rectifier, which are typified by television sets and switching regulators. It has also sparked the movement toward restriction of generation of parasitic harmonic currents up to the 40th harmonic around the world. This flow is different from electromagnetic wave interference (EMI) countermeasures. From the standpoint of other equipment that use the same line, basically there is a new concept regarding the use of commercial power supplies. Kikusui has promoted this problem on the same level as efficiency and electrical characteristics and has taken up suppression (reduction of higher harmonics) of the peak current and improvement of line distortion by using a choke input system. The choke input type PAD-L/LP Series has a lower harmonic component (Fig. 1) than the capacitor input system and there is no fear of the resonance phenomena which is generated by the phase-leading capacitor and lead inductance connected to the same line.

Since the peak value of the charging current is low, the waveform distortion of the commercial power supply caused by a voltage drop is also suppressed to a low value (Fig. 2).

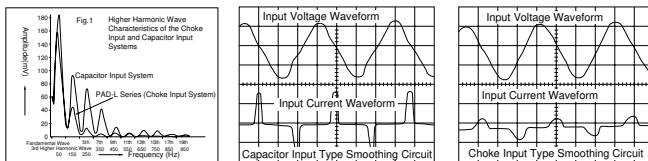


Fig. 2 Input vpltage-current curves

■ **Excellent reliability, life, and efficiency. Low input current.**
 When effective use of energy conservation is considered, the larger the power supply capacity, the more products with excellent power supply efficiency are demanded. The chock input system is superior from this standpoint also. Since the PAD-L/LP Series is equipped with a choke input type phase control circuit (preregulator) to reduce the collector loss of the series control transistor, its full-load current drain is approximately 74% (Kikusui ratio) of that of the capacitor input system. (Fig. 3) This is because the “reactive current”, which is a problem with the conventional capacitor input system, is stored in a choke coil and reused, and abnormal heating of the power transformer and enlargement of the element due to the tremendous surge on current in the thyristor are not a problem. There is als no fear of a large ripple current flowing in the electrolytic capacitor which governs the life of the power supply. (Fig.4)

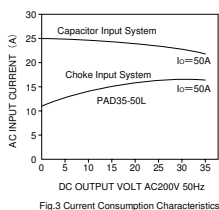


Fig. 3 Current Consumption Characteristics

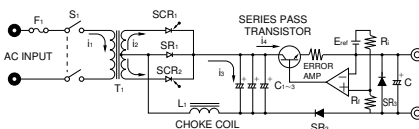


Fig. 5 Basic Circuitry of the PAD-L Series

Safety functions

Since power supply trouble and accidents caused by erroneous operation are linked to shutting down of the entire system and destruction of the expensive load, trouble-free reliability is very important. The protection circuit for preventing accidents in advance even if trouble should occur must operate positively in the safety direction. The PAD-L/LP Series is equipped with the following safety functions.

■ OverVoltage Protector (OVP)

Protects the load by instantly tripping the power switch circuit protector when erroneous operation or an accident generated an over-voltage. Since the OVP of the LP Series, in particular, is the preset type, the operating voltage is set by pressing the front panel preset button while watching the voltmeter. The operation voltage is checked without interrupting OVP operation even during aging.

- Since the LP Series uses a high-speed thyristor clover type OVP with a 200μs operation pulse width, use it with semiconductor and other loads that are especially susceptible to overvoltages.
- The L Series has an operation pulse width of 50ms and protects the load without erroneous operation by noise.

■ Overheating protection circuit

When the temperature of the main parts inside the equipment rises above the specified value, this circuit trips the power switch.

■ Voltage detector

When the smoothing electrolytic capacitor voltage rises above the rated voltage because the rear panel terminal board jumper was not installed or other mistake or trouble in the rectifier, this circuit immediately trips the rectifier.

■ Surge absorber

Protects the entire power supply against surge voltages generated on the line by lightning, etc.

■ Fire countermeasures

- The main power transformers uses Class B insulation. The insulation is made of a material that can withstand continuous use without any degradation of its insulating effect even at a high temperature of 130°C.
- The PC boards are made of incombustible glass epoxy or paper epoxy.
- The wiring uses heat resistant wire made by irradiating acceleration electron wire.

■ Reverse connection prevention circuit

Protects the power supply even if a reverse polarity voltage is applied to the output terminals.

■ Overcurrent detector

This circuit uses a comparison amplifier to constantly monitor the output current and prevents the power supply from exceeding its rating due to overinput during remote control and protects the power supply against overcurrent if the terminal board shorting bar is not installed by mistake.

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Application

Remote control with external voltage

Control objective	Control voltage *1	Input impedance
Output voltage	0 to Approx. 10V	Approx. 10kΩ
Output current	0 to 0.5V, 1V*2	100kΩ min.

*1 Since common is connected to a plus voltage, the control voltage must be floating (insulated).

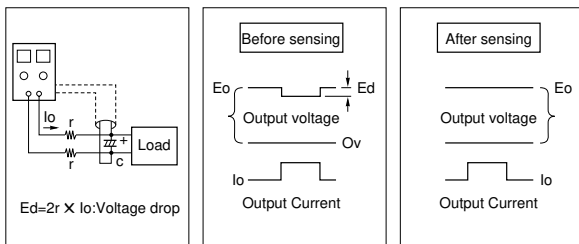
*2 Depends on the model.

Remote control with external resistance

Control objective	Control resistance	Current flowing in resistance
Output voltage	0 to Approx. 10kΩ	Approx. 1mA
Output current	0 to 550Ω, 1kΩ	Approx. 1mA

- Use a metal film resistor or wirewound resistor with a low temperature coefficient and good ageing stability as the control resistor.

Remote sensing



- This method compensates the voltage drop using the wiring between the power supply and load and its contact resistance. The voltage drop becomes a problem as the current increases. However, a drop up to about 1.2V at one side can be prevented by disconnecting the rear terminal board shorting bar and moving the voltage sense point to the load side. (For 0.3V and more, the maximum output voltage must be reduced.)
- Pay careful attention to the polarity and connect an electrolytic capacity of several hundred μF or more to the sensing terminal over the shortest distance possible. This is done to prevent the output impedance of the power supply seen from the load from becoming high because if the load line is long, the inductance component cannot be ignored. Especially, for an inverter that interrupts the current at a high frequency and similar loads, connect a capacitor of several thousand μF or more over the shortest possible distance.

Output ON/OFF control

- The output can be turned on and off with a contact signal from the outside.

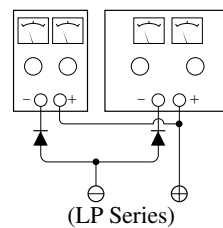
Contact signal	Output
ON	OFF
OFF	ON

Power tripping

- The input power switch can be tripped with an external contact signal.

Contact signal	Operation
ON	Power switch off

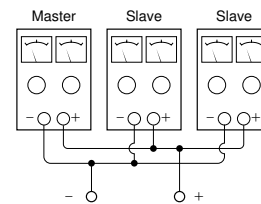
Parallel operation



- All models in the PAD-L Series can be set to the same output voltage and connected in parallel.
- Connect the PAD-LP Series in parallel through a diode to prevent burning of the high-speed OVP.

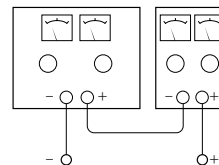
One control parallel operation

(Possible only for parallel connection of the same model.)



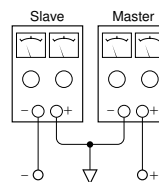
- The current capacity can be increased by connecting the same model. Output is controlled by one master.
- Perform remote sensing, remote control, output on/off, etc. with only one master.

Series operation



- All models in the PAD-L Series can be connected in series within ground voltage ±25V. (The maximum current when connected in series depends on the model with the lowest output current. Always use at current below this value.)

One control series operation



- This method increases the output voltage by connecting power supplies in series. The model at the plus side becomes the master. The output of the slave can be controlled by operation of only one unit.
- An example of a dual tracking power supply that can vary the plus and minus sides simultaneously is shown at the left.

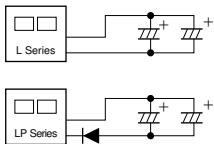
PAD-L/PAD-LP series

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Load

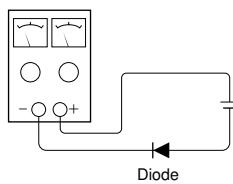
Since the PAD-L/LP Series meet a wide range of user needs, the use of various loads is also considered. Depending on the load, the use of a power supply as is may cause trouble or erroneous operation and countermeasures must be taken.

■ High capacity load



- There are no special problems, but the output voltage does not drop. With the PAD-LP Series, this may cause the high-speed OVP to burn up. Therefore, insert a diode in series with the power supply.

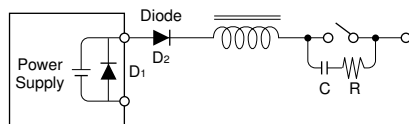
■ Secondary battery (storage battery, Nicd, etc.)



- Use the PAD-LP Series in series with a diode.
- Since the power supply output electrolytic capacitor charges when the power supply is connected to the load, sparks may fly. The power supply is not abnormal. This fear can be dispelled by making the voltages equal.

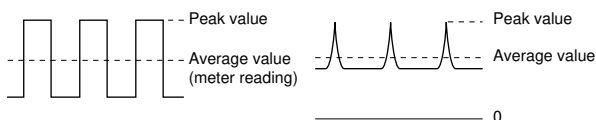
■ Inductive load

- The counter electromotive force generated by turning on and off of the power supply, or changing the voltage setting is shunted by protection diode D_1 inserted in parallel with the output so that the power supply is not damaged.
- When pulse noise generated from an inductive load is impressed at the same polarity as the power supply, protect the power supply by inserting diode D_2 in series with the power supply and inserting a noise prevention CR absorber across the switch.



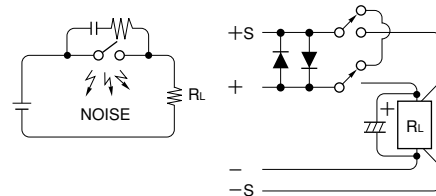
■ When the load current has a peak (motor, lamp, etc.)

- When the peak value is within the rated value even through the load current waveform of a digital circuit or motor drive circuit is within the rating by meter indication (average value), the current may momentarily enter the rated current region and the output voltage will drop and appear to be unstable. The basic countermeasure against this is to increase the output current. However, when the pulse width is narrow or the peak value is small, install a large capacitor at the load end.



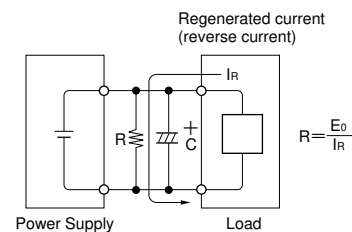
- When the output is turned ON and off with a mechanical switch
- When a DC output of 100V or more is opened and closed with a switch, arc discharge, etc. will cause the switch contacts to noticeably wear and generate noise. This noise may enter the power supply differential amplifier through the load line and cause the output to become unstable. Take noise countermeasures by inserting a CR absorber near the contacts, the same as for an inductive load.

- When performing remote sensing, always turn the sensing line on and off simultaneously.



■ Load that regenerates a current at the power supply side

- Since the PAD-L Series cannot absorb a reverse current from the load, and become unstable as the output voltage rises, connect a dummy load (R) through passes the peak value of the reverse current. When the reverse current is in the form of a spike, install a large electrolytic capacitor at the load end.



Wiring

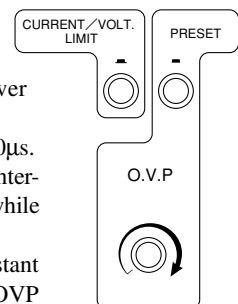
Nominal cross section area	Recommended current as a DC output line	Semiconductor allowable temperature 60°C (Ambient temperature 30°C)	Standard DC resistance 20°C
2(mm ²)	10(A)	27(A)	Approx. 9[Ω/km]
5.5	20	49	3
8	30	61	2.2
14	50	88	1.2
22	80	115	0.81
38	100	190	0.46
60		217	0.29
80	200	257	0.22
100		298	0.18
150	300	395	0.12

The wiring cross section area and current capacity and resistance value are related.

Features of PAD-LP Series

■ Preset type high-speed OVP (OverVoltage Protector)

- When the output voltage exceeds the OVP set value, a thyristor short circuits the output and suppresses the overvoltage and simultaneously trips the power switch.
- Overvoltages are detected in a fast 200μs.
- The set value can be checked without interrupting the protection operation even while the power supply is operating.
- CV (Constant Voltage) and CC (Constant Current) operation mode display and OVP operation, or power supply switch tripping, are sent to the outside by contact output.



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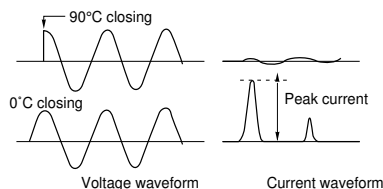
Surge Current

When the power supply is closed, a surge current flows according to the close timing. Called the "in-rush current", this surge current causes magnetic saturation of the core of the transformer and, theoretically, when the power switch is closed near the 90° ($\pi/2$) phase angle of the voltage waveform, surge current does not flow as a transient phenomena. When the switch is closed at the phase angle 0° (zero cross) timing, the maximum current shown in the table below will flow. Actually, the surge current differs with the hysteresis characteristic of the core material B-H curve and the direction of the residual flux with the timing at which the switch was turned off, or the impedance of the connected AC line.

■ PAD-L/LP Series typical surge current value (maximum value)
(Half value width of current waveform 2 to 5ms)

Type	III	IV	V
AC input voltage	220V	220V	220V
Peak current	700A	*200A	*400A

* The Type IV and V are equipped with a built-in surge current prevention circuit as standard.



PAD-LP Series Applications

If erroneous operation or trouble should occur, the load can be protected at high-speed and an external alarm can be simultaneously actuated by contact signal.

- Semiconductor and other loads and electronic circuits with a low overvoltage resistance
- Automatic systems that use a GPIB programmer (DPO2212A)
- When unmanned reliability tests and life tests are conducted for a long time
- Systems in which accidents, etc. may impress an overvolt

Computer Control

- The Power Supply has a capable of Computer Control by using with PIA4800 Series. (For the detailed features of PIA4800 Series, please refer to Page 5-2)
- The Power Supply has a capable of Computer Control by using with PIA3200. (For the detailed features of PIA3200, please refer to Page 5-9)
- The Power Supply has a capable of Computer Control by using with DPO2212A. (For the detailed features of DPO2212A, please refer to Page 5-20)

Specifications

(CV: Constant Voltage mode, CC: Constant Current mode)

Output		Model		Ripple		Power supply fluctuation		Load fluctuation		Dimensions	Weight	Input	
CV	CC	Standard type	High-speed OVP type	CV	CC	CV	CC	CV	CC	Type	Approx.	Voltage	Power
V	A	L Series	LP Series	mVrms	mArms	0.005%+mV	mA	0.005%+mV	mA		kg	V	kVA
0 to 16	0 to 100	PAD 16-100L DISCON		0.5	100	1	3	2	5	III	63	200/100	3.3
0 to 35	0 to 50	PAD 35-50L DISCON		0.5	10	1	3	2	5	III	58	200/100	3.3
	0 to 60	PAD 35-60L DISCON		0.5	10	1	3	2	5	III	61	200/100	3.8
	0 to 100	PAD 35-100L DISCON		0.5	50	1	3	2	5	IV	97	200	6.8
	0 to 200	PAD 35-200L		0.5	100	1	30	2	30	V	188	200	13
	0 to 200	PAD 35-200LT		0.5	100	1	30	2	30	V	190	200/3 ϕ	14.5
	0 to 300	<input type="checkbox"/>		PAD 35-300LPT	0.5	200	1	30	2	30	V ₂	220	200/3 ϕ
0 to 60	0 to 35	PAD 60-35L DISCON		0.5	8	1	3	2	3	III	62	200/100	3.8
	0 to 60	PAD 60-60L DISCON		0.5	20	1	3	2	5	IV	99	200	6.8
	0 to 120	PAD 60-120L		0.5	50	1	15	2	15	V	175	200	12
0 to 60	0 to 200	<input type="checkbox"/>	PAD 60-200LPT	0.5	100	1	30	2	30	V ₂	220	200/3 ϕ	19
0 to 110	0 to 20	PAD 110-20L		1	4	1	1	2	3	III	60	200/100	3.8
	0 to 30	PAD 110-30L DISCON		1	10	1	3	2	5	IV	96	200	6
	0 to 60	PAD 110-60L		1	20	1	12	2	10	V	170	200	11
0 to 250	0 to 8	PAD 250-8L *1		5	4	2	1	3	3	III	60	200/100	3.4
	0 to 15	PAD 250-15L DISCON		5	5	2	1	3	3	IV	94	200	6.0

[T] at the end of the Model No. represents 3-phase input.

- Constant current knobs are coarse and fine adjustment knobs.
- Constant current knob is 10 turns.

■ Voltage to ground
±250V DC, However,
*1 type: ±500V DC

Remarks of the input voltage:

100/200 100V-standard / changeable to 200V by user
200/100 200V-standard / changeable to 100V by user
(Other voltage changes are also available upon request.)

Leakage current

- A capacitor is not inserted between the input and the chassis.
There is no danger of circuit breaker erroneous operation and electric shock even when multiple units are used simultaneously.

PAD-L/PAD-LP series

REGULATED DC POWER SUPPLY (CV-CC)

Common specifications

- Constant voltage temperature coefficient
50p.p.m./°C (standard value)
- Transient response time
Time until the output voltage recovers to within 0.05%+10mV of the set value when the output current changes 5% to 100%.
50μs (Type V: 100μs)
- Ripple noise
5Hz to 1MHz, ±3dB bandwidth, average value indication, measured by grounding plus or minus output with an rms value display AC voltage waveform
- Indicator

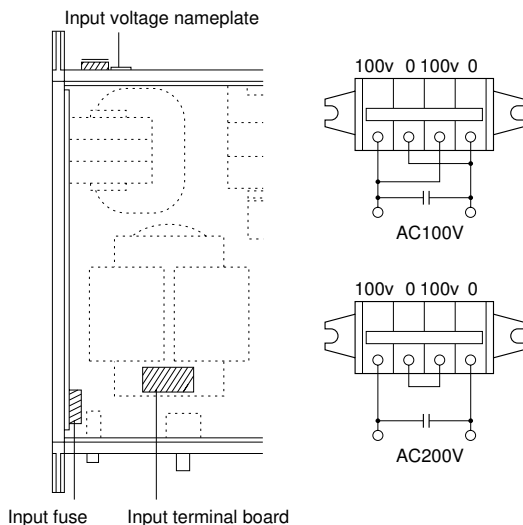
DC voltmeter	Type III, IV JIS Class 2.5 Type V, VI JIS Class 1.5
DC ammeter	Type III, IV JIS Class 2.5 Type V, VI JIS Class 1.5
- Ground
Plus or minus terminal can be grounded
- Insulation resistance
Chassis-input: 500V DC 30MΩ min.
Output-chassis: 500V DC 20MΩ min.
- Dielectric strength
No abnormalities when 1500VAC applied for 1 minute.
- Operating temperature range
0 to 40°C

- Operating humidity range
10 to 90% RH
- Cooling system
Forced air cooling using a fan
- Constant voltage operation display color
Green
- Constant current operation display color
Red
- Protection devices
 - Constant voltage, constant current automatic crossover
 - Overvoltage protector (OVP)...L Series
 - High-speed overvoltage protector (high-speed OVP)...LP Series
 - Overcurrent protection circuit (110% of output rated current)
 - Overvoltage protection circuit (rectifier smoothing electrolytic capacitor section)
 - Overheating protector (OHP)...Semiconductor cooling heat sink section (100°C)
 - Temperature fuse (subtransformer)
 - Temperature switch (Type V main transformer)
 - Input/output fuse
 - Input surge absorber

Power supply voltage 100/200V modification

Models with 100/200 entered in the "Input Voltage" column in the specifications, 100V ±10% or 200V ±10% input voltage power supply can also be used by changing the internal terminal board wiring.

1. The main power transformer terminal board is changed.
2. The input power fuse is changed.
3. The input voltage nameplate is changed.



Options

- DOM -2 digital voltmeter/ammeter
 - The DOM-2 is a manually switched 2-range voltmeter and 1-range ammeter.
 - 3 1/2 digits maximum display 1999
LED 7-segment display
 - Voltmeter ±(0.1% rdg + 1 digit)
 - Ammeter ±(0.5% rdg + 1 digit)



- OP-1 Output Voltage 3-Point Switching Option



- Three preset voltages can be selected with one touch by pushbutton switch. (Perfect for adjustment and data acquisition on the assembly line.)

- OP-2 3-Output Scanning Option



- Three preset voltages can be sequentially switched with a light touch. (Perfect for adjustment and data acquisition on the assembly line.)