INSTRUCTION MANUAL

DIGITAL PROGRAMMABLE POWER SOURCE

MODEL DPS V 20-1

KIKUSUI ELECTRONIC CORPORATION

On Power Supply Source, it is requested to replace the related places in the instruction manual with the following items.

(Please apply the item of ☐ mark.)

☐ Power Supply Voltage: to _ _ _ _ _ V AC

☐ Line Fuse: to _ _ _ _ _ A

☐ Power Cable: to 3-core cable (See Fig. 1 for the colors.)

Blue (NEUTRAL)
Brown (LIVE)
Green/Yellow (GND)

or

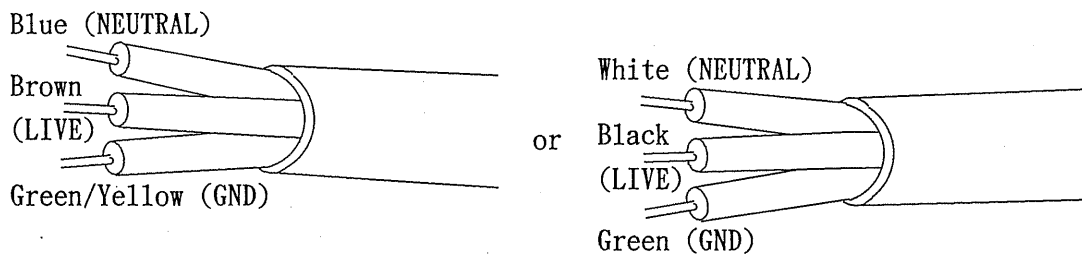White (NEUTRAL)
Black (LIVE)
Green (GND)

Fig. 1

Please be advised beforehand that the above matter may cause some alteration against explanation or circuit diagram in the instruction manual.

* AC Plug: In case of Line Voltage 125V AC or more, AC Plug is in principle taken off and delivered, in view of the safety.
(AC Plug on 3-core cable is taken off in regardless of input voltages.)
TO connect the AC plug to the AC power cord, connect the respective pins of the AC plug to the respective core-wires (LIVE, NEUTRAL, and GND) of the AC power cord by referring to the color codes shown in Fig. 1.

Before using the instrument, it is requested to fix a suitable plug for the voltage used.

TABLE OF CONTENTS

1. GENERAL

The DPS V 20-1 Digital Programmable Power Source is a bipolar
constant-current constant-voltage power source designed for use in
automatic test systems. Its output voltage can be controlled with
an external signal.

Voltage setting can be done with two ranges: 0 to ±1.999 V (1 mV
resolution) and 0 to ±19.99 V (10 mV resolution). Voltage setting,
including polarity setting, can be controlled with a 14-bit signal.

The output voltage is controlled with a TTL level negative logic
BCD signal. When the required data is ready, a strobe signal turns
on. The data is stored in an internal register and at the same time
the output voltage swiftly and accurately shifts to the preset values.

Compliance can be set for a range of approximately ±(50 mA to 1 A)
using a manual knob on the front panel. When the set value is reached,
the operation changes to the constant-current mode.

The output section is electrically isolated from the input control
section. Addresses can be specified as required. A multiple-channel
power source system can be easily set-up, making this instrument
extremely versatile.

This instrument can be used as a power source for semiconductor testing,
IC testing, circuit board testing as well as a regular power source
for many electronic devices. When used in conjunction with a Kikusui
GP-IB Interface, this instrument is compatible with many types of
computers and can be used in automatic measuring systems.

2. SPECIFICATIONS

Instrument name: Digital Programmable Power Source

Model No. :   DPS V 20-1

Output section

Type: Bipolar constant-voltage constant-current
        transfer type

Voltage: 0 to $\pm$19.99 V

Ranges: Two ranges of 2 V and 20 V

Resolutions: 1 mV and 10 mV

Setting accuracy: 0.03% + 0.03% of range (at 25°C (77°F))

Ripple and noise: 300 µV rms or less (at 10 Hz - 1MHz)

Programming noise: $\pm$50 mV peak or less (at rear terminal,
        20 V range)

Load regulation: 0.006% of range + 500 µV or less (at rear
        terminal), for 0 - 100% load change

Line voltage regulation: 0.002% or less, for $\pm$10% line voltage
         change

Response speed: 500 µsec or faster, for "-" maximum voltage
        to "+" maximum voltage within the range

Output current: 1 A maximum

Setting: Manual, approx. $\pm$(50 mA to 1 A)

Control section

Input/output signal: TTL level

- 2 -

Control signals

Data	Polarity	1 bit	
	Voltage	13 bits	(BCD)
Strobe		1 bit	(edge)
Address		4 bits	
$\overline{\text{Standby}}$		1 bit	
Range		2 bits	
Set		1 bit	
Direct zero		1 bit	
Direct standby		1 bit	
Data clear			(except polarity)

Output signals

Address coincidence

Data accept (DAC)

Error flag   o   Data overflow

             o   Range inconformity

Thermal down

Constant-current transfer (CC)

$\overline{\text{Ready}}$

Ambient temperature: 5°C to 35°C (41°F to 95°F)

Withstanding voltage of input/output circuit: 500 V maximum

Power requirements: 117 V ±10%, 50/60 Hz AC, approx. 100 VA (with full load)

Dimensions: 210W × 90H × 370D mm (8.3W × 3.6H × 14.6D in.)

(Maximum dimensions):   220W × 100H × 400D mm (8.7W × 4.0H × 15.8D in.)

Weight: Approx. 8.7 kg (19 lbs.)

Accessories: Instruction manual   1 copy

                         50P plug   1

3.   OPERATION METHOD

3.1 Description of Front Panel   (See Figure 3-1.)

① POWER switch:

The power switch (circuit breaker) is a rocker type.
The instrument power is turned on as the ON side in an
depressed.

② OUTPUT terminals:

The output terminals (binding posts) provide an output
of ±(0 to 20 V, 1 A). The white terminal is an L-side
terminal. These terminals are connected in parallel
with the output terminals on the rear panel.

③ CURRENT:

The current limiting knob has a range of approximately
50 mA to 1 A. When the current has reached the limit
value, the operation is transferred into the constant-
current mode.

④ DISPLAY lamps:

These LEDs indicate the operating state of the instrument.

3.2 Description of Rear Panel   (See Figure 3-2.)

⑤ ADDRESS switches:

These slide switches are for address settings of indi-
vidual instruments. When the controller's address line
is H.H.H.H or the control line is open, all attached
power supplies will be controlled regardless of their
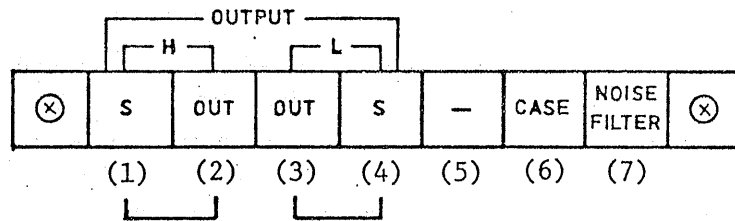address settings.

⑥ Fan motor:

Cooling fan motor.

⑦ Power cord:

    To be connected to an AC line outlet of correct voltage
    and frequency.

⑧ Terminal block

```
                ┌─────── OUTPUT ───────┐
                ┌─ H ─┐      ┌─ L ─┐
        ┌───┬─────┬─────┬─────┬─────┬─────┬──────┬───────┬───┐
        │ ⊗ │  S  │ OUT │ OUT │  S  │  —  │ CASE │ NOISE │ ⊗ │
        │   │     │     │     │     │     │      │FILTER │   │
        └───┴─────┴─────┴─────┴─────┴─────┴──────┴───────┴───┘
            (1)   (2)   (3)   (4)   (5)   (6)    (7)
            └──────┘     └──────┘
```

(1) When no sensing is required, short-circuit this sensing
    terminal (H side) to terminal (2).

(2) Output terminal (H side)

(3) Output terminal (L side)

(4) When no sensing is required, short-circuit this sensing
    terminal (L side) to terminal (3).

(6) Case ground terminal

(7) Center power line noise filter terminal. If this termaianl
    is connected to the case ground termianl, a current leak
    occurs although the filtering effect is improved.
    Conection of this terminal will vary with usage.

⑨ Connector

    For connection of control input (50-pin connector)
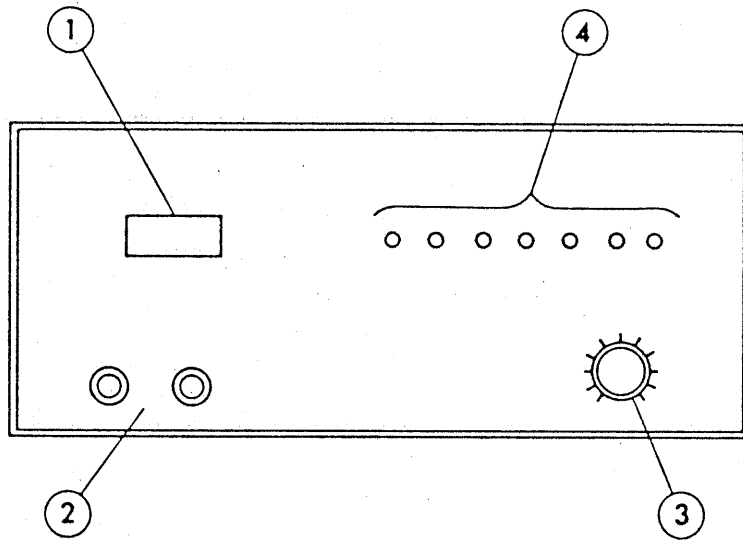
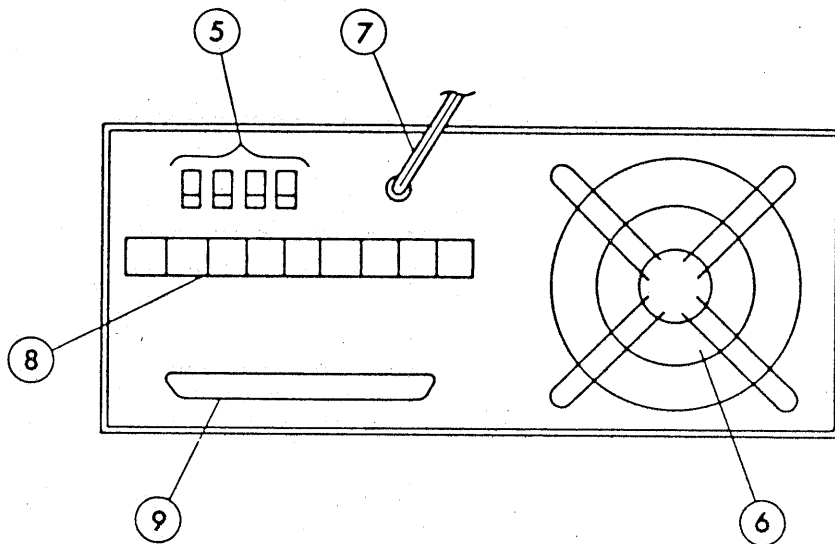   See section 3.3 Pins of Control Input Connector.

Figure 3-1. Front panel

Figure 3-2. Rear panel

3.3 Pins of Control Input Connector

Pin	Signal	Pin	Signal
1	STROBE	26	1 ⎫
2		27	2 ⎪
3		28	4 ⎬ LSD
4		29	8 ⎭
5		30	1 ⎫
6		31	2 ⎪
7		32	4 ⎬
8	$\overline{\text{STAND BY}}$	33	8 ⎭
9		34	1 ⎫
10		35	2 ⎪
11		36	4 ⎬
12		37	8 ⎭
13		38	1 ⎫
14	DATA CLEAR	39	⎪
15	DIRECT STAND BY	40	⎬
16	DIRECT ZERO	41	⎭
17	2^0 ⎫ RANGE	42	THERMAL DOWN
18	2^1 ⎭	43	DAC
19	2^0 ⎫ ADDRESS	44	2^2 ⎫ ADDRESS
20	2^1 ⎭	45	2^3 ⎭
21	C C	46	POLARITY
22	POWER ON SIG	47	ERROR
23	+5 V OUT	48	$\overline{\text{READY}}$
24	ADDRESS COINCIDENCE	49	SET
25	GND	50	GND

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3.4 Input/Output Control Signals
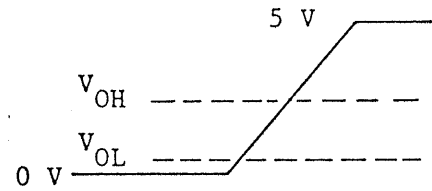
Example: TTL level
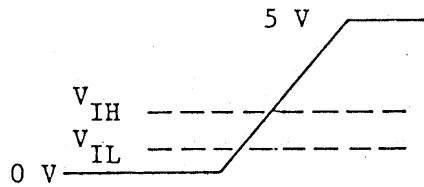
V_{IL}: 0.8 V max.

V_{IH}: 2 V min.

I_{IL}: −1.6 mA max. (V_{IL}=0.4 V)

I_{IH}: 40 µA max. (V_{IH}=2.4 V)

V_{OL}: 0.4 V max.

V_{OH}: 2.4 V min.

Output voltage control signal	At L level		Operation (1)
Polarity	At H level		+
	At L level		−
Strobe (data)	H → L → H		Operation (with edge)
Address	Level		Coincidence signal
Standby	At H level		Standby ON
	At L level		Standby OFF
Range	Level		* (R: Ranges to be used for respective models)
	2^1	2^0	
	H	H	strobe $R \leq 1$ [V]
	H	L	$1 < R \leq 10$ [V]
	L	H	(data) $10 < R \leq 100$ [V]
	L	L	$100 < R \leq 1000$ [V]
Set	At L level		Standby release
Direct zero	At L level		Output is zero irrespective of address.
Direct standby	At L level		Standby ON irrespective of address.

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Address coincidence	L level	Coincidence of address code
DAC	⊓ (pulse)	Reception of strobe
Error set	L level	Data overflow, invalid range setting
Thermal down	Relay makes contact	Instrument overheating
CC (constant-current transfer)	L level	Constant-current state
Ready	H level	
Data clear (10 μsec or over)	L level	Clears resister

* Example: For the model with 2 V range, 2^1 and 2^0 becomes H and L.

3.5 Timing Charts of Control Signals

(1) When power is ON

   o When the SET signal and STANDBY signal are L

Power

Standby

TYP. 150 msec

Register is reset in this period.
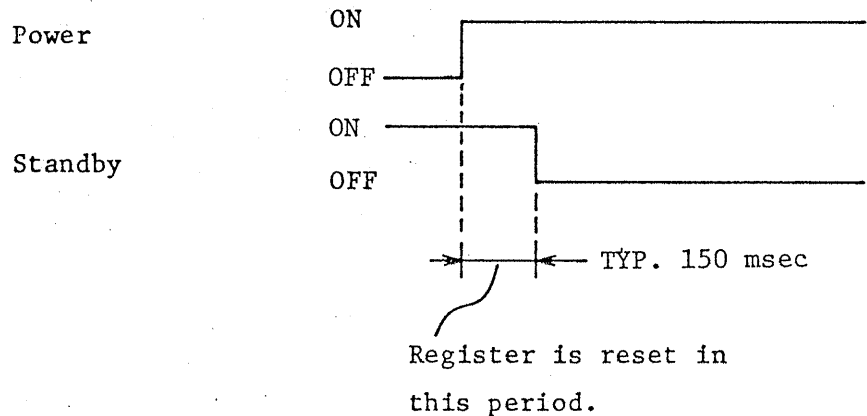
o When the SET signal is H and the STANDBY signal is L

Power

Set (or pulse)

Standby

10 μsec

Output

TYP. 60 msec

Register is reset. (TYP. 150 msec)
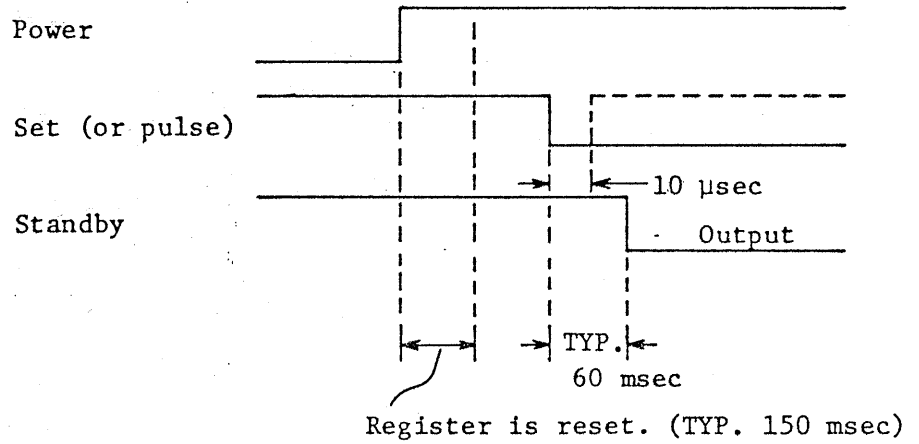
(2) Data, polarity, strobe and address

Data

Polarity

Strobe

Address

3 μsec min.

10μsec min.

30 μsec min.

0 min.

(3) Standby switch

Standby

ON

OFF

Standby relay

ON

OFF

→|TYP.|←   →|TYP.|←
60 msec   60 msec
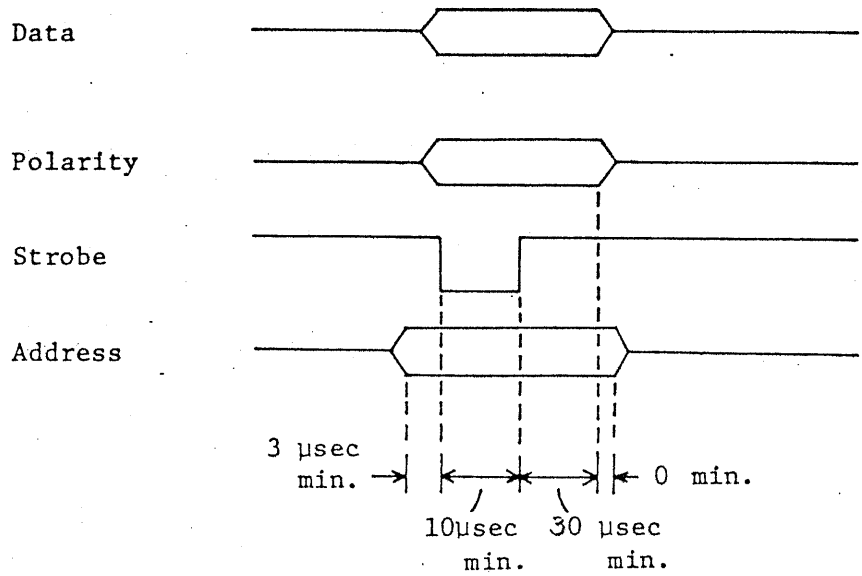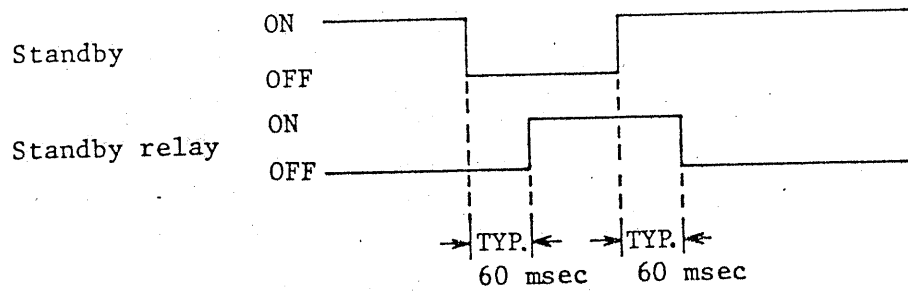
Electromagnetic relay is used for standby switch.

(4) $\overline{\text{Ready}}$

Strobe

$\overline{\text{Ready}}$

1 μsec max. →|

50 μsec max.

(5) Address coincidence

Address

Coincidence

→| |← Approx. 3 μsec
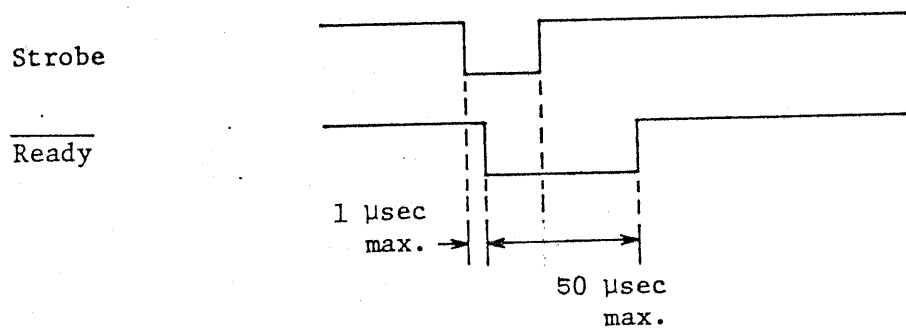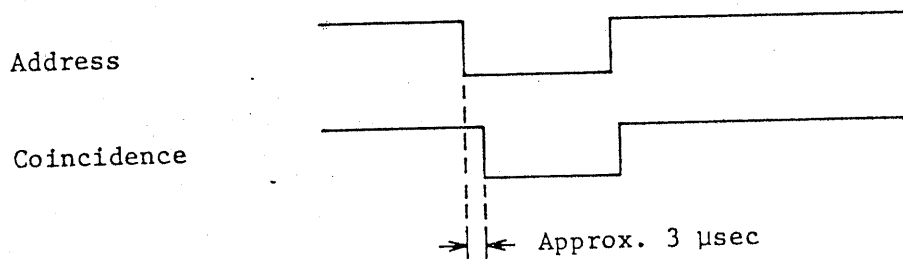
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(6) Error   o Invalid range setting

          o Data overflow

Strobe

Error

←Approx. 3 μsec

Reset with
valid input.

(7) DAC (data accept)

Strobe

DAC

20   20
μsec μsec

(8) Range

2^0

2^1

min
110μ
sec

min
30μsec

Strobe

min
25μsec
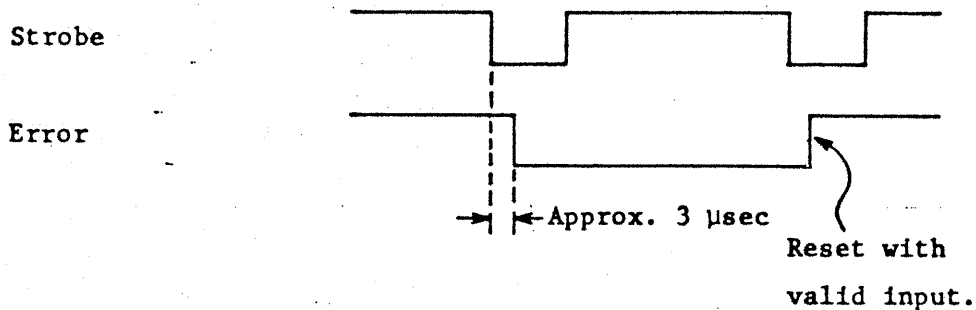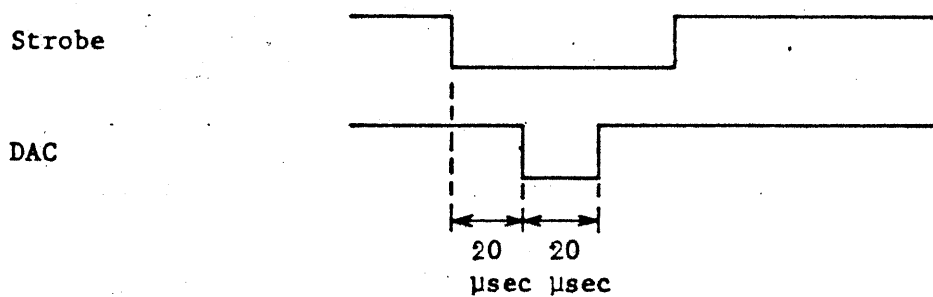
Range
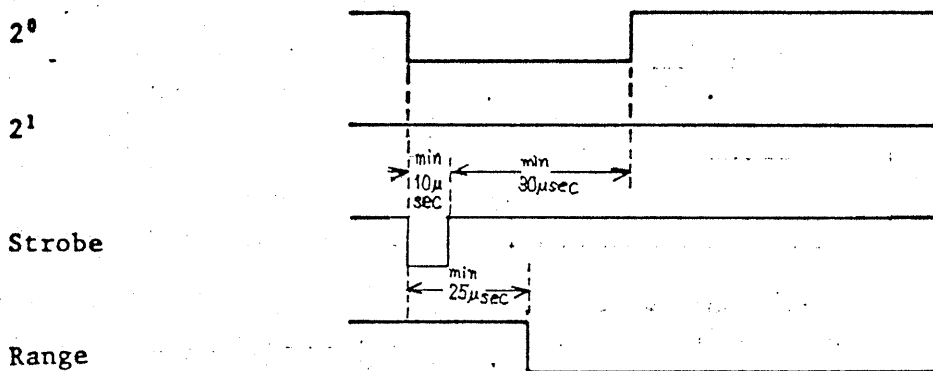
3.6 Preparations for Operation

(1) Connect the power cord to an AC line outlet of the correct voltage and frequency.

(2) Turn on the power switch.

(3) The instrument is ready for operation several minutes after turning on the power. When high accuracy is required, allow a stabilization period of 30 minutes or more.

(4) Enter data and set the initial values.

(5) Adjust the current limit knob to the required value.

(6) Apply the Set signal.

(7) Release the standby state. Note that relay chattering and overshoots may occur when the standby state is released.

o The Set signal needs only to be applied once each time the power is turned on.

o The direct standby and zero signals can be controlled independently of address specification. The direct zero signal is electrically switches the output signal to zero volts. The standby signal mechanically disconnects output signal. When the direct zero or standby signal is removed, the original state is automatically restored.

o If the controller's address setting is HHHH (0000) or if the address input is open, all attached power supplies will be controlled regardless of their individual addresses.

Note: No overshoots or undershoots are caused when the voltage varies in the same polarity. However, slight overshoots or undershoots may be caused if the voltage is small and both polarity and data are changed at the same time.

3.7 Example of Control

o Although various input/output signals are available, output voltage alone can be controlled only with data and strobe signals.

(1) For multi-channel operation, address setting on each instrument's rear panel must be set. The control code is a 4-bit binary negative logic signal (pin numbers 19, 20, 44 and 45).

(2) For a model which has different ranges, a range specification is required (pin numbers 17 and 18). The range specification is done with a 2-bit structure. If a fixed-range is required, this can be done by means of electrical connections.

The ranges are written with a strobe signal in the instrument. If the range setting is invalid, the data cannot be written. Be sure to check the code before setting the ranges. The range codes are as follows:

When the maximum value is	2^1	2^0
0.1 to less than 1	0	0
1 to less than 10	0	1
10 to less than 100	1	0
100 to less than 1000	1	1

Of the 2-bit negative logic code, "1" is the L level. The
V series is in the [V] unit and the C series is in the [mA]
unit.

Examples:			2^1	2^0
V 20-1	2 V range		0	1
	20 V range		1	0
C 20-1	100 mA range		1	0
	1 A range		1	1

(3) When setting is not required for a model which has the Set
signal feature., make electrical connections so that the
bit signal is for "1" (L level). When the power is turned
on, an output signal of 0 V DC will be produced. To operate.
this model, set it in the "1" state after initial set up.
Alternately, a negative-going pulse signal (⊓) may be applied
(pin number 49).

(4) Set data with a negative logic BCD signal and apply a strobe
signal.

Although control at the TTL level is most recommendable,
control may be done with relays, transisters, switches,
etc. (pin number 1 (strobe), pin numbers 26 - 41 (data)).

(5) For standby control (isolation with output relay)

The standby state is reset as the level is changed from
H to L. It is set as the level is changed from L to H.
(Edge operation) (Pin number 8)

OFF ⟶ ⌐_⌐ ⟵ ON   The standby state is controlled
in the addressed state.

(6) Direct standby (If not required, set OPEN or H) (Pin number 15)

    This standby state is controlled irrespective of address. This standby state is reset by the H level and set by the L level. (Level operation)

(7) Direct zero (If not required, set OPEN or H) (Pin number 16)

    This signal is for DC ON/OFF control of the output voltage. When this signal is at the L level, the output voltage becomes zero. This signal does not clear the contents of the register and, therefore, the previous set voltage is restored when this signal is returned to the H level.

(8) Data clear (If not required, set OPEN or H) (Pin number 14)

    This is the clear bit signal of the data register. When this signal is set at the L level, the contents of the register are cleared and the output becomes zero. (A negative-going pulse may be used instead.)

3.8 Actual Example of Control

To obtain an output with varied steps

$0/0.01 \text{ V} - 9.99 \text{ V}$

0 V

		DPS	
Decimal counter	Inverter	37	8
D		36	4
C		35	2	MSD
B		34	1
A			

TTL
74190 × 3

	37	8
36	4
35	2	MSD
34	1
33	8
32	4
31	2
30	1
29	8
28	4	LSD
27	2
26	1

Clock →

1	Strobe
18	2^1
17	2^0	Range
8	Standby
49	Set
25	GND
50	

Clock

Strobe

LSD 1 2 4 8

1 2 3 4 5 6 7 8 9 0 1 2

- 17 -
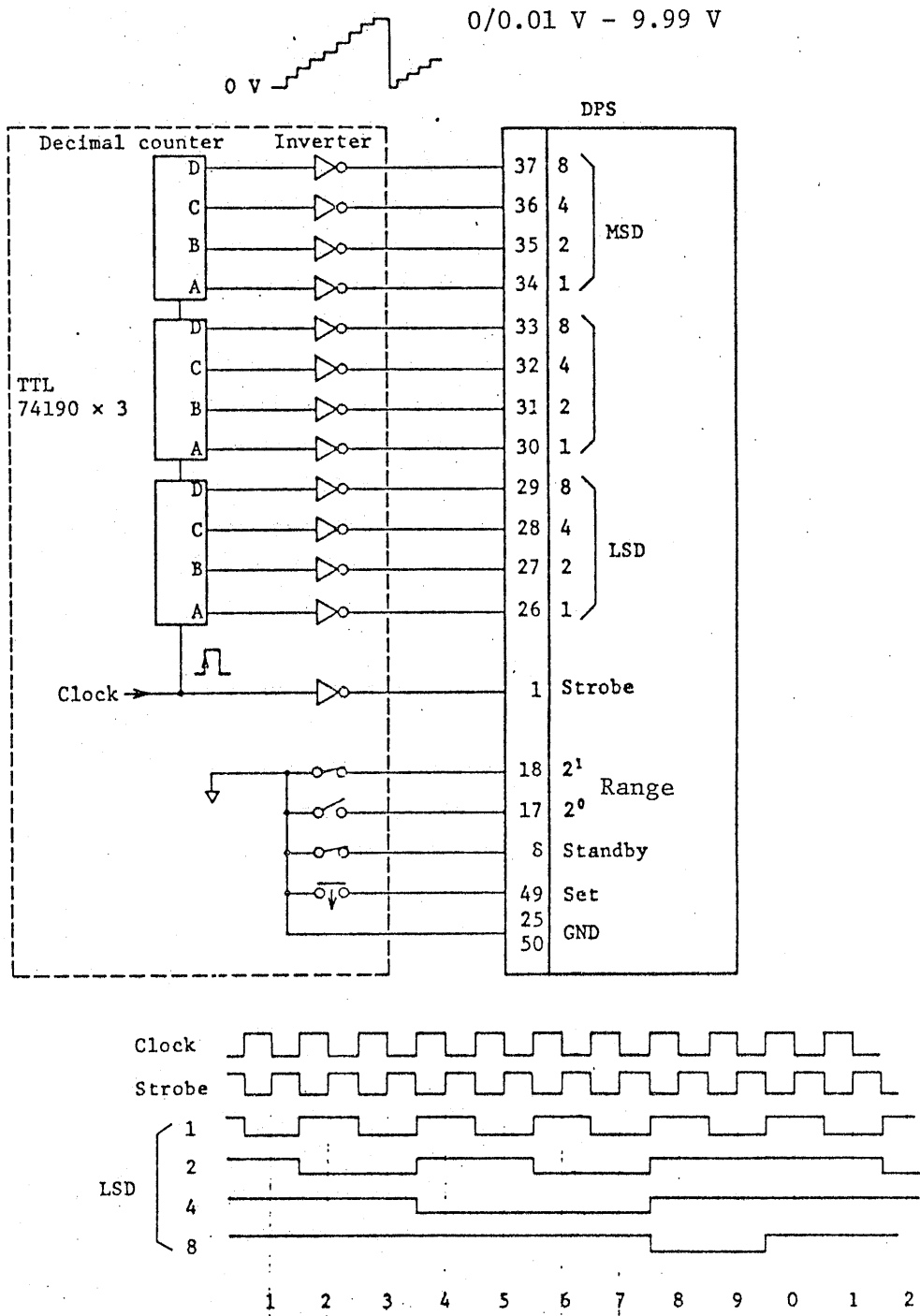
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4. OPERATING PRINCIPLE

4.1 Circuit Structure

The circuit structure of this instrument is shown with a block diagram in Figure 4-1.

Figure 4-1

4.2 Operation Description

The input/output Logic Level signal is pulled up by a resister (10 kΩ). Data entered at the TTL level is subjected to a buffer effect at the D I/O interface section, it is isolated with a photocoupler, and then it is stored in the register.
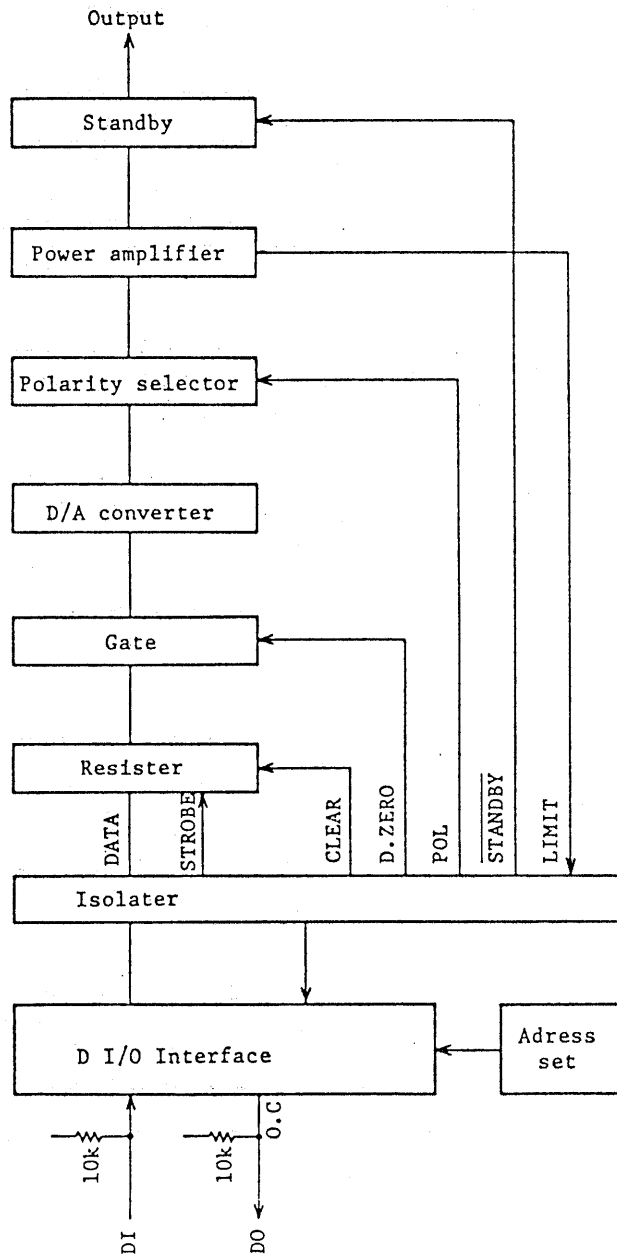
The Strobe signal is passed on when address "0" is specified (or when open) or when the address set at the instrument (main unit) conforms with the specified address. The Strobe signal then is fed via the isolator to the register to let the data stored in the register. The stored data is maintained, until the next Strobe signal is applied, even when the input is varied.

The Data Clear signal clears the register, making all bits "0". The stored data is fed via a gate to the D/A converter. The gate is for the direct zero signal, and is capable of making all bits "0" temporarily without clearing the register.

Resister

D/A converter

Direct zero
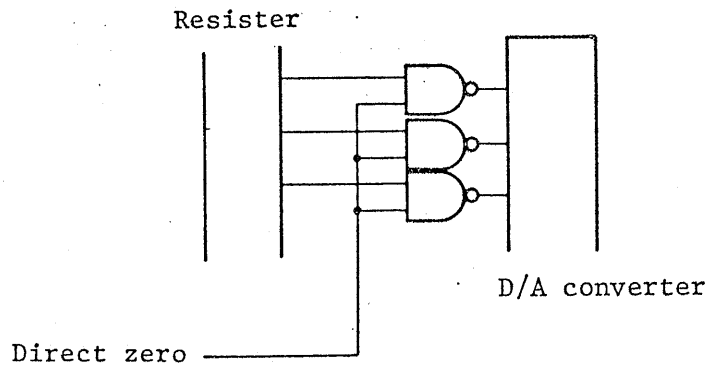
For the gate, a NAND gate is used as the D/A converter input is a complimentary type. When the gate is closed, its output becomes the H level.

The digital signal is converted into an analog signal by the D/A converter, the polarity of the analog signal is selected by the Polarity signal, and the resultant signal is fed to the output amplifier.

The Polarity Selector, being controlled with the Polarity
signal and an FET switching circuit, selects between polarity
inversion and non-inversion.
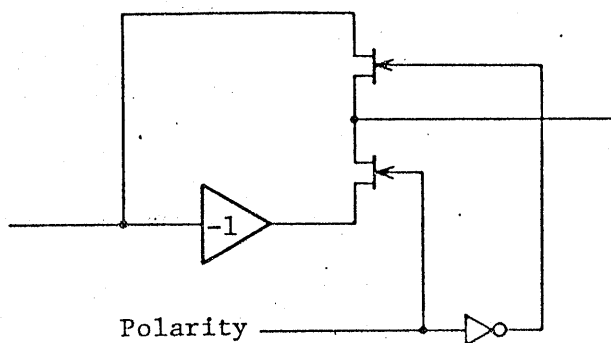
To reduce the effects of the ON resistance of the FET switch
circuit, the voltage is received with a voltage follower and
its output is fed to the output amplifier.

The power amplifier consists of an IC (initial stage), tran-
sistor circuits, and control transistors. It is a high speed,
high stability, high accuracy operational amplifier.

The output current limiter monitors the voltage developed
across the resistor inserted in series with the load circuit.
When the monitored voltage has exceeded the preset voltage,
the limiter circuit makes up a closed loop with the final
stage of the constant-voltage amplifier. The instrument
operation switches to the constant-current mode and remains
in this mode. This mode is indicated on the front panel.
When in this mode, the output is delivered through the isolator.

This instrument has a motor-driven fan to cool the control
transistors of the output section.

In order to guard against instrument overheating, a thermal
sensor has been installed on the heat sink of the control
transistors. The thermal sensor trips at 70°C (158°F) and
the instrument is released into the standby state.

5. APPLICATION

5.1 Examples of Controls of DPS Series

(1) Direct control with CPU

CPU: Various controllers (computers, digital equipment, etc.)

```
┌─────┬─────┐                        ┌─────┐
│ CPU │ I/O │───────────────●───────▶│ DPS │   Output
└─────┴─────┘                │       └─────┘
                             ▼
                        Expandable
```
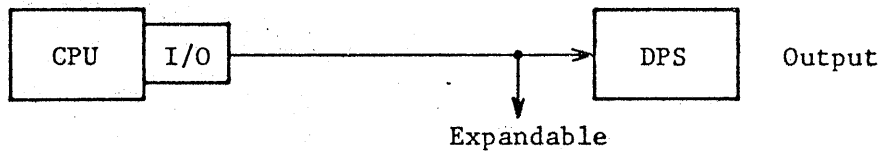
(2) Control with standard interface

```
┌─────┐  GP-IB   ┌────────────┐                ┌─────┐
│ CPU │──────────│ Controller │────●──▶        │ DPS │   Output
│     │ (HP-IB)  │  IF01-DPS  │    │           └─────┘
└─────┘          └────────────┘    │
                                   │           ┌─────┐
                                   ●──▶        │ DPS │   Output
                                   │           └─────┘
                                   ▼
```
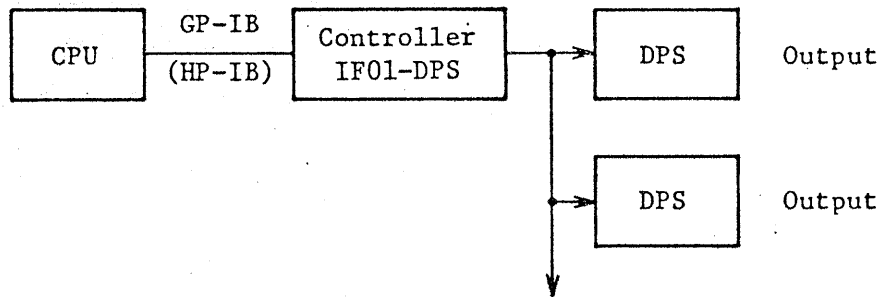
Up to 15 units can be controlled.

(3) Function generation with KIKUSUI MODEL CM01-DPS

```
┌────────────────┐                      ┌─────┐
│ DPS controller │──────────────●──────▶│ DPS │   Output
│    CM01-DPS    │              │       └─────┘
└────────────────┘              ▼
                            Expandable
```
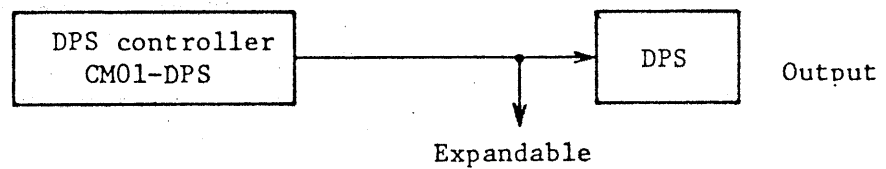
Non-volatile memory of 64 steps available

(4) Remote control

```
┌────────────┐                         ┌─────┐
│   Manual   │                         │ DPS │   Output
│ controller │──────────────●─────────▶│     │
│  CS01-DPS  │              │          └─────┘
└────────────┘              ▼
                        Expandable
```
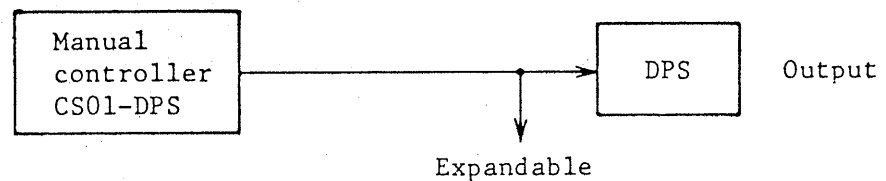
5.2 Examples of Use of DPS Series

(1) For programmable control of generator

Oscillating frequencies of a frequency generator can be
program-controlled. For example, apply the DPS output to
the VCG (voltage-controlled generator) terminal of a
function generator.

```
┌────────────┐      ┌───────┐              ┌──────────────────────┐
│            │      │       │          ┌──▶│ FUNCTION GENERATOR    │
│ CONTROLLER │─────▶│  DPS  │──────●   │   │ 457A, 458A, 459       │
│            │      │       │      │   │   └──────────────────────┘
└────────────┘      └───────┘      │   │
                                   │   │   ┌──────────────────────┐
                                   └───┼──▶│ SWEEP  GENERATOR      │
                                       │   │         462           │
                                       └──▶└──────────────────────┘
```
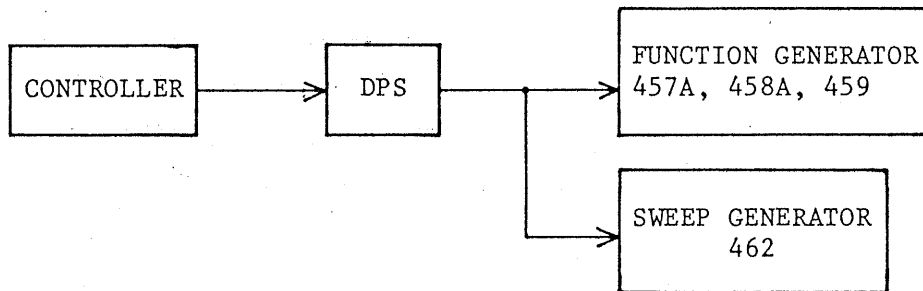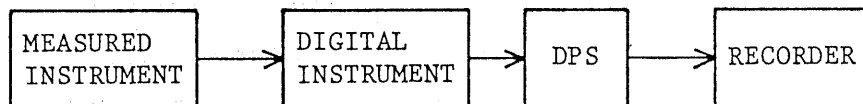
Output amplitude control also is programmable. For example,
apply the DPS output to the VCA (voltage-controlled ampli-
tude) terminal of a function generator.

```
┌────────────┐      ┌───────┐      ┌──────────────────────┐
│            │      │       │      │ FUNCTION GENERATOR    │
│ CONTROLLER │─────▶│  DPS  │─────▶│         457           │
│            │      │       │      │                       │
└────────────┘      └───────┘      └──────────────────────┘
```

(2) To use as a simple D/A converter

```
┌────────────┐   ┌────────────┐   ┌───────┐   ┌────────────┐
│ MEASURED   │──▶│ DIGITAL    │──▶│  DPS  │──▶│  RECORDER  │
│ INSTRUMENT │   │ INSTRUMENT │   │       │   │            │
└────────────┘   └────────────┘   └───────┘   └────────────┘
```

(3) To use as a signal source (an example for impurity density
measurement of semiconductors)

SPECIMEN

```
┌─────────┐                ┌──────────┐      ┌─────────────────────┐
│         │         ◯      │ C/V      │      │ WAVEFORM RECORDING  │
│  DPS    │────────────────│ CONVERTER│──────│ EQUIPMENT           │
│         │                │          │      │ 8700, 8800 SERIES   │
└─────────┘                └──────────┘      └─────────────────────┘
     │                      GP-IB                      │
     └──────────────────────────┬────────────────────── ┘
                                │
                          ┌──────────┐
                          │   CPU    │
                          └──────────┘
```
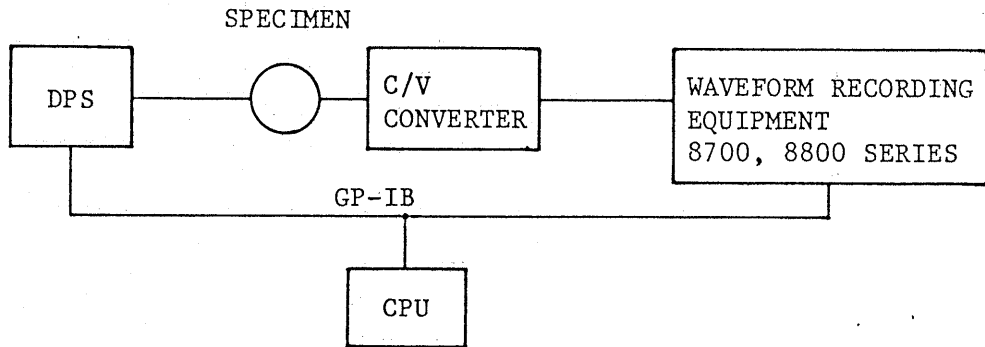
(4) For digital control of outputs of large ratings

For DC voltage/current:

```
┌─────────┐            ┌────────────────────────┐
│         │            │ REGULATED DC POWER     │
│  DPS    │───────────▶│ SUPPLY                 │      OUTPUT
│         │            │ PAD-L·PAD·PAC·PAB      │
└─────────┘            └────────────────────────┘
```
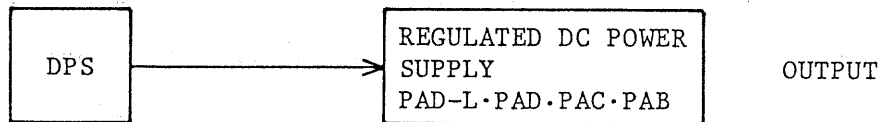
(Minor modification is required.)

For bipolar power:

```
┌─────────┐            ┌────────────────────────┐
│         │            │ BIPOLAR POWER SUPPLY   │
│  DPS    │───────────▶│ POW SERIES             │      OUTPUT
│         │            │                        │
└─────────┘            └────────────────────────┘
```
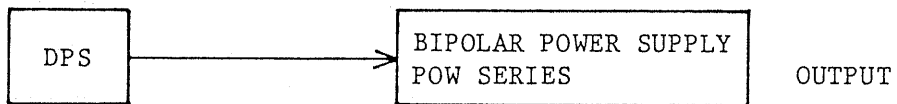
For constant-current load device:

```
┌─────────┐            ┌────────────────────────┐
│         │            │ ELECTRONIC LOAD        │
│  DPS    │───────────▶│ PLZ SERIES             │      OUTPUT
│         │            │                        │
└─────────┘            └────────────────────────┘
```
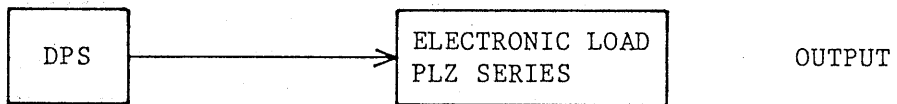
6. MAINTENANCE

6.1 Layout of Components
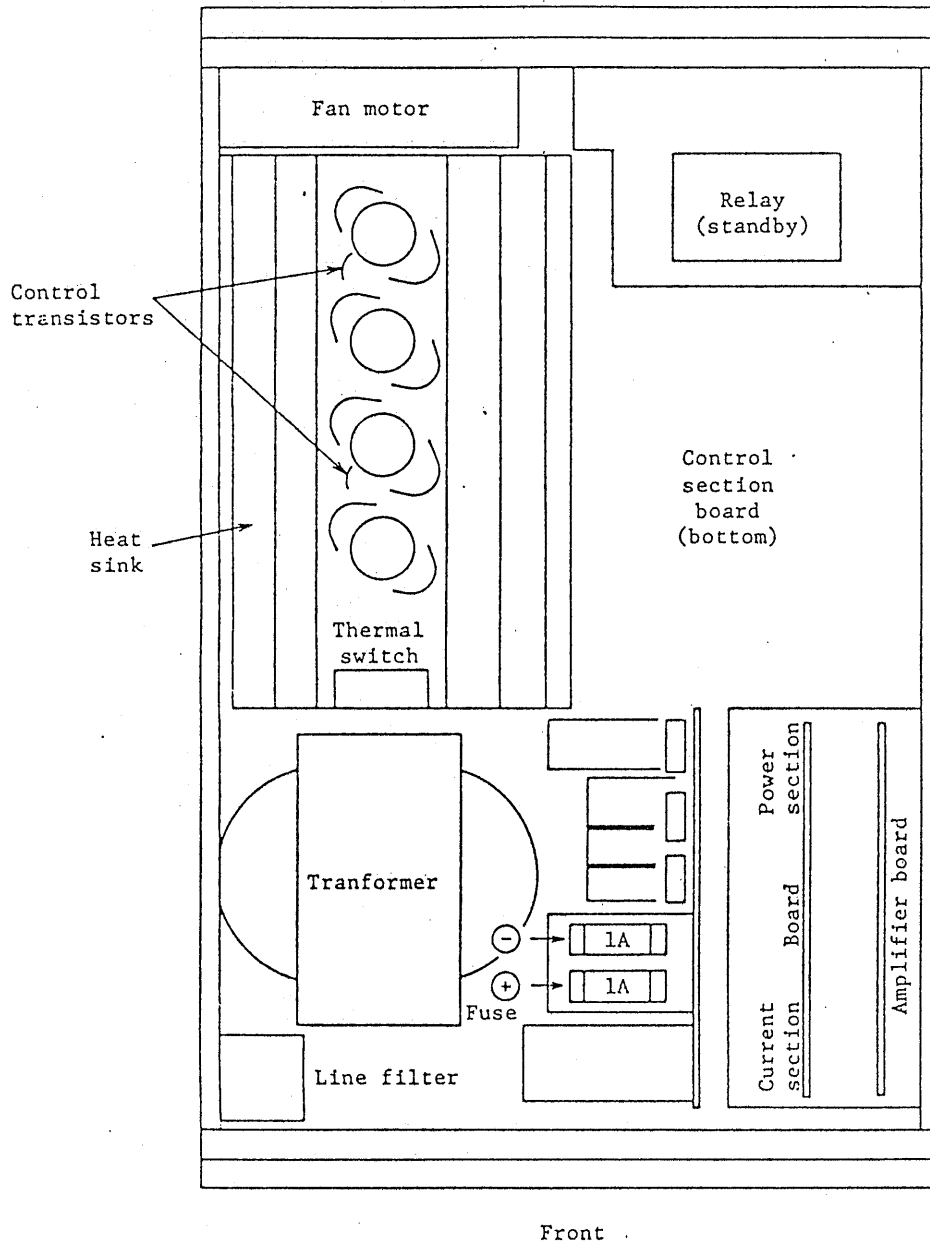
Figure 6-1 (Top view)

Layout of potentiometers

*1, *2: For control

*3: For interface

*4: For power amplifier

Figure 6-2

- 26 -
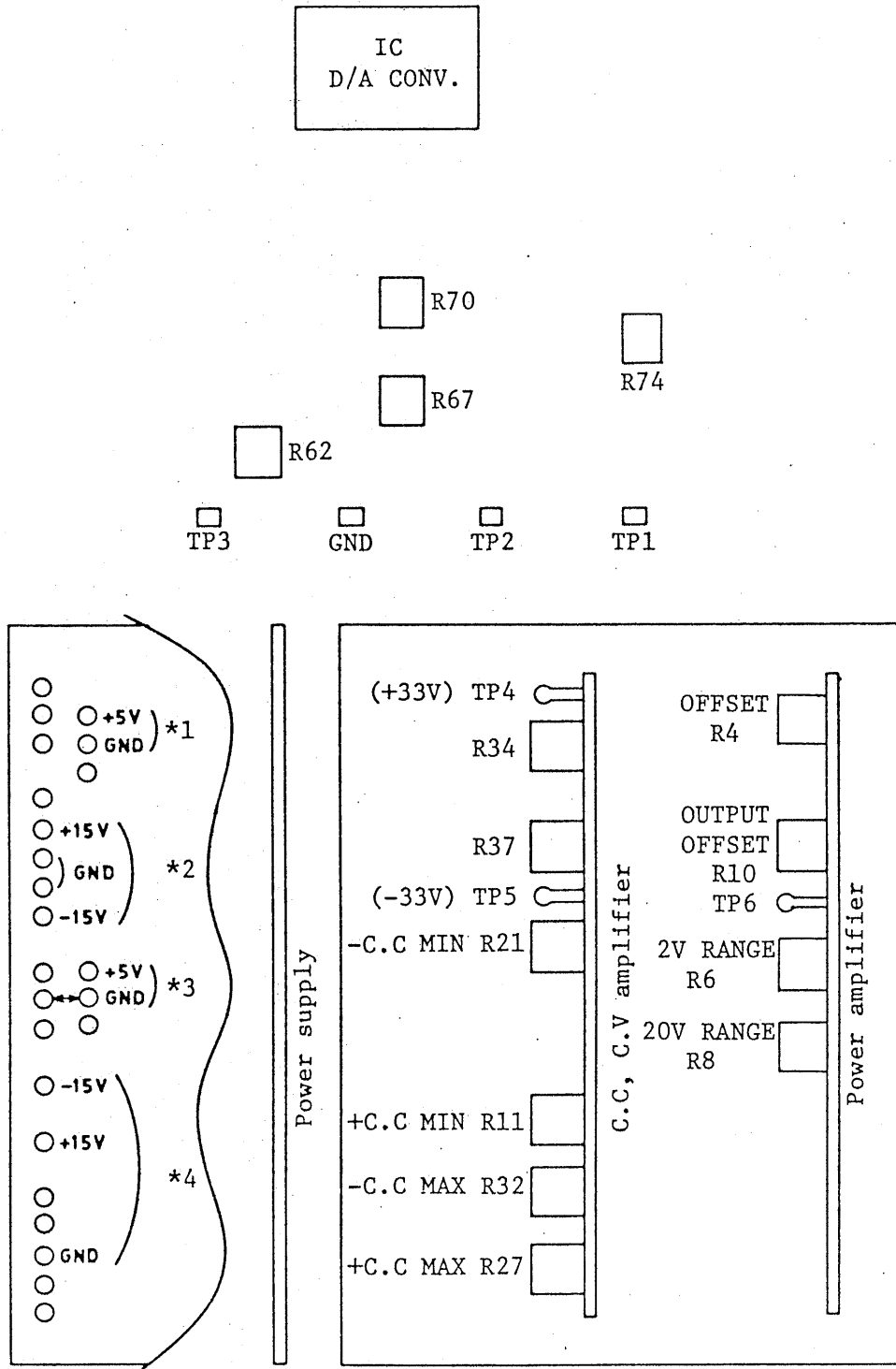
6.2 Adjusting Procedures (See Figure 6-2.)

(1) Check and Adjustment of Supply Voltages

1-1 Check of +15 V and -15 V supplies of control circuit

Each of these supplies employs a 3-terminal fixed-output
IC. Connect a voltmeter between control GND terminal
and +15 V terminal, and check that the voltage is within
14.2 V to 15.8 V. Connect a voltmeter between control
GND terminal and -15 V terminal, and check that the vol-
tage is within -14.2 V to -15.8 V.

1-2 Check of +5 V supply of control circuit

This supply employs a 3-terminal fixed-output IC. Connect
a voltmeter between control GND terminal and +5 V terminal,
and check that the voltage is within 4.75 V to 5.25 V.

1-3 Check of +15 V and -15 V supplies of power amplifier

Each of these supplies employs a 3-terminal fixed-output
IC. Connect a voltmeter between power GND terminal and
+15 V terminal, and check that the voltage is within 14.2 V
to 15.8 V. Connect a voltmeter between power GND terminal
and -15 V terminal, and check that the voltage is within
-14.2 V to -15.8 V.

1-4 Check of 5 V supply of interface circuit

This supply employs a 3-terminal fixed-output IC. Connect
a voltmeter between interface GND terminal and +5 V terminal,
and check that the voltage is within 4.75 V to 5.25 V.

1-5 Adjustment of ±33 V supplies of power amplifier
(CC, CV amplifier board)

Connect a voltmeter between power GND pin No. 4 (L side)
and TP4. So adjust potentiometer R34 that the voltmeter
reads within 32.5 V to 33.5 V. Connect a voltmeter to
TP5 and adjust the potentiometer R37 so that the voltmeter
reads within -32.5 V to -33.5 V.

(2) Offset adjustment of IC

o Enter data [+0000].

2-1 Connect a digital voltmeter between pin 6 (TP1) of MC16
of D/A converter and GND terminal, and adjust potentio-
meter R74 so that the digital voltmeter reads within
±20 µV.

2-2 Connect a digital voltmeter between pin 6 (TP2) of MC15
of inverter and GND terminal, and adjust potentiometer
R67 so that the digital voltmeter reads within ±20 µV.

2-3 Connect a digital voltmeter between pin 6 (TP6) of MC1 of
power amplifier and GND terminal, and adjust potentiometer
R4 so that the voltmeter reads within ±20 µV.

(3) Gain adjustment of D/A converter

Set the range at 2 V (0, 1) or 20 V (1, 0).
Enter data [-0999].

3-1 Connect a digital voltmeter between TP6 and GND.
Adjust the potentiometer R70 so that the voltage becomes
+4.995 V ±250 µV.

(4) Power amplifier offset and gain adjustment

   o Set the range at 20 V (1, 0) and enter data [-0000].

4-1 Connect a digital voltmeter to the output terminal and
      adjust the potentiometer R10 so that the voltmeter reads
      a value within ±50 μV.

   o Change data to [-0999].

4-2 Adjust the potentiometer R8 so that the output voltage
      becomes -9.99 V ±500 μV.

   o Change data to [-1000].

4-3 Adjust the potentiometer R58 of the D/A converter section
      so that the output voltage becomes -10.00 V ±500 μV.

   o Change data to [+1999].

4-4 Adjust potentiometer R62 of the inverter section so that
      the output voltage becomes +19.99 V ±1 mV.

4-5 Vary each input data and measure the output voltage to
      check that it is within the tolerance. If it is not within
      the tolerance, adjust it with the corresponding potentio-
      meter.

   o Set the range at 2 V (0, 1) and enter data [-1999].

4-6 Adjust the potentiometer R6 so that the output voltage
      becomes -1.999 V ±100 μV.

4-7 Vary each input data and measure the output voltage checking
      to insure that it is within the tolerance. If it is not
      within the tolerance, adjust it with corresponding potentio-
      meter again.

(5) Adjustment of output current

Set the output voltage at zero. Connect a slide-wire
rheostat and a DC ammeter in series to the output terminals.
(Select a slide-wire rheostat of a resistance which will
allow a current of 1 ampere or more to flow when the output
voltage is applied.)

5-1 Turn the current limit knob on the front panel to the
extreme counterclockwise position. Enter "-" data to
produce the output voltage. Varying the resistance of
the rheostat, adjust the potentiometer R21 of the current
amplifier so that the operation is transferred into the
constant-current mode when the output current is approxi-
mately -30 mA.

5-2 Turn the current limit knob to the extremely clockwise
position. Reduce the resistance of the rheostat and so
adjust potentiometer R27 of the current amplifier that
the operation is transferred into the constant-current
mode when the output current is approximately -1.05 A.

5-3 Repeat alternately the procedures of 5-1 and 5-2 so that
the best conditions are obtained for both requirements.

5-4 Turn the current limit knob on the front panel to the
extreme counterclockwise position. Enter "+" data to
produce the output voltage. Varying the resistance of
the rheostat, adjust the potentiometer R11 of the current
amplifier so that the operation mode will switch to the
constant-current mode when the output current is approxi-
mately +30 mA.

5-5 Turn the current limit knob to the extreme clockwise
position. Reduce the resistance of the rheostat and
adjust the potentiometer R32 of the current amplifier so
that the operation switches to the constant-current mode
when the output current is approximately +1.05 A.

5-6 Repeat alternately the procedures of 5-4 and 5-5 so that the best conditions are obtained for both requirements.