

SM1540-D

SM7020-D

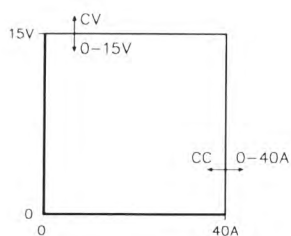
SM3004-D



SWITCHED MODE DC POWER SUPPLIES

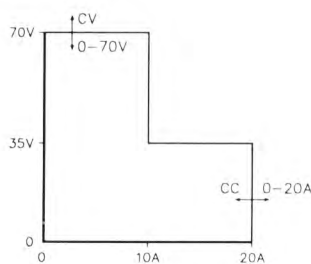
SM 1540-D

- * 600 W
- * 0 - 15 V 0 - 40 A



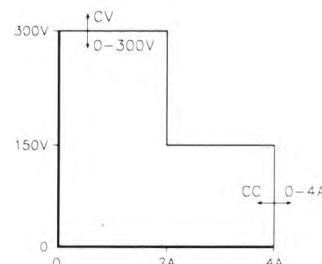
SM 7020-D

- * 700 W
- * **AUTORANGING**
- 0 - 35 V 0 - 20 A
- 35 - 70 V 0 - 10 A



SM 3004-D

- * 600 W
- * **AUTORANGING**
- 0 - 150 V 0 - 4 A
- 150 - 300 V 0 - 2 A



- 100 kHz power conversion technique.
- Efficiency 90 %.
- Weight only 7.4 kgs.
- Natural convection cooling, no blower, no noise.
- Designed for long life at full power
- Remote programming of voltage and current by analog voltages 0 - 5 V.
- **IEEE 488** or **RS232** programming with external interface PSC 44M or PSC232 (pin compatible).
- Master / Slave parallel and series operation with equal current and voltage sharing.
- Input / output insulation 3750 V rms.
- 10 turn potentiometers, 0.03% resolution
- 48 hours burn-in

		SM 1540-D	SM 7020-D	SM 3004-D
Output				
voltage range		0 - 15 V	0 - 70 V	0 - 300 V
current range		0 - 40 A	0 - 20 A	0 - 4 A
max: output power		600 W	700 W	600 W
AUTORANGING (2 ranges)		no	yes	yes
max. output current / volt. range		40 A / 0 - 15 V -	20 A / 0 - 35 V 10 A / 35 - 70 V	4 A / 0 - 150 V 2 A / 150 - 300 V
Input				
AC input , 50 - 60 Hz	110 V range 230 V range	90 - 132 V 185 - 265 V	95 - 132 V 192 - 265 V	95 - 132 V 192 - 265 V
current (110 V AC)		8.4 A rms	9.6 A rms	8.3 A rms
current (230 V AC)		3.9 A rms	4.5 A rms	3.9 A rms
DC input		215 - 350 V	215 - 350 V	220 - 350 V
fuses	230 / 110 V	8 AT / 16 AT	8 AT / 16 AT	8 AT / 16 AT
standby input power ($V_o=I_o=0$)		7.5 W	7.5 W	7.5 W
standby input power ($V_o=V_{max.}$)		13.5 W	16.5 W	21.5 W
Efficiency				
DC input, full load		88 %	90 %	90 %
AC input, full load		87 %	89 %	88 %
Regulation				
Load 0 - 100%	CV	5 mV	5 mV	20 mV
Line 190 - 265 V AC	CV	5 mV	5 mV	20 mV
Load 0 - 100%	CC	25 mA	12 mA	3 mA
Line 190 - 265 V AC	CC	25 mA	12 mA	3 mA
Ripple + noise, rms / p-p	CV	2 / 10 mV	3 / 15 mV	10 / 50 mV
	CC	10 / 25 mA	5 / 15 mA	1 / 3 mA
Temp. coeff., per °C	CV		$5 \cdot 10^{-5}$	
	CC		$1 \cdot 10^{-4}$	
Stability				
during 8 hrs after 1hr warm-up and $t_{amb} = 25 \pm 1 \text{ } ^\circ\text{C}$	CV		$3 \cdot 10^{-4}$	
	CC		$1 \cdot 10^{-3}$	

Analog Programming		CV	CC
Programming inputs			
input range		0 - 5 V	0 - 5 V
accuracy		$\pm 0.2\%$ + 0 mV ... + 8 mV	$\pm 0.5\%$ + 0 mV ... + 20 mV
temp. coeff. offset		10 $\mu\text{V} / ^\circ\text{C}$	150 $\mu\text{V} / ^\circ\text{C}$
input impedance		1 MOhm	1 MOhm
Monitoring output			
output range		0 - 5 V	0 - 5 V
accuracy		$\pm 0.2\%$ - 3 mV ... + 11 mV	$\pm 0.5\%$ - 5 mV ... + 0 mV
temp. coeff. offset		10 $\mu\text{V} / ^\circ\text{C}$	150 $\mu\text{V} / ^\circ\text{C}$
output impedance		20 Ohm	20 Ohm

Reference voltage on prog. connector	V_{ref} TC	$5.165 \pm 31 \text{ mV}$ typical 12 ppm / max. 30 ppm
Status outputs CC-status OVP-status		5V / 10 mA = logic 1 5V / 10 mA = logic 1
Remote shutdown		with + 5V or relay contact

Programming speed	SM 1540-D		SM 7020-D		SM 3004-D	
programming UP						
settling within	50 mV	500 mV	50 mV	1 V	200 mV	5 V
output voltage step	0 → 15 V	0 → 15 V	0 → 35 V	0 → 35 V	0 → 150 V	0 → 150 V
time, (100 % load)	30 ms	18 ms	50 ms	12 ms	50 ms	14 ms
time, (10 % load)	30 ms	10 ms	50 ms	12 ms	40 ms	12 ms
output voltage step	-	-	0 → 70 V	0 → 70 V	0 → 300 V	0 → 300 V
time, (100 % load)	-	-	100 ms	40 ms	100 ms	60 ms
time, (10 % load)	-	-	100 ms	12 ms	60 ms	16 ms
programming DOWN						
settling within	50 mV	500 mV	50 mV	1 V	200 mV	5 V
output voltage step	15 → 0.5 V	15 → 0.5 V	35 → 2 V	35 → 2 V	150 → 10 V	150 → 10 V
time, (100 % load)	30 ms	20 ms	50 ms	10 ms	50 ms	14 ms
time, (10 % load)	200 ms	200 ms	200 ms	100 ms	180 ms	120 ms
output voltage step	-	-	70 → 2 V	70 → 2 V	300 → 10 V	300 → 10 V
time, (100 % load)	-	-	100 ms	55 ms	100 ms	70 ms
time, (10 % load)	-	-	800 ms	120 ms	800 ms	700 ms
Programming bandwidth						
small signal	50 Hz		50 Hz		50 Hz	
large signal, 100 % load	50 Hz		50 Hz		50 Hz	
large signal, 10 % load	5 Hz		5 Hz		5 Hz	

	SM 1540-D	SM 7020-D	SM 3004-D
Recovery time			
recovery within	50 mV	50 mV	300 mV
di/dt of load step	4 A/μs	2 A/μs	0.5 A/μs
time, @ 50 - 100% load step	100 μs	150 μs	100 μs
max. deviation (high / low outp. range)	200 mV	80 / 150 mV	450 / 900 mV
Noise suppression			
line - line ⇒ output	88 dB	82 dB	75 dB
line - earth ⇒ output	88 dB	88 dB	75 dB
Output impedance			
CV, 0-100 kHz	< 40 mOhm	< 60 mOhm	< 700 mOhm
Pulsating load			
max. tolerable AC component			
of load current			
f > 1 kHz	10 A rms	5 A rms	1 A rms
f < 1 kHz	40 A peak	20 / 10 A peak	4 / 2 A peak

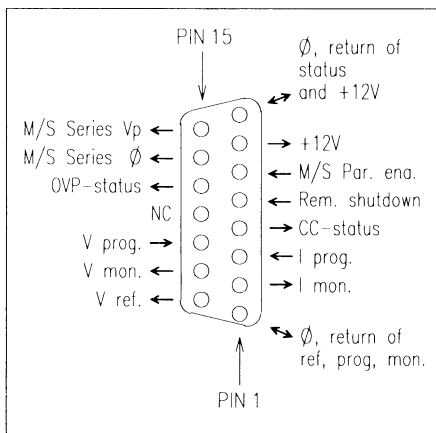
Insulation		
input / output	3750 Vrms (1 min.)	
creepage / clearance	8 mm	
input / case	2500 Vrms (1 min.)	
output / case	600 V DC	
Safety	EN 60950 / IEC 1010	
EMC	Emission	EN50081-1, EN55022B, VDE 0871B, EN61000-3-2, EN61000-3-3
	Immunity	EN50082-1, EN50082-2, EN61000-4-2-lv3, EN61000-4-4-lv4, ENV50140-lv3, ENV50141-lv3, ENV50204-lv3, EN61000-4-5-lv3-diff-mode-on-output, EN61000-4-5-lv2-comm-mode-on-output, EN61000-4-5-lv4-on-input, EN61000-4-11 (lv=level)
Operating Temperature at full load	- 20 to + 50 °C	
Humidity	max. 95% RH, non condensing, up to 40 °C max. 75% RH, non condensing, up to 50 °C	
Storage temperature	- 40 to + 85 °C	
Thermal protection	Output shuts down in case of insufficient cooling	
MTBF	500 000 hrs	

Hold-Up time 100% load Vin = 220V AC 50% load Vin = 220V AC	20 ms 45 ms
Turn on delay after mains switch on	500 ms
Inrush current	3C A @ 230V AC input

	SM 1540-D	SM 7020-D	SM 3004-D
Series operation max. total voltage Master / Slave operation	600 V yes	600 V yes	600 V yes
Parallel operation max. total current Master / Slave operation	no limit yes	no limit yes	no limit yes
Remote sensing max. voltage drop per load lead	2 V	2 V	not available
OVP trip range	0 - 17 V	0 - 80 V	0 - 350 V

Potentiometers front panel control with knobs resolution	standard 0.03 %	standard 0.03 %	standard 0.03 %
screwdriver adjustment at front panel at rear panel	option P001 option P002	option P001 option P002	option P001 option P002
Meters digital scale voltage / current accuracy	digital / 3.5 digit 0 - 15.00 V / 0 - 40.0 A 0.5% + 2 digits	digital / 3.5 digit 0 - 70.0V / 0 - 20.0 A 0.5% + 2 digits	digital / 3.5 digit 0 - 300 V / 0 - 4.00 A 0.5% + 2 digits

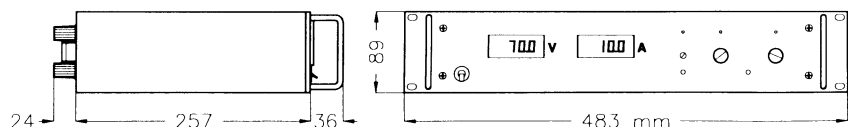
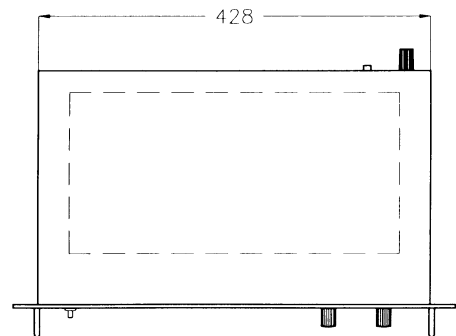
Input Terminals input connections	10 Amp / 65 °C Euro-connector at rear panel		
Output Terminals at rear panel	M8 bolts	6 mm bind post	4 mm bind post
Programming connector	15 pole D-connector at rear panel		
Cooling	convection cooling		
Enclosure degree of protection	IP20		
Dimensions behind front panel front panel	428 x 89 x 257 mm 483 x 89 mm (19", 2 U)		
Weight	7.4 kg		



Connections programming connector

CV= Constant Voltage
CC=Constant Current
OVP=Over Voltage Protector

Specifications measured at
 $t_{amb} = 25 \pm 5 \text{ }^\circ\text{C}$ and $V_{in} = 220 \text{ V AC}$,
50 Hz unless otherwise noted.



DESCRIPTIONS

1) OUTPUT

The SM7020-D and SM3004-D feature an AUTORANGING facility where the power supply automatically switches over between two current ranges. This switching, which is unnoticeable the user, results in a versatile power supply with **twice the output voltage range**. This means for the SM7020-D: the maximum output power (700W) is available at both 35V and 70V. For the SM3004-D: 600W at both 150V and 300V. Fig. 2 - 1 shows the output ranges.

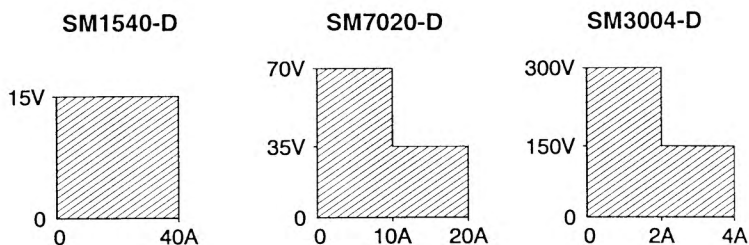


fig. 2 - 1

the output ranges
every point in hatched area can be used

Note: the voltage and current settings will never be altered by the AUTORANGING, only the maximum attainable current will change. E.g. on the SM3004-D, with an initial setting of 1.5A. When the voltage is decreased from 200V to 150V the max. current output remains 1.5A as originally set.

◦ DISPLAY CV/CC SETTING FUNCTION

The setting of the voltage and current control can be observed on the front panel meters by pressing the Display CV/CC Setting button. This allows the current limit to be set when operating in the CV mode without shorting the output terminals, and the voltage limit to be set when operating in the CC mode without opening the load leads.

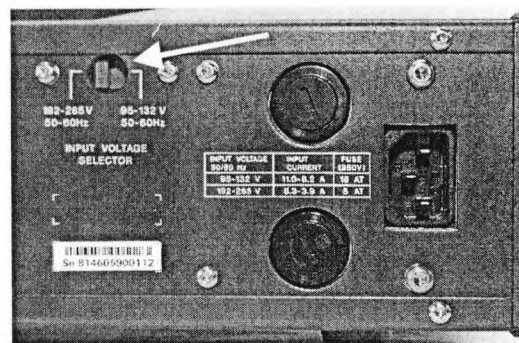


fig. 2 - 2

input voltage selector at rearpanel

◦ OVERLOAD PROTECTION

The power supply is fully protected against all overload conditions, including short circuit.

2) INPUT VOLTAGE

The power supplies have a wide input voltage range. The 2 ranges (110V / 220V) are selectable with a switch on the rearpanel, see fig. 2 - 2. In the 220V position the units can also be used as a DC/DC converter.

◦ nonstandard line input voltage

The units will still operate at a line input voltage lower than standard, but with a reduction in output power. Fig. 2 - 3 shows the max. output current as a function of output voltage with AC or DC line input voltage as a parameter.

Example: When the required output voltage is 12.5 V at a line input voltage of 150 V AC.

Fig. 2 - 4 shows the maximum current for the SM1540-D to be 32.8 A.

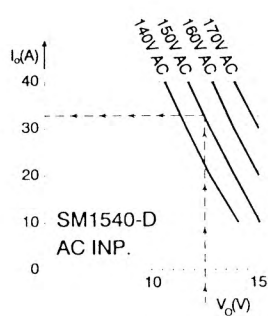
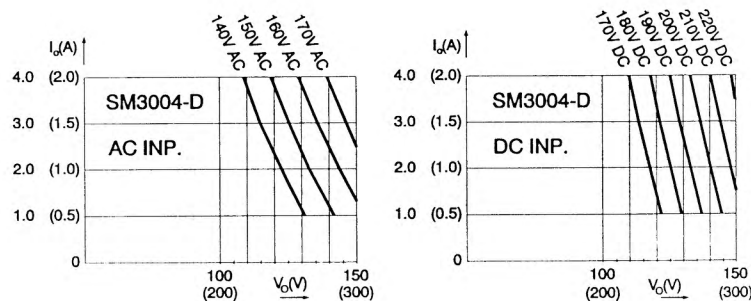
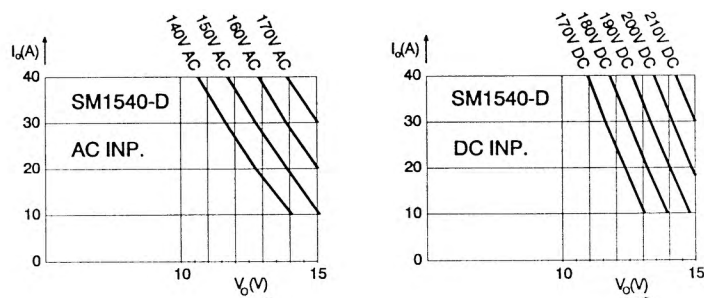


fig. 2 - 4

example how to use the graph

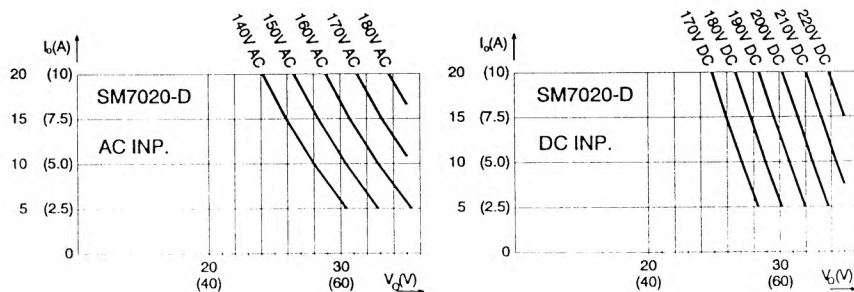


fig. 2 - 3

max. output current vs output voltage with AC or DC line input voltage as a parameter

3) **INPUT CURRENT**

The input circuit has a large series choke to improve the waveform. The result is: a lower rms input current, less mains distortion and no large peak currents. The units also have an inrush current limiter and a soft start circuit, for smooth switch on.

◦ FUSES- At 220V: 8A Slow blow, at 110V: 16A Slow blow.

4) **STANDBY INPUT POWER**

The unit consumes very little power when in standby. This makes it possible to leave the input power on and use the Remote ShutDown input (pin 5 on prog. connector rear panel) to disable the output.

5) **EFFICIENCY**

The efficiency is very high and constant over a wide output current range, see fig. 2 - 5. High efficiency also means low power loss and low heat generation.

6) **REGULATION**

The load regulation should be measured directly on the output terminals. A few cm of cable can have a voltage drop of several mV (at high current!).

7) **RIPPLE & NOISE**

The output ripple is very low with almost no spikes. The ripple voltage has to be measured directly on the output terminals using a probe with very short connections (to avoid pick up of magnetic fields). See fig. 2 - 6 and fig. 2 - 7.

◦ LOW TEMPERATURE

At -20 °C the CV ripple increases to the following values:

	SM1540-D	SM7020-D	SM3004-D
CV ripple (rms/pp) @ -20 °C	6 / 20 mV	10 / 35 mV	no change

8) **PROGRAMMING INPUTS**

The output voltage and current can be programmed by an external analog voltage. This programming is very accurate and linear, (non-linearity < 0.15 %). The levels are all standardised on 5V. Always use a **shielded cable** for programming.

The inputs have a protection circuit formed by a series resistor and a parallel zener, see fig. 2 - 8. The capacitor limits the speed to a safe value. Note that the analog inputs (and outputs) are **not floating, but the common is connected to the negative output terminal**. Wrong connection of Ø can cause earth loops which can trip the fuse. After removing the fault, the fuse will reset (PTC-fuse). To prevent earth loops, use isolated programming with the **ISO AMP MODULE** (δ-product).

The programming mode (program and manual) can be selected by means of the prog. switches which are situated below the programming connector, see fig. 2 - 10.

9) **IEEE 488 / RS232 PROGRAMMING**

The prog. connector on the power supply is both pin and level compatible with the external interfaces **PSC44M** and **PSC232** (both δ-products).

Voltage and current can easily be programmed and read back, also the CC and OVP status can be read by the computer. Always use a **shielded cable** for programming.

10) **MONITORING OUTPUTS**

The monitor outputs give a voltage 0 - 5 V proportional to the output current or voltage. The output current can easily be measured without an external shunt using the I monitor, see fig. 2 - 9. The monitor outputs are buffered by op-amp's and protected by series resistors and parallel zeners see fig. 2 - 11. The table in fig. 2 - 12 shows the impedance levels of the monitoring outputs.

Note: in case of a **pulsating load**, the I monitor voltage will not exactly

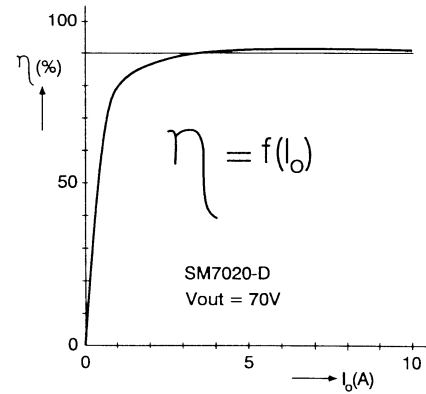


fig. 2 - 5
efficiency vs output current, SM7020-D
DC input, Vout = 70 V

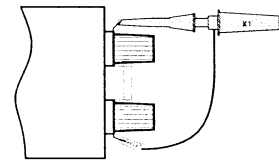


fig. 2 - 6
measuring ripple voltage
WRONG!

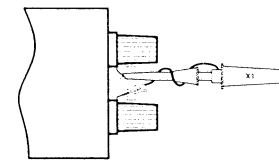


fig. 2 - 7
measuring ripple voltage
RIGHT!

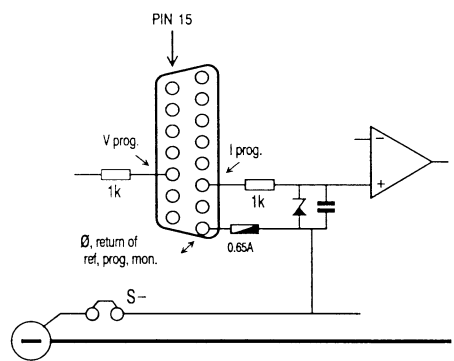


fig. 2 - 8
programming inputs
(internal circuit)

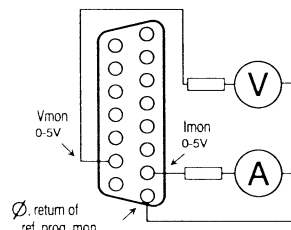


fig. 2 - 9
external meters
using monitor outputs

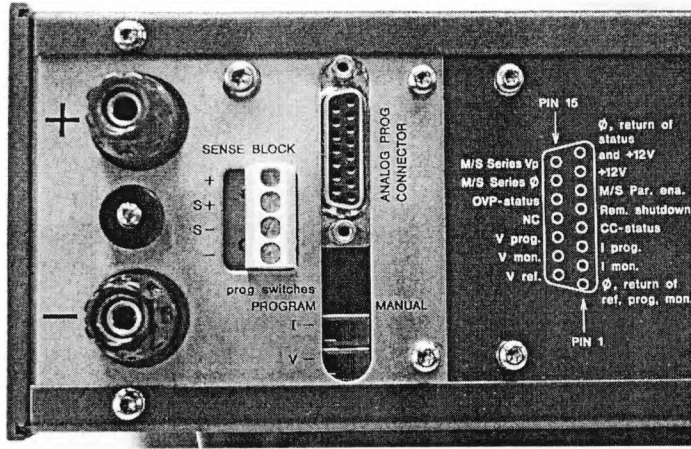


fig. 2 - 10 location of output terminals, sense block, analog prog. connector and PROG. / MAN. switches on rear panel (SM3004-D has no sense block).

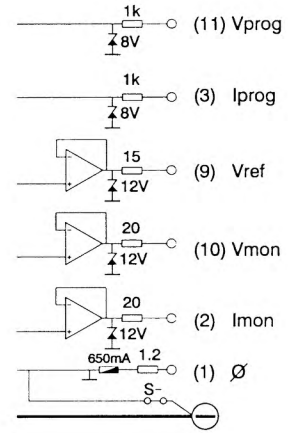


fig. 2 - 11 buffered monitor outputs (internal circuit)

Output	pin	Ro	Io max
Vref	9	15 Ohm	10 mA
Vmon	10	20 Ohm	10 mA
Imon	2	20 Ohm	10 mA
+12V	7	500 Ohm	25 mA
∅	1	1.2 Ohm	

fig. 2 - 12 outputs on programming connector

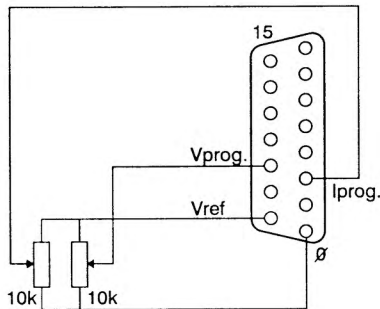
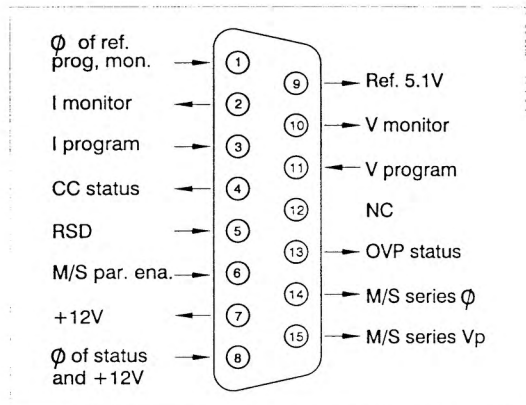


fig. 2 - 14 external potmeters

match the output current. This is mainly caused by the current through the output capacitors. Remote sensing will worsen this effect.

11) STATUS OUTPUTS

The status outputs have an open output voltage of 5 V and a short circuit current of 10 mA. This makes it possible to drive directly: an opto-coupler, a TTL gate or a CMOS gate (put leakage resistor to ∅).

12) REMOTE SHUTDOWN (RSD)

A voltage of +5V on the Remote ShutDown input on the programming connector will switch off the power circuit of the unit. In standby mode the power supply consumes very little power.

It is also possible to use a relay contact or a switch to shut down the unit: connect a switch between Vref and Rem. Shudt. (pin 9 and 5). Note: The Remote ShutDown will also cause the OVP-led to burn and the OVP-status will be high.

13) PROGRAMMING RESPONSE TIME

The response time is measured with a step waveform at the CV prog. input. Programming from a low to a high output voltage is nearly load independent, but programming down to a low voltage takes more time

pin	description
1	∅, return of reference, prog. inputs and monitor outputs.
2	current monitor output (0 - 5V)
3	current programming input (0 - 5V)
4	CC status output, logic 1 = CC mode (5 V / 10 mA)
5	Remote shutdown
6	M/S parallel, slave enable (only for autoranging)
7	+12 V output (Ri = 500 Ohm)
8	∅, return of status outputs, +12 V and remote shutdown
9	reference voltage 5.1 V
10	voltage monitor output (0 - 5V)
11	voltage programming input (0 - 5V)
12	NC
13	OVP status output, logic 1 = OVP mode (5 V / 10 mA)
14	M/S series, output for slave (∅)
15	M/S series, output for slave (prog.)

fig. 2 - 13 connections ANALOG PROG. CONN.

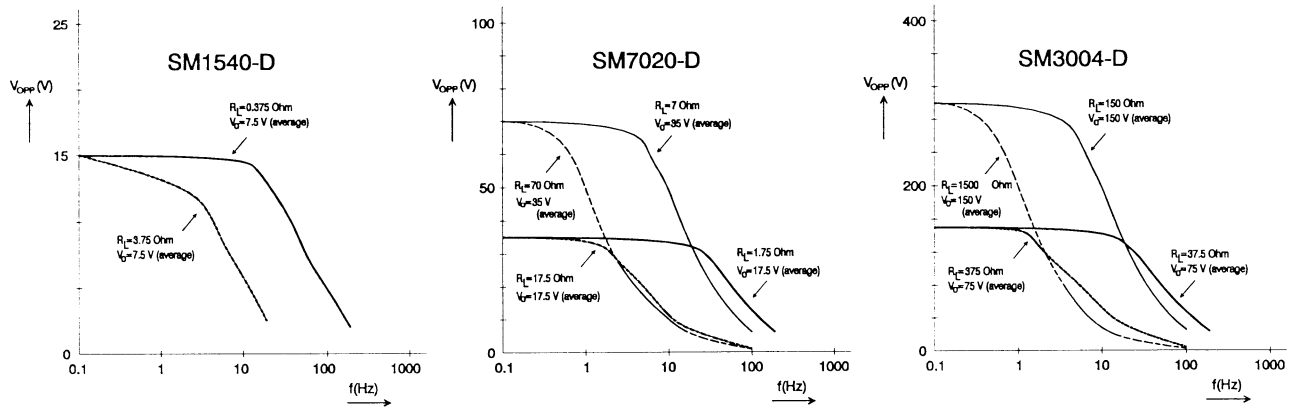


fig. 2 - 15
max. peak to peak output voltage swing vs frequency

on lighter loads. This is caused by the output capacitors, which can only be discharged by the load because the power supply cannot sink current.

14) **PROGRAMMING BANDWIDTH**

For small signals the bandwidth is 50 Hz, but for large signals there is a limitation in the maximum amplitude of the output waveform. The output capacitors limit the max. slew rate. Fig. 2 - 15 shows the maximum peak to peak output voltage swing as a function of frequency, with the load as a parameter. The higher the load resistance the lower the max. amplitude. The measurements were carried out using a sine wave. The DC level of the output is 50 % of the max. output voltage. On the SM7020-D and SM3004-D measurements were also carried out at 25 % of the max. output voltage.

15) **RECOVERY TIME**

Fig. 2 - 16 shows the recovery time for the SM7020-D at 25 °C, a 50 - 100 % load step and at maximum output voltage. At -20 °C the recovery time increases by 100 µs.

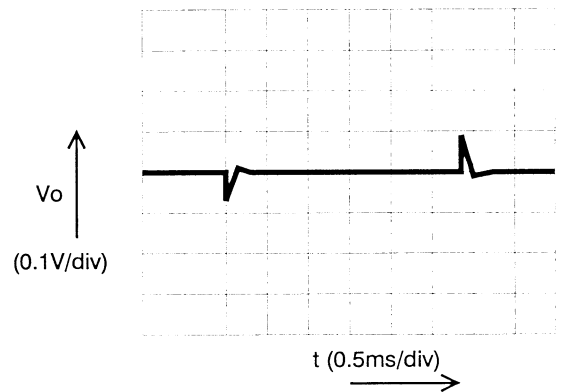


fig. 2 - 16
recovery time SM7020-D
50 - 100 % load step, V_o = 70 V

16) **NOISE SUPPRESSION (input / output)**

The input / output noise suppression is measured with a pulse generator (a) in series with the line input or (b) between input and case (earth). The generator should produce a high energy pulse of about 300 V. If there is an electrical connection between the output and the input through the oscilloscope, you will get a false reading. The suppression for the SM3004-D is lower, but the relative disturbance on the output is comparable to the SM1540-D.

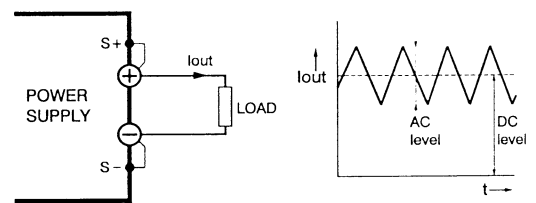


fig. 2 - 17
pulsating load current

17) **PULSATING LOAD**

To avoid overheating the output capacitors, the AC component of the load current should be limited. See fig. 2 - 17.

One method of decreasing the AC current through the output capacitor is by using a large external electrolytic capacitor in parallel with the load. Care must be taken so that the capacitor in combination with the lead inductance will not form a series resonant circuit!

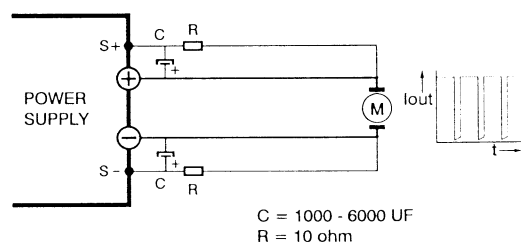


fig. 2 - 18
remote sensing on a pulsating load

	SM1540-D	SM7020-D	SM3004-D
AC-level max.	10 A rms	5 A rms	1 A rms

When using **remote sensing** on a pulsating load (for instance a DC-motor), use a capacitor between S+ and + and between S- and - and a series resistor in the sense leads. See fig. 2 - 18. Like this the AC-component caused by the voltage drop across the load leads, is filtered.

18) INSULATION

For safety the insulation of the separating components (transformers) between input and output is tested at 3750 Vrms during 1 minute. This is tested before assembling.

Warning! The 3750 Vrms cannot be tested afterwards on the assembled unit because the insulation between the components on the input side to the case (like the bridge rectifier) is specified at 2500 Vrms. Since the insulation output - case is low (only 600 VDC) the insulation of the primary components to case will break down when 3750 Vrms is applied between input and output ($2500 \text{ Vrms} + 600 \text{ VDC} < 3750 \text{ Vrms}$). See also fig. 2 - 19.

Note: when testing the insulation, take care to charge and discharge the capacitors between input - case and output - case slowly (e.g. in one second). This to prevent high peak currents, which could destroy the power supply. Make sure to have discharged the capacitors completely before using it again.

19) RFI SUPPRESSION

Both the input and output have RFI filters, resulting in very low conducted RFI to the line and load. Due to the output filter the output voltage is very clean, having almost no spikes.

20) OPERATING TEMP

At full power the operating temperature range is -20 to $+50$ °C. From 50 to 75 °C the output current has to be derated linearly to 20 % at 75 °C. See fig. 2 - 20. These temperatures hold for normal use, i.e. the air must be able to pass freely vertically along and through the unit.

21) THERMAL PROTECTION

A thermal switch shuts down the output in case of insufficient cooling. After cooling down the unit will start working again. In this condition the OVP led on the frontpanel will burn, and the OVP status output will be high.

22) HOLD - UP TIME

The hold - up time depends on the load, output voltage and line input voltage. A lighter load, a lower output voltage or a higher line input voltage all result in a longer hold - up time, see fig. 2 - 21. For example: the SM1540-D at 220 VAC input and 12 V / 40 A output will have a hold-up time of 50 ms.

23) TURN ON DELAY

The output voltage is available 0.5 sec after mains switch on.

24) INRUSH CURRENT

The inrush current is limited by a 50 Ohm PTC resistor, resulting in a very low current during switch on. The input current during switch on will be lower than during operation at full load.

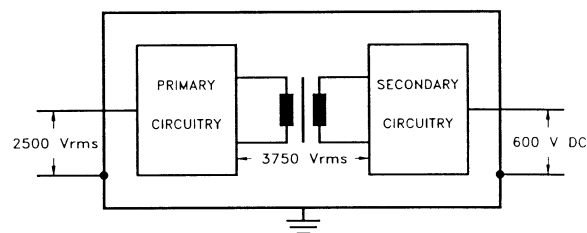


fig. 2 - 19
insulation test voltages

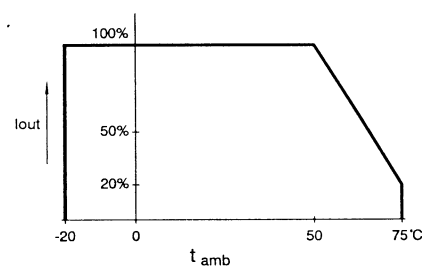


fig. 2 - 20
operating temperature ranges

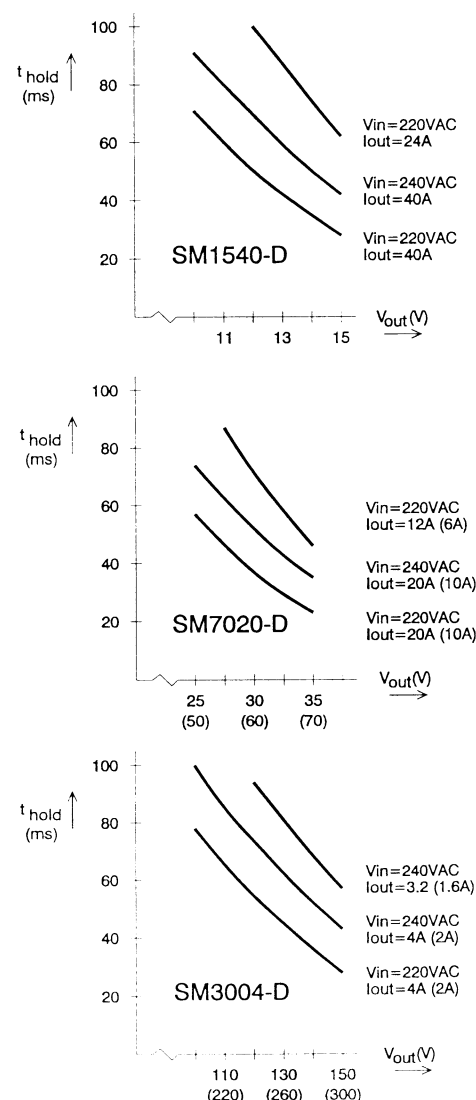


fig. 2 - 21
holdup time vs V_{out} with line input
and I_{out} as parameter

25) **SERIES OPERATION**

Series operation is allowed up to 600V total voltage. The power supplies can be connected in series without special precautions.

For easier control, Master / Slave operation is recommended (fig. 2 - 23).

By using the *Master / Slave - Series* feature a **dual tracking** power supply can be made with one unit as master and one as slave. See fig. 2- 22 (detailed descriptions in chapter "operations").

26) **PARALLEL OPERATION**

Paralleling of the units has no limitations. The power supplies can be connected in parallel without special precautions.

For easier control, Master / Slave operation is recommended (fig. 2 - 24).

Note: Master / Slave parallel operation is not recommended for more than 4 units, consult factory for a solution with more than 4 units.

27) **MASTER / SLAVE OPERATION**

The Master / Slave feature makes it possible to use the power supplies as building blocks to form one large unit, see fig. 2 - 23 and 24.

Mixed parallel - series operation is also possible (fig. 2 - 25), to a maximum of 600V.

The resulting combination of units behaves like one power supply and can be programmed on the master. In the Master / Slave mode the autoranging feature still works. Fig. 2 - 26 shows a computer controlled M / S parallel combination.

The slaves will follow the master. The result is true **current or voltage sharing** in the parallel or series mode respectively.

For series and mixed parallel - series operation the **MASTER / SLAVE SERIES ADAPTER** (&-product) is recommended. Without this ADAPTER it is also possible but it often gives problems. For parallel operation connections can easily be made on the analog programming connector.

In series mode the master controls one slave, which in turn controls the second slave and so on. In parallel mode the master controls all the slaves.

28) **REMOTE SENSING**

The voltage at the load can be kept constant by remote sensing. This feature is not recommended for normal use but only when the load voltage is not allowed to vary a few millivolts. Always use a **shielded cable** for sensing. Note that the SM3004-D has no remote sensing.

In order to compensate for the voltage drop across the load leads, the unit will have to supply a higher voltage: $U_{out} = (\text{voltage drop across each lead}) + (\text{voltage across the load})$, see fig. 2 - 27. The **OVP** reads the voltage directly at the output and the setting must be increased by the total voltage drop across the load leads.

The voltmeter is connected to the sense leads and therefore reads the voltage across the load and **not** the voltage on the output terminals.

The sense leads are protected for **accidental interruption**, in which case the output voltage will go to a max. of 115% of the set value.

Warning: Do not interrupt the minus lead while the S- lead is still connected to the load, during operation. It is possible that the capacitor C808 on P385 or P386 will be damaged.

For sensing on a **pulsating load** see par.17) of this chapter.

29) **OVP**

The Over Voltage Protector will protect your circuit from unwanted high voltages.

A high output voltage could be caused by accidental interruption of leads, accidentally turning up the voltage potmeter or a defect in the power supply. The OVP circuit uses a separate voltage divider connected directly to the output terminals.

The OVP limits the output voltage to a value which can be set by the OVP potmeter on the front panel. While doing this, press the DISPLAY OVP SETTING button to read the limit value in the left display. The led on the front panel will indicate whether the OVP has reached the limit. The OVP status output will give a logic 1 (+5 V)

Note: The Thermal Shutdown and Remote Shutdown will also cause the OVP-led to burn and the OVP-status will be high.

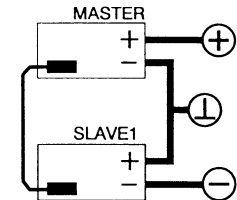


fig 2 - 22

Dual tracking power supply

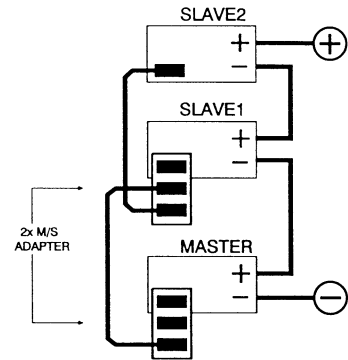


fig 2 - 23

Master / Slave Series operation

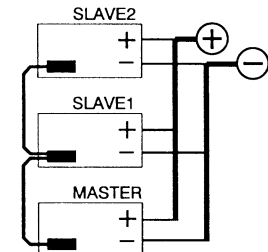


fig 2 - 24

Master / Slave Parallel operation

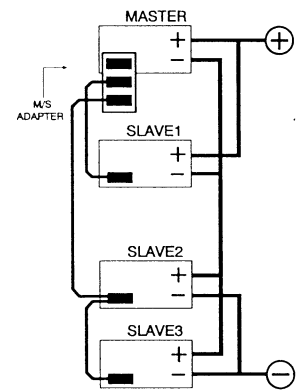


fig. 2 - 25

Master / Slave mixed Series-Parallel

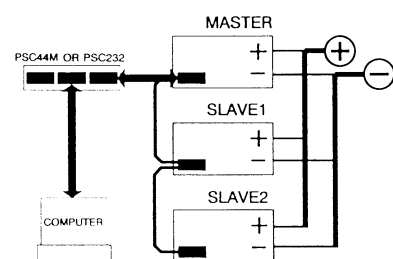


fig. 2 - 26

the Master / Slave combination can also be programmed with the interfaces PSC44M or the PSC232

When the OVP status output is used as an indication for accidental interruption of leads, a defect in the power supply etc., it is recommended to set the limit well above the working output voltage to avoid accidental limiting. The recommended OVP set voltages can be read from the following table:

Unit:	SM1540-D	SM7020-D	SM7020-D	SM3004-D	SM3004-D
		range 0 - 35 V	range 35 - 70 V	range 0-150 V	range 150-300 V
V _{ovp}	V _{out} + 2V	V _{out} + 3V	V _{out} + 5V	V _{out} + 10V	V _{out} + 25V

Example: For a SM7020-D set at 24V output voltage it is recommended to set the OVP on 24 + 3 = 27V.

30) **POTENTIOMETERS**

- Standard: - CV and CC potentiometers with knobs at front panel, OVP potentiometer with screwdriver adjustment at the front panel.
- Option P001: - Screwdriver adjustment for CV, CC and OVP at the front panel, fig. 2 - 28.
- Option P002: - Screwdriver adjustment for CV, CC and OVP at the rear panel (no potentiometers at front panel), fig. 2 - 29.

31) **COOLING**

The cooling is by natural convection, **no noisy blowers** are present. The unit should have sufficient free space to let the air flow vertically through the unit. See fig. 2 - 30. A distance of minimum 5 cm around the unit is recommended.

For long life the temperature of the air entering the unit, should be below 35 °C under normal conditions. Under extreme conditions it should be below 50 °C.

32) **DIMENSIONS**

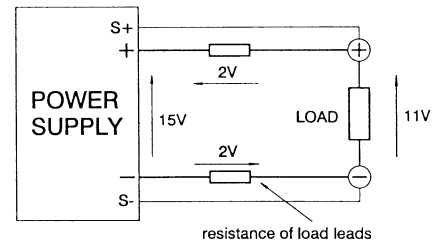
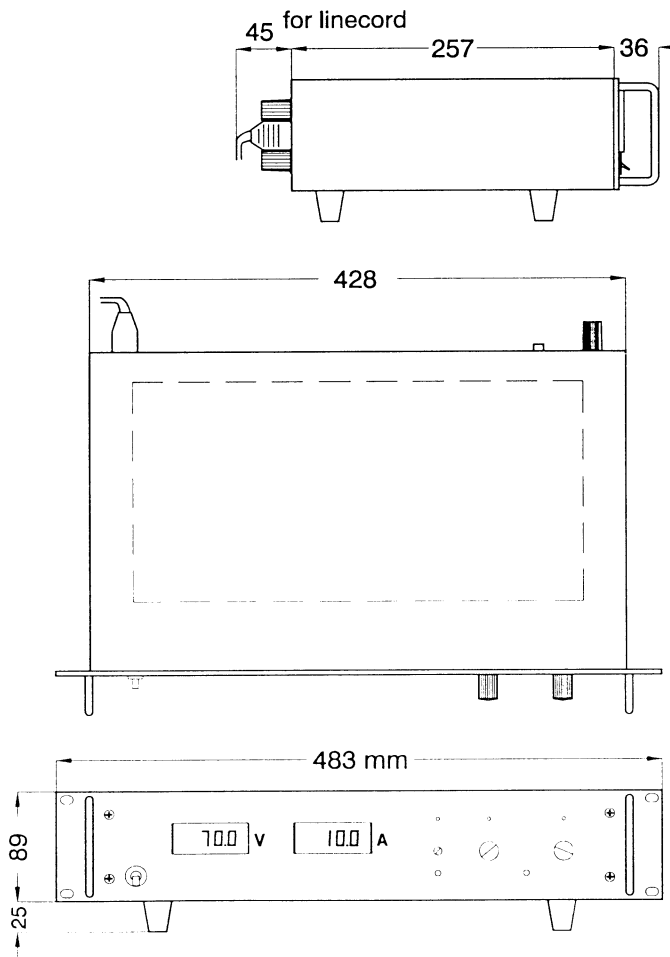


fig. 2 - 27

remote sensing, voltage drop in load leads subtracts from max. output

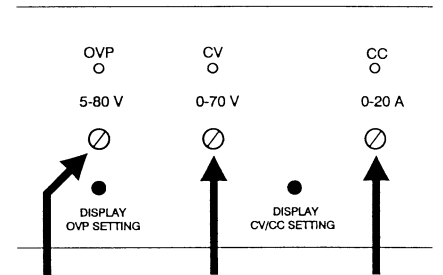


fig. 2 - 28

optional screwdriver adjustment at front panel

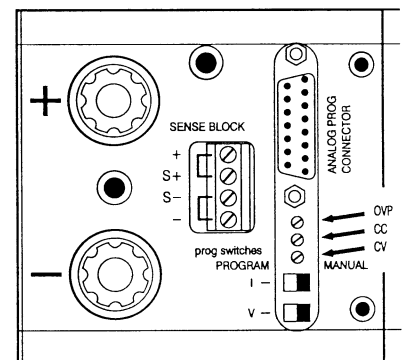


fig. 2 - 29

optional screwdriver adjustment at rearpanel

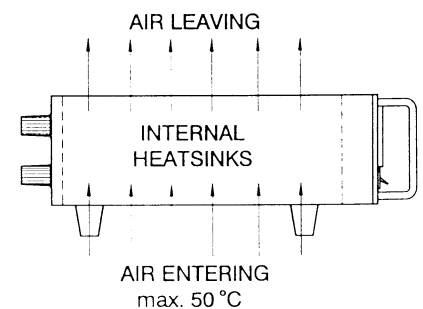


fig. 2 - 30

vertical airflow through the unit

CIRCUIT DESCRIPTION

The 220 V AC line voltage is rectified by a bridge rectifier and smoothed by a large electrolytic capacitor. The 50 Hz choke in the input circuit improves the waveform of the input, so that no low frequency distortion is produced on the line voltage.

Carefully designed RFI filters protect the line and the load from the high frequency interference produced inside the power supply.

When the unit is switched on, the electrolytic capacitor is charged via the resistor of the SOFT START circuit, so no large inrush current will flow. As soon as the voltage is sufficiently high the power supply starts working and the series resistor is bypassed by a triac.

The operating switching frequency of 100 kHz has many advantages like small size, light weight, low ripple and fast regulation.

The rectified 220 V (300 V DC) is chopped by the transistors and transformed to a lower voltage. This 100 kHz power converter is of the feed forward type. The regulation is achieved by pulse width modulation.

Careful design, over-rating of vital components, several built-in protections and cool operation (because of the very high efficiency) make the SM series very reliable power supplies which can be used continuously at maximum rating.

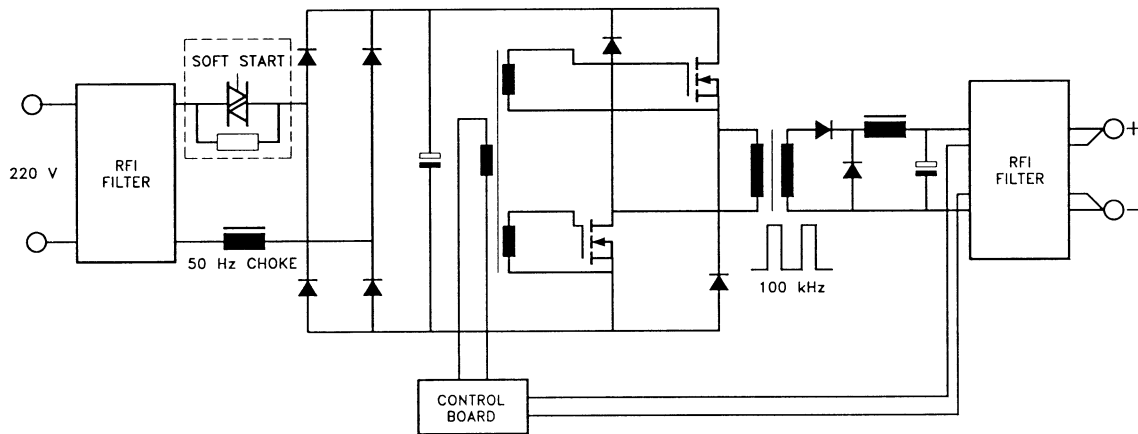


fig. 2 - 31 simplified functional diagram of SM1540-D, SM7020-D, SM3004-D

OPERATING MANUAL

1) OPERATING THE UNIT FOR THE FIRST TIME

- Set the **input voltage selector** switch found on the rear panel to the required input voltage (110/230V). A wrong setting can seriously damage the unit. Do **not** switch the selector switch when the unit is in use.
- Check input fuses. For 110 V operation fuses have to be replaced. See text at rear panel.
- Check that there is no condensation on the unit. If there is, allow some time to dry.
- Set the prog. switches on the rear panel on **MANUAL**.
- Check that there is a link between + and S+ and between – and S– on the SENSE BLOCK (on rear panel). **SM3004-D has no remote sensing!**
- Set OVP potentiometer (on front panel) to maximum (fully clockwise). Use a screwdriver to set the OVP voltage.
- With **high output current** (SM1540-D!) make sure to use low resistive connections between the power supply and the load:
 - Mount the cable lugs between the two nuts and washers.
 - Only use nuts and washers supplied with the unit (tinned brass).
 - Never use extra washers, spring washers, serrated locks etc.
- Switch on unit.
- Turn both the CV and CC potentiometer a few turns clock wise. A voltage should now be present on the output.
- By pressing the DISPLAY CV/CC SETTING button the meters will show the setting of the CV and CC potentiometer.
- By pressing the DISPLAY OVP SETTING button the volt meter will show the setting of the OVP potentiometer.
- When the power supply is used on a fixed output voltage it is highly recommended to set the Over Voltage Protector. As set out in the following table:

SM1540-D	SM7020-D range 0 - 35 V	SM7020-D range 35 - 70 V	SM3004-D range 0 - 150 V	SM3004-D range 150 - 300 V
Vout + 2V	Vout + 3V	Vout + 5V	Vout + 10V	Vout + 25V

Example: For a SM7020-D set at 24V output voltage it is recommended to set the OVP on $24 + 3 = 27V$.

- Check that the cooling of the unit is not obstructed.

2) ANALOG PROGRAMMING

- Put the appropriate switch(es) in the position **PROGRAM**.
- Connect the programming voltage source(s) (0 - 5 V) to the ANALOG PROG. CONNECTOR on the rear panel. See fig. 3 - 1 and fig. 3 - 2. Always use a **shielded cable** for programming.
- If only the voltage is programmed, the maximum current can still be set with the CC potentiometer and vice versa. If this is not desirable the CC or CV can be set with an external potentiometer, in order to have a fixed setting.
- CAUTION:** The analog inputs are not isolated from the output. The \emptyset of the prog. input (pin 1) is internally connected to the S–, the S– is connected to the negative output. To protect the internal wiring a 650 mA self-resetting fuse is connected in series (F600 on P385, P386 or P387), see fig. 3 - 4. For isolated analog programming the **ISO AMP MODULE** (δ -product) is recommended to avoid earth loops.
- To avoid hum or noise, the programming cable may have to be twisted in some cases.
- To program the unit by current instead of voltage, simply use a parallel resistor as a current to voltage converter.

3) IEEE 488 / RS232 PROGRAMMING

- With the external IEEE 488 /RS232 interface **PSC44M / PSC232** (both δ -products) simply connect the prog. connector of the power supply with the mating connector of the PSC44M / PSC232 (pin compatible). Always use a **shielded cable**.
- Set both prog. switches to the position **program**.
- Both CV and CC can be programmed and read back. The CC and OVP status can also be read by the computer.

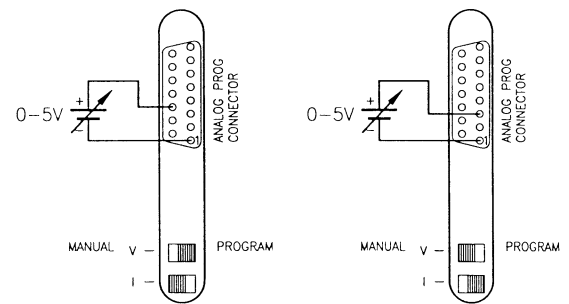


fig. 3 - 1
programming by voltage
left voltage -, right current programming

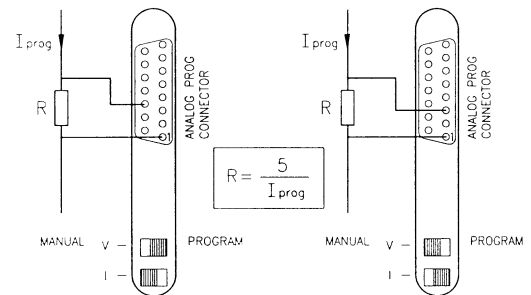


fig. 3 - 2
programming by current
left voltage -, right current programming

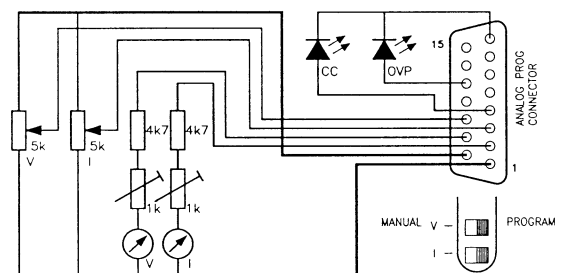


fig. 3 - 3
remote control

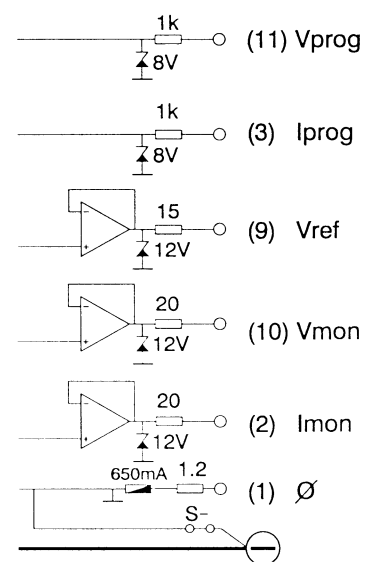


fig. 3 - 4
internal circuit of programming inputs and outputs

4) **MONITORING OUTPUTS**

- The 5 V level is compatible with most interfaces.
- The monitoring outputs can drive a meter directly, fig. 3 - 3.

5) **STATUS OUTPUTS**

- The status outputs have a separate Ø connection (pin 8) to avoid unwanted offsets in the programming. This pin is protected with a 650 mA fuse (F601 on P385, P386 or P387).

6) **REMOTE SENSING**

- Not available on SM3004-D.
- Remove the links on the SENSE BLOCK (on rear panel) and connect sense leads (thin **shielded** measuring wires) to S+ and S-. See fig 3 - 5 and fig. 3 - 6.
- With remote sensing the voltage on the load can be kept constant. The voltage drop in the load leads will be compensated. This feature is not recommended for normal use, because it can easily give problems.
- Max. 2 V per load lead can be compensated. Note that the voltage drop in the leads decreases the max. output voltage rating. In fig. 3 - 7 it can be seen that on a 15V power supply only 11V will be available on the load when 2x 2V compensation is used.
- In order to prevent interference it is advisable to twist the sense leads. To minimise the inductance in the load leads keep the leads close to each other. The inductance of the loads leads could give a problem with pulsating loads. In this case a large electrolytic capacitor in parallel with the load will help. Check that the capacitor in combination with the load leads does not form a resonant circuit resulting in a large AC current flowing in the leads.
- Since the **voltmeter** is internally connected to the sensing terminals, it will automatically indicate the **voltage on the load**. Note that the voltage measured on the load will be lower than on the output terminals.
- The Over Voltage Protector measures the voltage on the output terminals, so the OVP setting should be increased by the total voltage drop in the load leads.

7) **BATTERY CHARGER**

- The CV / CC regulated power supplies are ideal battery chargers. Once the output is set at the correct voltage the battery will charge constantly without overcharging. This can be useful for emergency power systems.

◦ **Protective measures**

Use a CIRCUIT-BREAKER in series in order to protect the power supply from **accidental reverse connection**, see fig. 3 - 8. The circuit-breaker should have a DC voltage rating 2x the battery voltage. Use the very fast type (Z), a type meant for protecting semiconductors.

The unit has a reverse diode in parallel with the output, this diode and the wiring cannot withstand the thousands of amperes supplied by a wrongly connected battery.

Suggested Circuit Breakers for protection power supply			
Model	Type number Circuit Breaker	Brand	Remarks
SM1540-D	S281 UC-Z 40	ABB	
SM7020-D	S281 UC-Z 20	ABB	extra parallel diode on output =OPTION P021
SM3004-D	S282 UC-Z 4	ABB	2 poles in series, extra parallel diode on output =OPTION P022

- **Remote sensing** cannot be recommended, because it easily causes defects inside the power supply in case of wrong connection. If you really need remote sensing, please use the circuit in fig. 3 - 9 . The internal circuit can be protected by relatively small

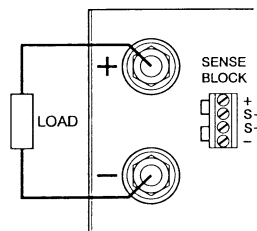


fig. 3 - 5
local sensing

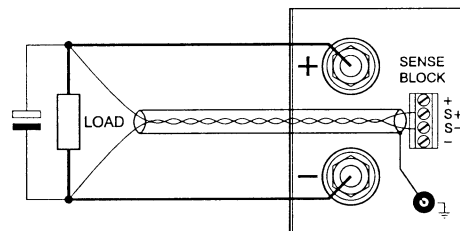


fig. 3 - 6
remote sensing with shielded wires

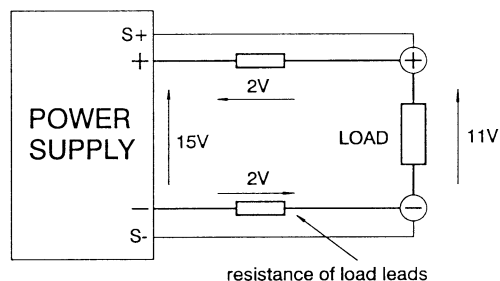


fig. 3 - 7
remote sensing, voltage drop in load leads subtracts from max. output

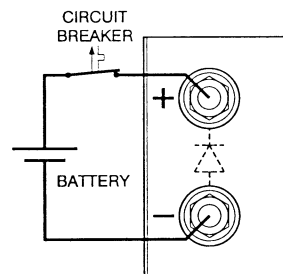


fig. 3 - 8
charging battery with a circuit-breaker in series

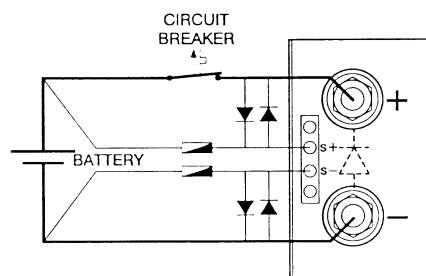


fig. 3 - 9
protecting sense wires with diodes

anti-parallel diodes. To protect the anti-parallel diodes, please connect the fuses in series as indicated in fig. 3 - 9 . A practical choice for the fuses is 250mA, the diodes can be any normal 3 or 5A type.

- Note: The **SM7020-D** and **SM3004-D** need an extra parallel diode on the output, without this diode the internal diode will still blow. The diode should have a surge current rating of resp. 2000 and 3000 amps during 1msec ($I_{FSM} = 2000 / 3000$ A). For the SM7020-D 2x BYT52PI200 and for the SM3004-D 2x BYT261PIV400 from ST will work. The SM7020-D with option P021 and the SM3004-D with option P022 have an extra diode built-in.

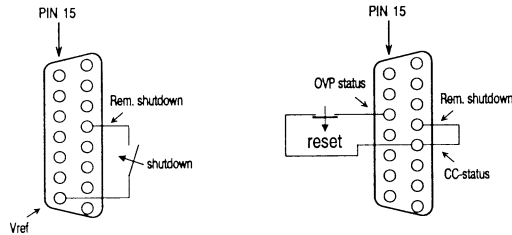


fig. 3 - 10

left: remote shutdown with switch,
right: Over Current Trip

8) REMOTE SHUTDOWN / OVER CURRENT TRIP

- The remote shutdown can be operated with +5V or a relay contact, fig. 3 - 10.
- Using the remote shutdown input, an **Over Current Trip** could be made., fig. 3 - 10.

9) MASTER / SLAVE SERIES OPERATION

- For series operation the **MASTER / SLAVE SERIES ADAPTER** (δ -product) is recommended. The advantage is that the masters position can be the upper or the lower unit (in particular for higher voltages, e.g. 150V and 300V). Other advantages are the fast and easy way of connecting.
- First, connect output terminals and test system in **normal series** operation. Ensure that all (output) power connections are reliable. An interruption of one of the power leads can cause a fuse to blow in the unit, see "trouble shooting".
- The voltage drop in the connecting leads between the units should be kept < 10 mV.
- Second, switch off all units. When using the **M / S SERIES ADAPTER** connect units as shown in fig. 3 - 11. Use standard 15 pole (1:1) **shielded cables**. Without the ADAPTER, plug in prog. connectors with the connections according to fig. 3 - 12. Both prog. switches of the slaves should be in the position **PROGRAM**. Always use **shielded cables**. The shielding must be connected to the case of the supply.
- Do not forget the jumper on the slaves between pin 3 and pin 9 of the prog. connector. This jumper sets the current limit of the slaves at maximum.
- The max. number of slaves is only limited by the max. total voltage of 600 V.
- The **AUTORANGING** feature still works.
- WARNING when not using the M / S SERIES ADAPTER:** the master must always be on the positive (=upper) side of the combination. Wrong connection can damage the power supplies.

10) MASTER / SLAVE PARALLEL OPERATION

- Note: Master / Slave parallel is not recommended for more than 4 units, consult factory for using more than 4 power supplies in parallel.**
- First connect output terminals and test system in **normal parallel** operation. Ensure that all power connections are reliable. An interruption of one of the (output) power leads can cause a fuse to blow in the unit, see "trouble shooting".

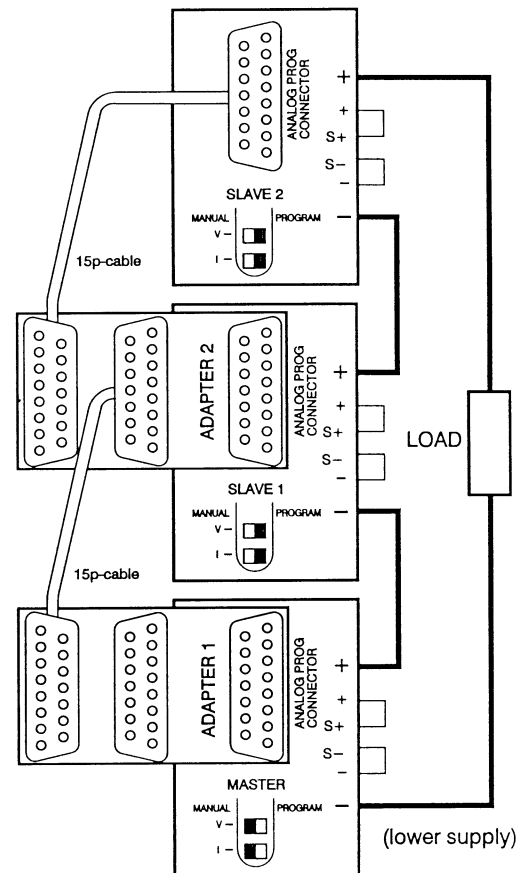


fig. 3 - 11

master slave series connection with
two **M / S SERIES ADAPTERS**

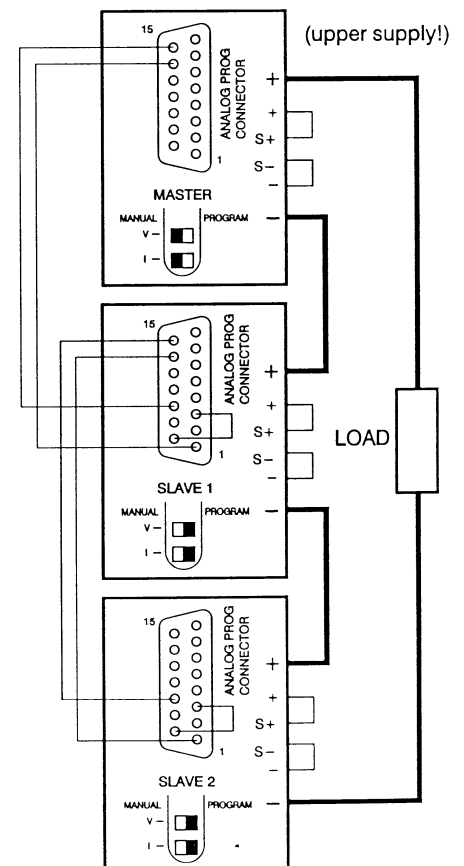


fig. 3 - 12

master slave series connection

- Second, switch off all units. Plug in prog. connectors with the connections according to fig. 3 - 13 (buss bar topology). Always use a **shielded cable**. The shielding must be connected to the case of the supply.
Disconnect the links between the S- and - of the slaves **only**. If not removed the current sharing will not be proportional.
Both prog. switches of the slaves should be in the position PROGRAM.
- The purpose of the link between pin 9 and 11 is to set the voltage limit of the slaves at maximum.
- an extra link on the slaves (between pin 6 and 8) is needed for the AUTORANGING feature.
- Keep the load close to the master. Keep wiring between master and slaves short. The voltage drop between a unit and the buss bar should be kept < 10mV.
- Accidental interruption of a negative load lead of a unit during operation will cause fuse F600 to blow, see section 'trouble shooting'.
- The S- and S+ could be connected to the load if desired, but this is not recommended because of the complexity.

12) **MASTER / SLAVE MIXED SERIES / PARALLEL OPERATION**

- For complex combinations as mixed series - parallel always use the **MASTER / SLAVE SERIES ADAPTER** (δ -product).
- See fig. 3 - 14 for an example of how to connect 2 units in series in parallel with 2 units in series, controlled by 1 master.
- Note: A Master / Slave combination can always be programmed, also with the **IEEE488 / RS232 controller (PSC 44M / PSC232 (both δ -products))**.

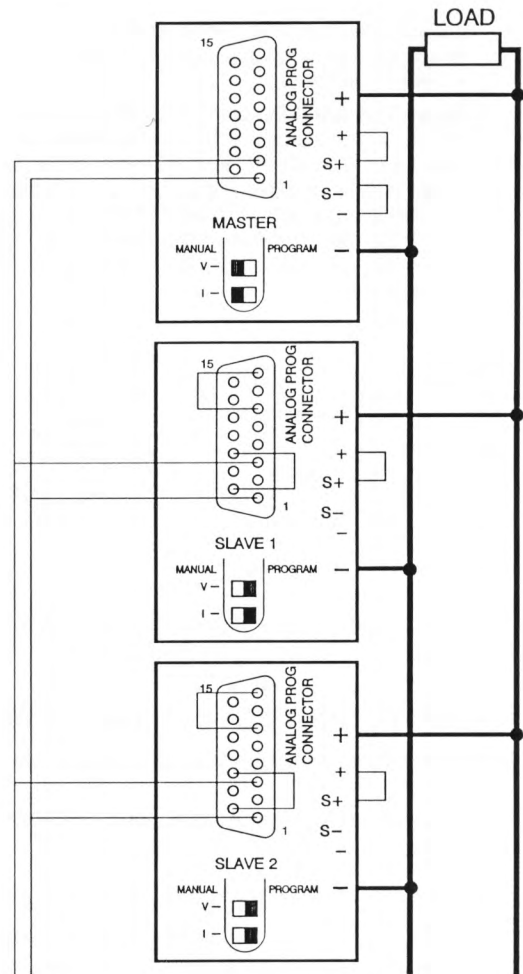


fig. 3 - 13
master slave parallel connections

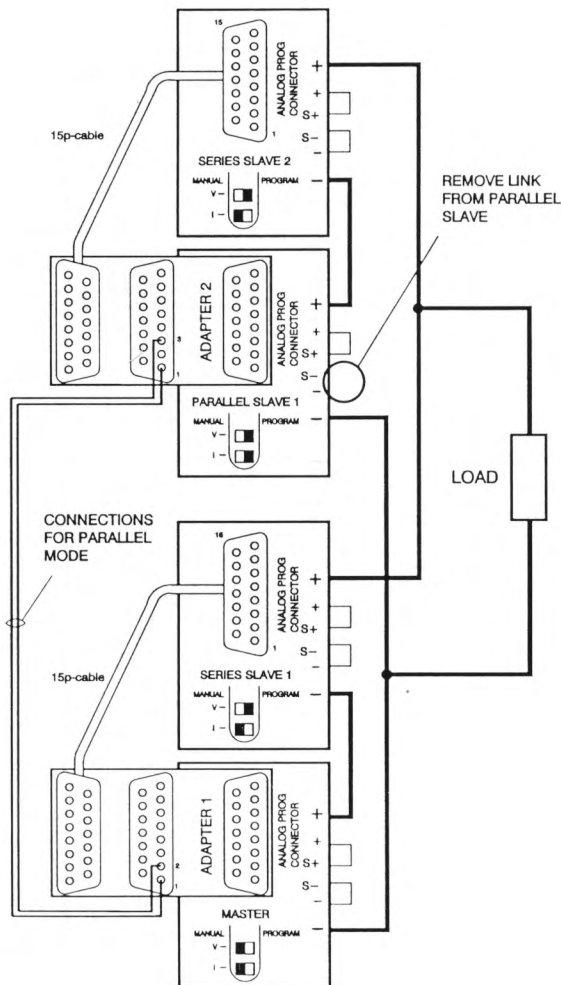


fig. 3 - 14
master slave mixed series - parallel connections with
two M / S SERIES ADAPTERS

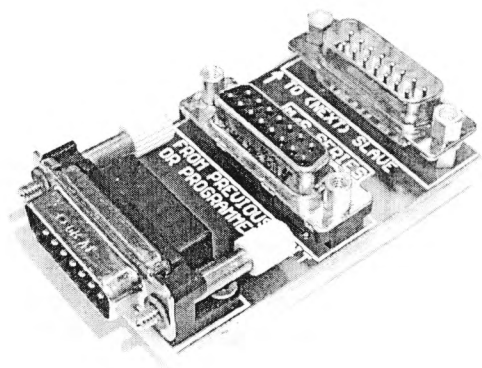


fig 3 - 15
The Master / Slave Series Adapter

OPERATING AND STORAGE CONDITIONS

1) TEMPERATURE

- The operating temperature range at full load is -20 to +50 °C. But this temperature range only holds when the perforated bottom and cover are unobstructed and the temperature of the air entering is not higher than +50 °C. See fig. 3 - 16.
- **Please note: a lower temperature extends the life of the power supply.**
- When the power supply is **mounted in a cabinet** please note that the temperature of the air entering should be kept low. Also avoid a short circuit in the airflow i.e. hot air leaving the perforated cover entering the bottom again.
- The storage temperature range is -40 to +85 °C.

2) HUMIDITY

- During normal operation humidity will not harm the power supply, provided the air is not aggressive. The heat normally produced in the power supply will keep it dry.
- **Condensation.** Avoid condensation inside the power supply, break-down could be the result. Condensation can occur during a period the power supply is switched off (or operating at no load) and the ambient temperature is decreasing . Always allow the power supply to dry before switching it on again.

3) GALVANIC INDUSTRY

- For using the power supplies in the galvanic industry it is strongly recommended to take precautions against an aggressive environment.
- An aggressive environment with acid, salt, etc. can harm the electronic components. Sometimes even the copper traces of the pc-boards dissolve.
- To avoid problems the power supplies should be mounted in a relative clean room, or mounted in a cabinet receiving clean air with over pressure. Or a cabinet with a heat exchanger.

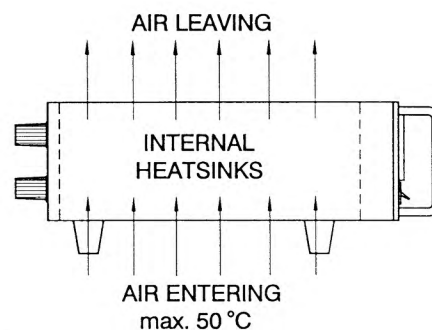


fig. 3 - 16

leave enough space below and above the unit
to let the air flow through it.

MAINTENANCE

1) GENERAL

- The SM-series power supplies normally need no maintenance or calibration. Only care must be taken that the cooling of the unit is not obstructed.

TROUBLE SHOOTING

1) GENERAL

- In case you need assistance for repairing the unit, please first fill in the Problem Report (also in this manual) and fax it to us.

2) NO OUTPUT (normal operation)

- Check input voltage selector at rear panel. Wrong selection can cause serious damage to the unit. Do not operate the selector switch when the unit is switched on.
- Check input fuses. For 11 V operation fuses have to be replaced. See text at rear panel for values.
- Check position of prog. switches at the rear panel, they should be on MANUAL.
- Check the connections on the SENSE BLOCK (at rear panel), there should be a link between + and S+ and between - and S-.
- Set OVP potentiometer (at front panel) at maximum (fully clock wise).
- Switch on unit.
- Turn both the CV and CC potentiometer a few turns clock-wise. A voltage should be present on the output.

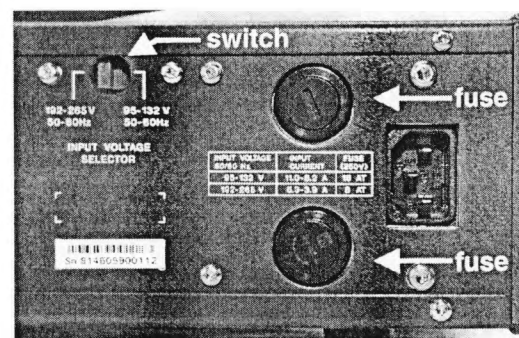


fig 3 - 17

Location of the input Selector Switch and
the input fuses at the rear panel

3) **PROGRAMMING DOES NOT WORK OK**

- Check position of prog. switches at rear panel.
- **The unit works OK in manual control**, but in programming mode the output voltage / current has a large error.

Probably the fuse in series with Ø (pin 1) of prog. connector tripped, the fuse (F600 = 650 mA) is a self-resetting type. See fig.3 - 18.

- To check the fuse (F600) measure the voltage between Ø and the minus output, during the fault condition. The voltage should only be a few mV, a high voltage means that an unwanted current is flowing through pin 1 of the prog. connector. Please check why current is flowing through pin 1, see also next paragraph 'programming offsets' and fig.3 - 19.



fig. 3 - 18 location of programming fuses on output board P385, P386 or P387.

4) **PROGRAMMING OFFSETS**

- **Unwanted offsets in the programming can be caused by earth loops.**

Fig. 3 - 19 shows a typical earthing problem. In case the load has a connection to earth and the programming source as well, problems could occur. Improper choice of the earthing point of the load can give a voltage drop of $\Delta V1$. Connecting the minus or zero to a separate earth connection can give a voltage drop of $\Delta V2$. Because the internal wires of the programming input are thin, the voltage drops $\Delta V1$ and $\Delta V2$ will be across the internal wiring as well. Resulting in a error voltage in series with the programming voltage.

- The best **solution** for this is using a floating programming source with the help of the **ISO AMP MODULE** (δ -product) or a floating load.

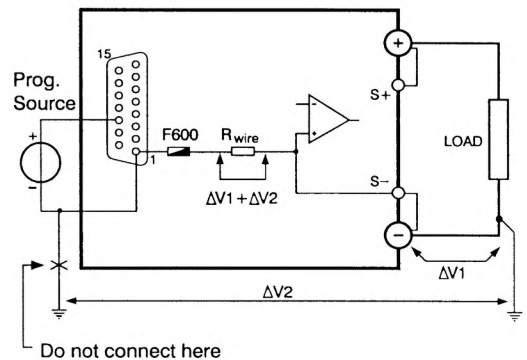


fig. 3 - 19 unwanted programming offsets

5) **STATUS OUTPUTS FAIL**

- Check fuse F601 in series with Ø (pin 8), see fig. 3 - 18. To check the fuse (F601) measure the resistance between Ø and the minus output, an open circuit means a blown fuse. F601 = 650 mA.

6) **MASTER / SLAVE PARALLEL PROBLEMS**

- Accidental interruption of a minus lead of a unit during operation will cause fuse F600 to blow. See fig. 3 - 18. To check the fuse (F600) measure the resistance between Ø (pin 1 of prog. conn.) and the minus output, the fuse is a self resetting type. F600 = 650 mA
- **AUTORANGING** behaves abnormally. Check link between pin 6 and 8 on the prog. connector of the **slaves**.
- Check link between pin 9 and 11 on the prog. connector of the **slaves**
- Current sharing is not ok. Probably the links between S- and - of the **slaves** are not removed.

7) **OUTPUT VOLTAGE IS HIGHER THAN SET VALUE**

- Check connections on **SENSE BLOCK** (on rear panel), For normal operation there should be a link between + and S+ and between - and S-. See also fig. 3 - 20. When remote sensing is used, check the wires of the sensing.

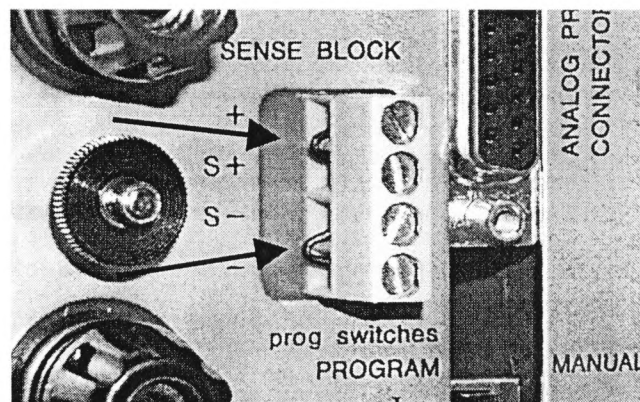


fig. 3 - 20 for normal operation links should be connected between S+ and + and between S- and -

8) **OVP LED burns.**

- Check OVP setting.
- Overheating also causes the OVP led to burn (see fig 3 - 22), cooling down will reset the thermal protection.
- You are using Remote Sensing. Even a short voltage pulse >3V between – and S – causes the OVP circuit to limit the output voltage.
- Remote Shutdown voltage is applied to the prog. connector.

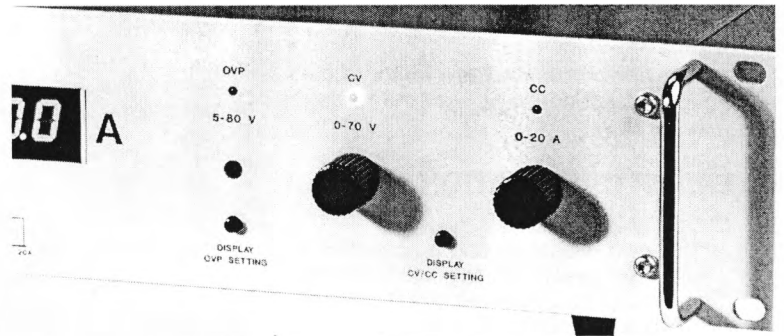
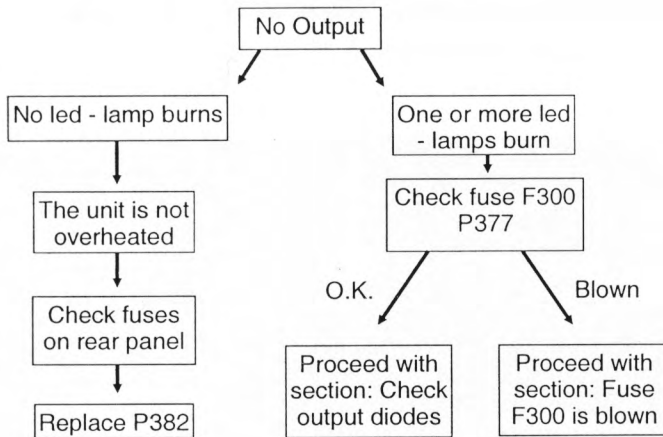


fig 3 - 22 Location of OVP, CV and CC LED's

9) **NO LEDS burn.**

- Overheating can be the cause, cooling down will reset the thermal protection.
- Check input power and input fuses (on rear panel)

10) **CHECK POINTS IN CASE OF A SERIOUS FAILURE**



- Check output diodes. Defective diodes give a short.
 SM1540-D Check diodes D400 - D403
 SM7020-D Check diodes D400 and D402 on P380
 SM3004-D Check diodes D400 - D404, D410 - D414, D420 - D424, D440 - D434 on P381
 Replace defective parts.
- Fuse F300 is blown. Do not replace F300 until unit is repaired. Probably defect on P378. First check output diodes, see above.
- Repairing P378. Check diodes D301 - D308, check transistors Q300 - Q303. When defective they usually give a short. Replace defective components.
- If necessary, send P378 for repair.

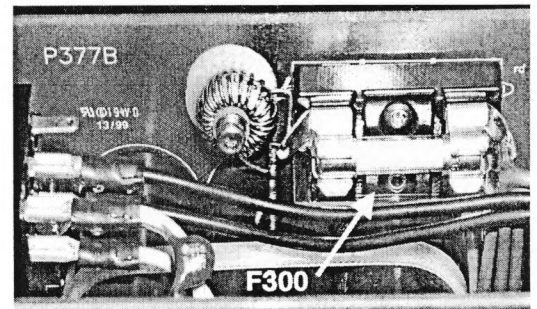


fig. 3 - 21 Location of F300 on P377

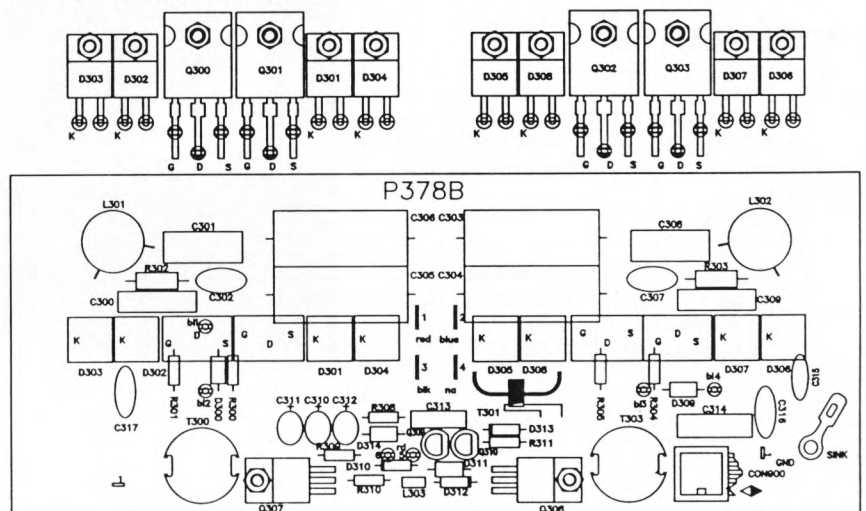


fig 3 - 23 P378: indicated are the polarity of the diodes (K) and the FET's (G/D/S)

CALIBRATION

1) GENERAL

- The power supplies are factory calibrated and normally need no further calibration.

2) METER CALIBRATION

- **DIGITAL METERS**
The zero indication can be calibrated with R712 and R716, the full scale indication can be calibrated with R706 and R708 on P388 (fig. 3 - 24).

3) SPECIAL CALIBRATIONS

- The following calibrations must be done by qualified personnel only. Wrong calibration causes malfunction. These calibrations are only needed after special repairs.
Warning ! Damage caused by wrong calibration is not warranted.

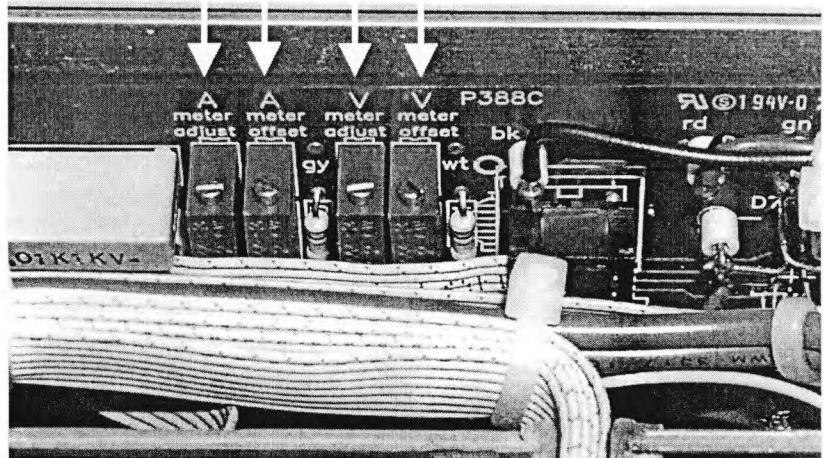


fig. 3 - 24 Meter calibration with 25-turn potmeters on P388

- **CALIBRATING MAX. CURRENT RANGE or CALIBRATING CC MONITOR FULL SCALE.**

The max. output current can be calibrated with R686. R686 is located on P385, P386 or P387. See fig. 3 - 25. Program CC input with exactly 5.00 V. Set output voltage to a low value, ensuring the power supply is in CC mode. Measure the output current with an accurate shunt. Calibrate the current with R686 exactly on the rated max. current.

Warning! Wrong calibration can damage the unit.

- **CALIBRATING THE CC MONITOR OFFSET.**

With R652 on P384 the offset of the CC monitor voltage can be calibrated. See fig. 3 - 26. The unit has to be unloaded, the output voltage set on a low value. Measure the offset voltage of the CC monitor on the prog. connector. Calibrate the offset on a negative value between -10 mV and zero mV.

Warning! wrong calibration can damage the unit.

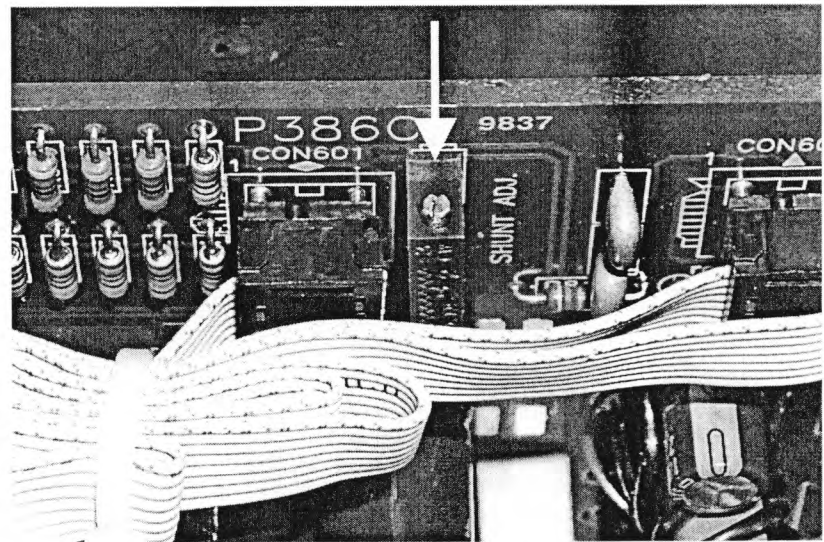


fig 3 - 25 calibrating max current P385, P386 or P387

SPARE PARTS

- When ordering spare parts please state: Model, Serial number, Component number and Component description.
example:

ModelSM7020-D
Serial no.....814605900112
Component no.D402
Component descr..BYV52-PI-200

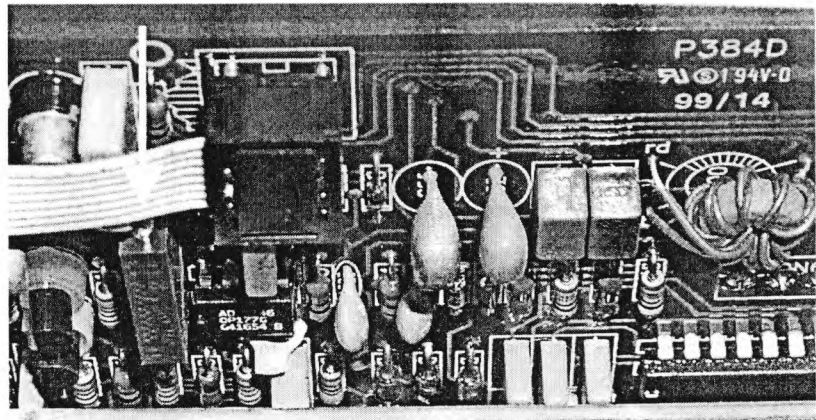


fig. 3 - 26 After lifting P384, CC monitor can be calibrated

DELTA ELEKTRONIKA BV



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From:

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PROBLEM REPORT

Type number

Serial number

Date

CONDITIONS BEFORE OR DURING FAULT	
Output voltage, Output current	
Ambient temperature, Input voltage	
Programming used, Remote sense used	
Master / Slave used (parallel or series mode)	
Setting of Prog. Switches and setpoint of OVP	

FAULT DESCRIPTION	
Output voltage present	
Max. Output power available	
Problem continuous or intermitten	
Which LED-lamps are burning, which are not	
+12 V on programming connector present	

Remarks:

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