Title:

Technical Manual for
POW -728, -729, -730, and -732
Powersupplies for RC Computers.

A/S REGNECENTRALEN

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Powermodules.

Abstract:

This manual contains applicable information about the improved CHS 7XX-8XX powersupply.

CONTENTS PAGE

1. GENERAL DESCRIPTION. 1.

The powersupply set POW 728 with POW -729 -732 are technical improvements and redesigns of, and intended for replacements for the previous powersystem used for powering the CHS 701-702 - CHS 801-802 chassis.

The design-philosophy used in the previous line is largely adopted for this line. A certain degree of compatibility is maintained allowing intermix of old and new powermodules to some extent.

The improvements compared to the old types are as follows:

a. Enabling remote voltage sensing, reducing generator impedance at the load.

b. Centralizing of voltage reference, creating a simple voltage adjustment procedure and a voltage definition independent of the component characteristics in the powerconverter modules.

c. Improvements in the powermodule performance i.e. higher output power and higher efficiency.

d. Improvements in the load characteristics make parallel connection of more generators of the same type easier.

e. Improvements in the power-up and -down procedures and voltage supervision.

f. Reducing the RF noise generated by the switch mode power supply.

g. By increasing the power reservoir the sensitivity to short line transients (missing half waves) is reduced.

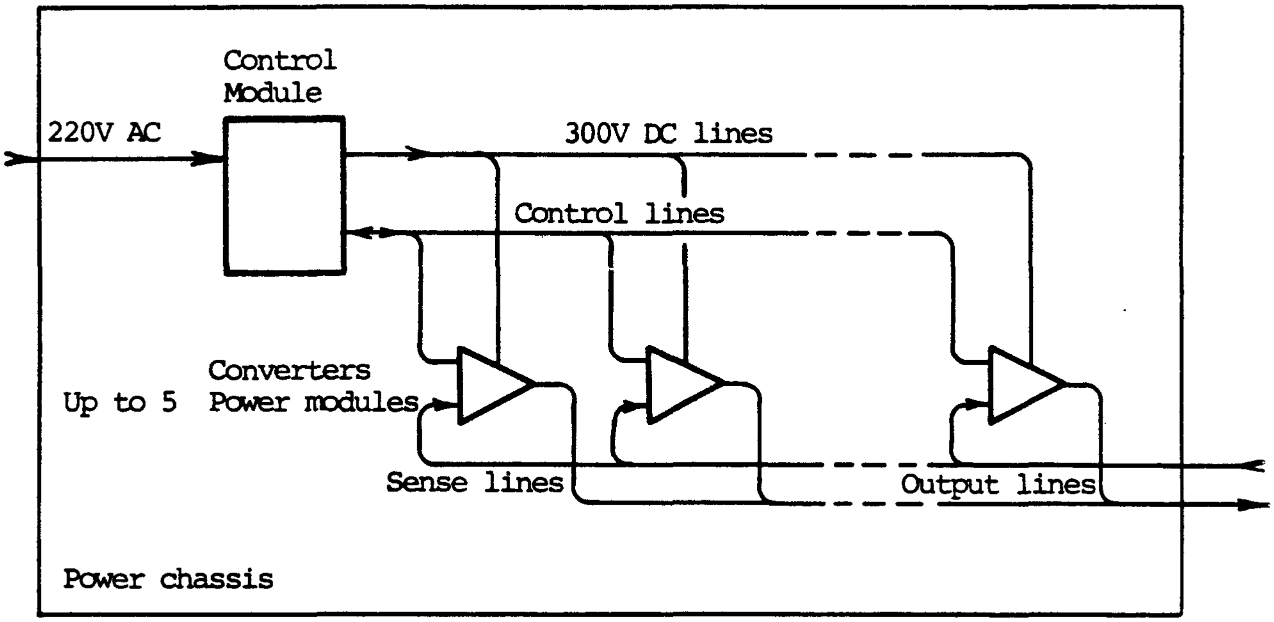


Fig. 1. Energyflow.

As the old, the new system includes a Powerchassis with a common "Control Module" and up to five "Power Modules".

The Powerchassis provides interconnection between mains, powermodules and load. Also the powercabinet provides enough forced air-cooling to ensure reliable operation at the worst allowed ambient climatical conditions.

The Control Module POW 728 contains mains fullwave rectifying and energystore containing a usable energy at nominal mains voltage (220V AC) of 16 joule from the last mains voltage peak (310V). This is enough to ensure the insensitivity to one missing half-wave at full load (600 W input) and low mains voltage (210V). It is also enough to ensure maintenance of output voltage appr. 2 msecs. after powerinterrupt at full load.

The Control Module also contains the following functions:

a. Voltage reference.

b. 20 KHz clockgenerator for syncronizing the powermodules to eliminate audible beatfrequencies.

c. A soft start-up circuit which assures a long risetime for the referencevoltage during power up and thereby a corresponding slow rise of the output voltages. This precaution limits the current resultant from charging the load capacitors.

d. Power survey circuits, which upon powerfailure generates a Power INTerrupt signal, which may indicate to the running software that it should prepare for shutdown, and appr. 2 milliseconds later drop the Power OK signal, thereby resetting the connected hardware.
Also the circuit ensures that input voltage and all outputvoltages are inside specified tolerances before the "POK" signal is set and that appr. 2 milliseconds elapse from "POK" until the "PINT" signal is dropped. A visual indicator is provided which is turned on by any "PINT" and off by a manual "reset" switch accessible through the backcover of the powerchassis.

The Power Module is a DC to DC switched-mode converter of the flyback type. Through almost all the load characteristics it operates as a "ringing choke" converter, this elliminates regulation difficulties around the change in regulation mode.

The powermodules regulate the output voltage to maintain a voltage on the sense lines having a fixed ratio to the reference voltage. This ratio is defined by precision resistors. The reference voltage defines the local value of "5 Volt", so the POW 730 maintains a voltage equal to -18/5 x Uref rather than -18Volt. The voltage regulation is active in the load interval 0 to 100 Watts. Above that value the module enters the high impedance (0,25 - 3 Ohm) region, limiting the output current.

2. SPECIFICATION.

POW 728 Common control module.

		min.	nom.	max.	unit
Mains	frequency	45	50	66	Hz
requirements:	Voltage	198	220	242	Volt RMS
	Voltage	280	311	342	Volt peak

Performance:

Rectification: Full wave

300V DC at 600 Watt input:

		min.	nom.	max.	unit
	Voltage	$U_{peak}-32$		$U_{peak}-2$	Volt
	Ripple			30	Volt peak to peak

300V DC level activating "PINT"

		min.	nom.	max.	unit
	Upint	213		235	Volt
Delay from PINT to ¬POK		1.5			msec.
Delay from POK to ¬PINT		1.5			msec.
Clock	frequency	18	20	22	KHz
Uref:	adjust-ability:	4.75	5	5.25	Volt
	Stability:			1	%

All Power modules.

	min.	nom.	max.	unit
Ambient temperature	15		50	^oC
300V DC operating	200	310	350	Volt
Input power			125	Watt
Output power		100		Watt
Output regulation measured at sense lines	Uout-1%	Uout	Uout+1%	

POW729 +5 Volt module.

			min.	nom.	max.	Unit
Uout	(Iout < 20A)			Uref		
Rout	(Iout > 20A)			0.25		OHM
Voltage ok:		Uout >	4.65	4.70	4.75	Volt (high going)
			4.50	4.60	4.70	Volt (low going)
Ripple	(f < 1MHz)				250	mV
Ripple + HF-noise					500	mV

POW 730 -18 Volt module.

			min.	nom.	max.	Unit
Uout	(Iout < 5.5A)			-3.6xUref		
Rout	(Iout > 5.5A)			3		OHM
Voltage ok:		Uout <	-17.5	-16.9	-16.3	Volt (low going)
			-17.2	-16.5	-15.8	Volt (high going)
Ripple	(f < 1MHz)				150	mV
Ripple + HF-noise					500	mV

POW 731 +12 Volt module.

			min.	nom.	max.	Unit
Uout	(Iout < 8.5A)			2.4xUref		
Rout	(Iout > 8.5A)			1.4		OHM
Voltage ok:		Uout >	11.0	11.3	11.6	Volt (high going)
			10.5	11.0	11.4	Volt (low going)
Ripple	(f < 1MHz)				200	mV
Ripple + HF-noise					500	mV

POW 732 -12 Volt module.

			min.	nom.	max.	Unit
Uout	(Iout < 8.5A)			-2.4xUref		
Rout	(Iout > 8.5A)			1.4		OHM
Voltage ok:		Uout <	-11.7	-11.3	-10.9	Volt (low going)
			-11.4	-10.9	-10.4	Volt (high going)
Ripple	(f < 1MHz)				200	mV
Ripple + HF-noise					500	mV

3. PRINCIPLES OF OPERATION.

In this chapter the three major parts are discussed in details.

3.1. Control Module.

The control module has three tasks to satisfy:

a. Providing 300V DC primary power.

b. Providing servicepower and signals.

c. Providing system control and survey.

correspondingly three seperate electrical circuits are found on the control module board.

3.1.1. Line Rectifying and Energy Store.

This circuit consists of a Graez rectifier bridge, connected directly to the line voltage (220V AC) through a small resistor. The rectifier charges the energystore which is composed of six 100 microfarad electrolytical capacitors. From these capacitors the primary power for the converters are taken.
The energystore contains a usable energy of

$$E = \frac{1}{2}C(U_1^2 - U_2^2)\ [\text{joule}]$$

Where C is the capacity (600 microfarad).
U_1 is the initial voltage, and U_2 is the lower limit of primary voltage for the converters to operate (200 Volt)
Assuming U_1 = 310Volt this gives

$$E = \frac{1}{2}\cdot 600\cdot 10^{-6}(310^2-200^2)\ \text{Joule} = 16{,}8\ \text{Joule}$$

with a load of 600 W, the maximum time of operation from the last 310 Volt peak is

16,8 Joule/600W = 28 msec.

WARNING:	The large energy at high voltage represents a potential danger for deadly electrical chock.

The energy store is constantly discharged through 50 K ohm. This ensures that the primary voltage has descended to an undangerous value U_t=48 Volt from the highest initial value U_0=350V and without any load at the time t after power has been removed:

$$t = R \cdot C \cdot Ln(U_0/U_t) = \underline{60 \text{ secs.}}$$

> NOTE: After having turned off power, wait 1 minute before touching any interior part of the power system.

3.1.2. Service Power and Signalsource. 3.1.2.

Service power is obtained via a 12 Veff Line transformer, a double rectifier and filter capacitor and provides a 16 Volt unregulated DC source capable of supplying 200 mAmps.

One signal line for use in the converters originates in the controle module. This line (the clock-line) carries three signals to the converters.

1. Converter switching frequency,
2. maximum converter dutycycle and
3. reference voltage.

The voltage on this line is a square wave alternating between appr. 0V and appr. 11 Volt.

All converters syncronize to the frequency of this square wave.

The dutycycle of this signal indicates to the converters the maximum dutycycle of output transistor conduction, that is conduction of the output transistor is inhibited during the low-time of the clockline. This is used for soft start up, as the dutycycle at power up is increased slowly from zero to nominal. The average voltage measured over one entire cycle is the reference voltage. All the converters regulate their output to maintain the corresponding senseline voltage at a specific relation (ratio) to this reference voltage.

The reference voltage is derived over an adjustable voltage divider as a fraction of the output of an integrated 12 volt regulator.

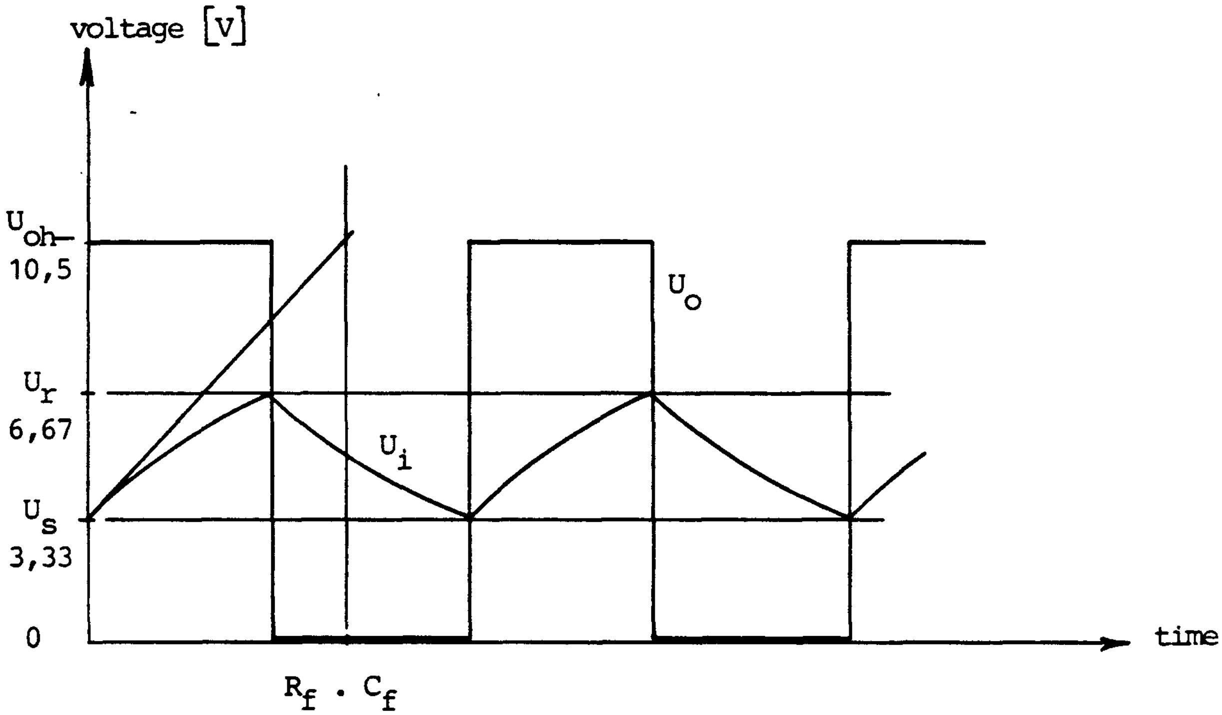


Fig. 2.

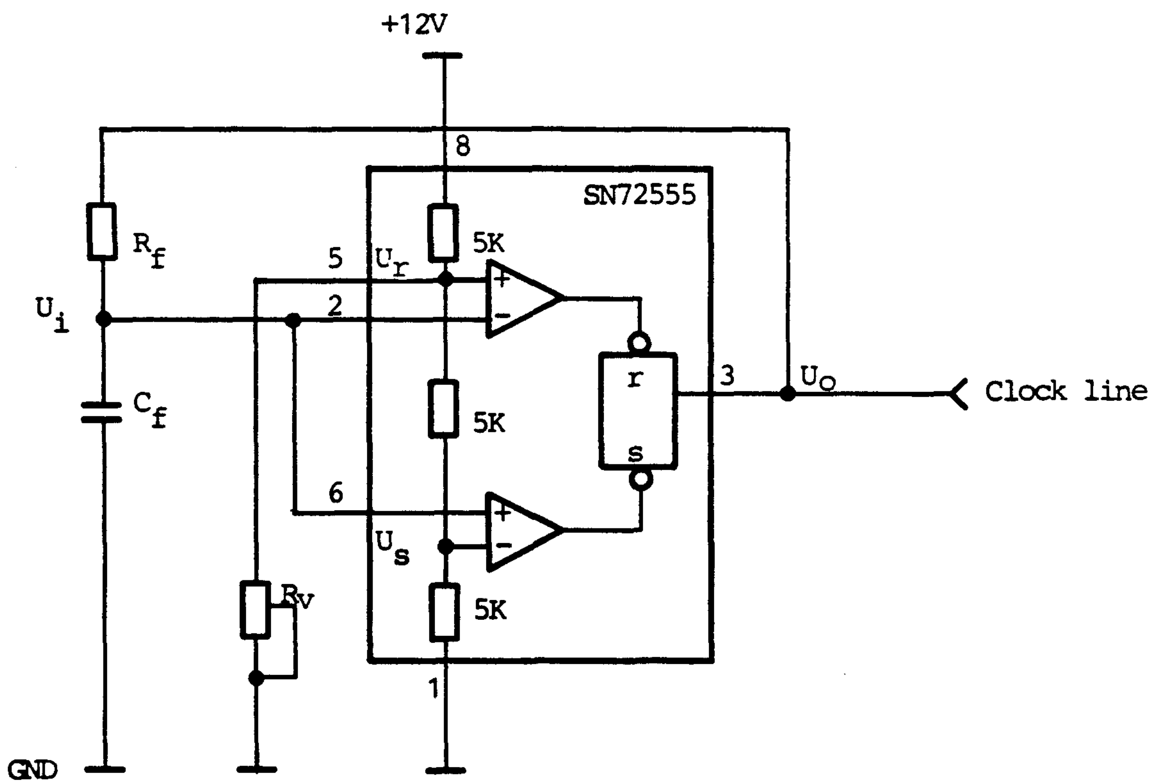


Fig. 3.

The clock signal generator is in principle composed of a timer of type 72555, an integrator R_f C_f and a voltage adjust resistor R_v as shown on figure 3.

The 72555 contains a flipflop and two voltage comparators, one sets the flipflop when U_i is lower than U_s, and the other clears it when U_i is higher than U_r. Also contained are the three 5Kohm resistors which together with R_v define U_r and U_s in relation to 12 volt stabilized. The waveforms generated from this circuit are shown on figure 2.

It can be shown that for constant 12 volt, the average value of U_o is very independent of the U_o high and low levels.

During start up, the control circuit controls the dutycycle of the clock-linesignal by clamping the voltage U_r low (This of course affects the reference voltage).

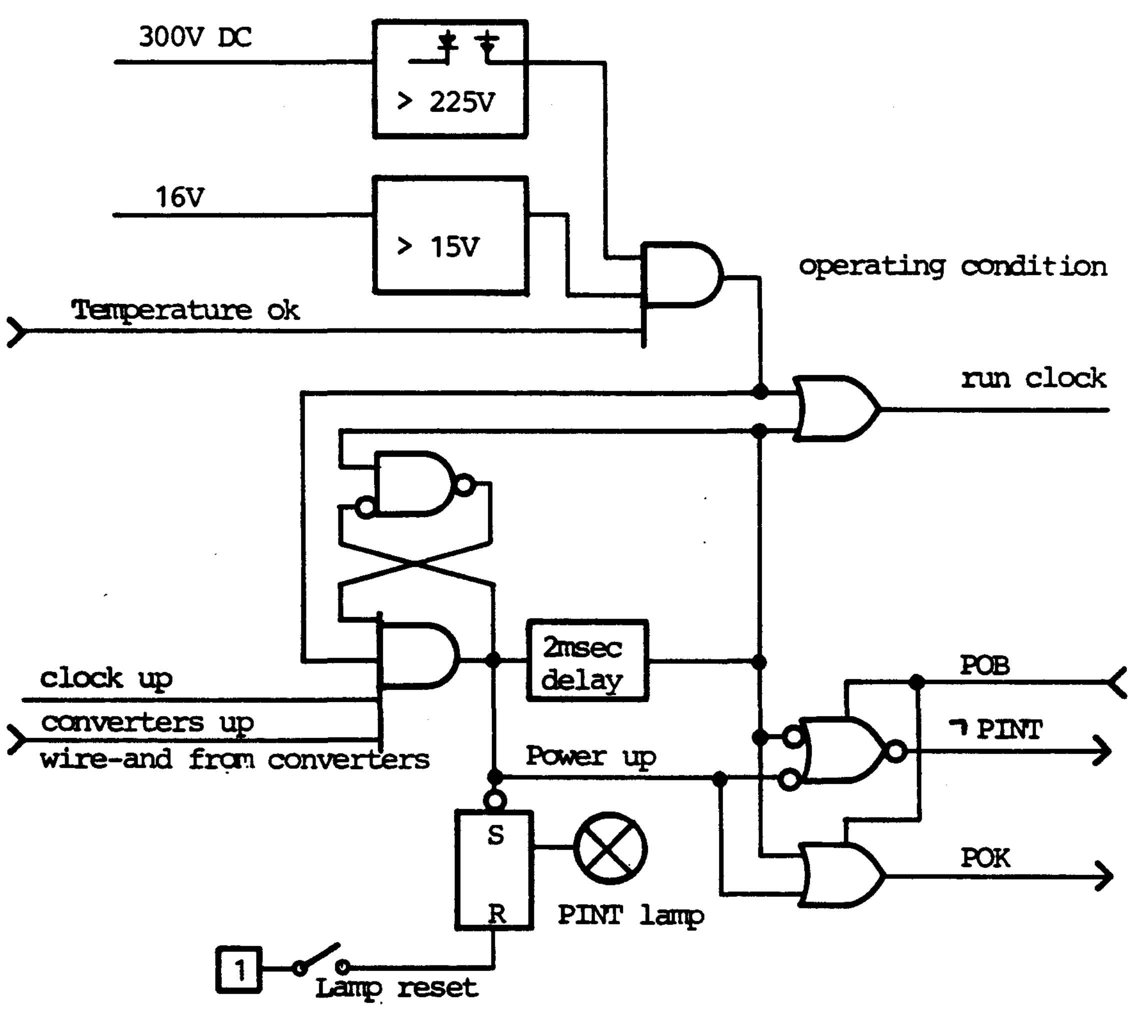


Fig. 4. Logic operation of control circuit.

3.1.3. Control Circuit.

The control circuit performs the following functions:

1. Primary - and service-power supervision.
2. Generation of PINT and POK signals.
3. Power-up and -down control.
4. Visual indication of PINT.

The primary power supervisor is constituted of a level detector indicating whether the primary power voltage is higher or lower than 225 Volts ± 5%. The result is signalled through an optocoupler (current zero or greater than 1mA). This signal is anded to the result of the service power voltage measurement and the value from the "Temperature OK" input from Powerchassis to give an "operating condition" signal. See figure 4. "Operating condition" or "Power up delayed" conditions the clockgenerator:
When both are low, the clock is stopped immediately, when one of them (always operation condition) rises, the clock generator will start with slowly rising durycycle. When clock-dutycycle is on nominal, the "clock up" signal will become true.
When all connected converters are satisfied with their sensed voltages, the "converters up" signal rises allowing "power up" to rise (because "power up delayed" is still false, "power up" is not latched low). "Power up" allows POK. Approximately 2 milliseconds later the "power up delayed" becomes true, the power interrupt is free to fall (-, PINT to rise), and the PINT lamp may be manually turned off. If power fails (or the chassis overheats), the "power-up" alls and is latched low, power interrupt is set as well as the "PINT lamp" is turned om.

Two milliseconds later the power up delayed falls, releasing the power up latch but dropping the POK signal and stopping the oscillator, provided that the alert was not caused by a secondary overload or a converter burnout.

3.2. Converters. 3.2.

The power converters provide the following functions:

1. Power transformation and galvanic separation
2. Voltageregulation
3. Overload protection (current limiting)
4. Voltage checkout

3.2.1. Powertransformation. 3.2.1.

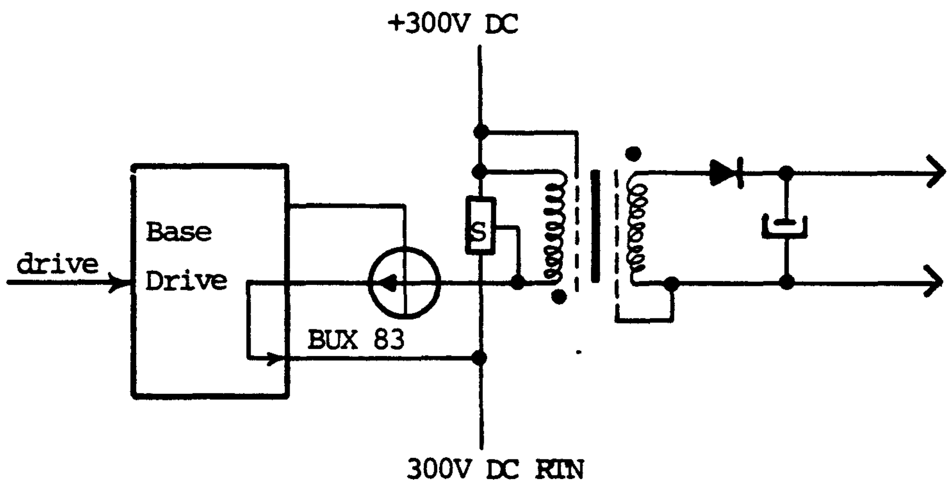


Fig. 5.

On fig. 5 the principle for powertransformation is shown. The mode of operation is that of a ringing choke flyback converter. That means that the clock period normally is divided into three slots as shown in figure 6:

- a: Conduction period
- b: Flyback period
- c: Waiting period

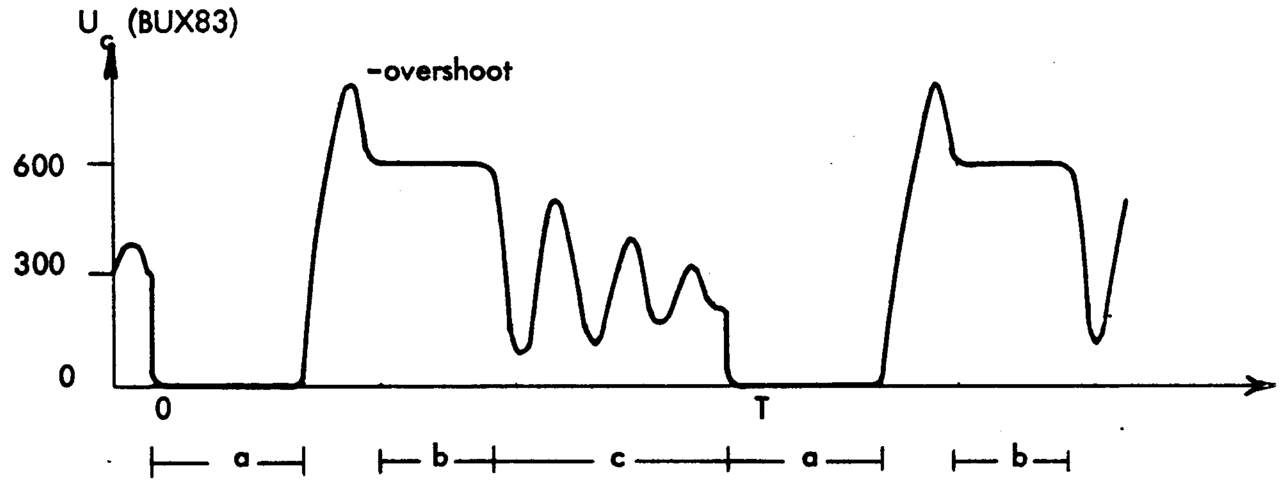
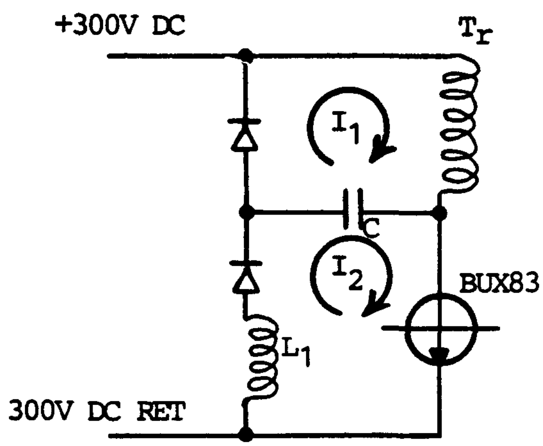


Fig. 6.

During the conduction period, the 300V DC voltage is applied through the transistor BUX83 and the base drive circuitry to the primary winding of the transformator. The secondary rectifier is reverse biased and hence not conducting. That means that the transformer-action is that of a selfinduction. With constant voltage applied, the current through the primary will increase at a constant rate, charging the transformer airgap with magnetic energy.

When the transistor now is turned off, the voltage on both transformer windings will reverse, and current will flow through the rectifier diode into the output and output capacitor, discharging the magnetic energy stored in the transformer into the output. During this period the secondary current will decrease from the maximum value to zero at a constant rate (a constant voltage is in fact applied to the secundary). After this the converter enters the waiting period, waiting for a new cycle to be initiated. During this period neither the transistor nor the output diode are conducting and the transformer "rings" i.e. the voltage on the windings will show damped sinusoidal oscillations at a frequency determined by transformer characteristics and stray capacitances and caused by a small amount of residual energy left in the system when the secondary diode turns off.

This behaviour has given rise to the name "ringing choke". Let a, b and c represent the time duration of the three periods, then the ratio b/a equals the ratio between input voltage and n * output voltage, where n is the ratio between the number of winding in primary and secondary. Hence varying a is a way to control the output voltage against varying primary voltage. If we call the total cycle time T, the ratio a/T is proportional to the transferred power as long as the converter is in the ringing choke region. The conclusion is that the converter can be entirely controlled by simply controlling the time a.



I_1 is the snooper current path.
I_2 is the capacitor recovery path.
T_r is the transformer primary stray inductance.

Fig. 7.

During none of the periods a, b or c significant power is dissipated in the switch transistor collector circuit. However, in the transition time between the conducting- and the flyback-period, the collector voltage on BUX83 swings from zero to 600 Volt with maximum current flowing in the transformer primary and a very high voltage overshoot. This is at the limit of what the transistor can stand, and represents an unnecessary powerloss in the transistor. This is the reason for the existence of the snooper circuit. See figure 7.

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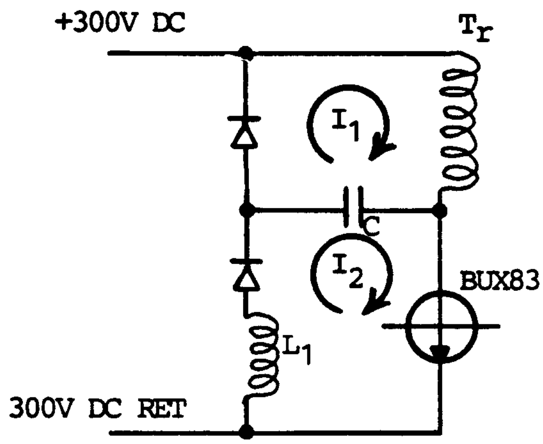

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A high voltage switching powertransistor is characterized by a very small current amplification if low collector-emitter saturation voltage is to be guaranteed. This would require much service power if the driver circuit should drive the switchtransistorbase directly. Therefore the emittercurrent in the switch-transistor is let through a winding on the base drive transformer, that is the basecurrent is taken from the transistor emittercurrent rather than from the more "expensive" service powersource. Another advantage is that the basecurrent all the time (except at the very beginning of each cycle) is proportional to the strongly varying collectorcurrent, minimizing the base drive power dissipation. This mode of operation is to some degree similar to that of a thyristor, but shorting the primary of the drive transformer will turn off the transistor. This is also the case when the drive transformer saturates.

The primary of the basedrive transformer consists of two windings: a startwinding to which a short pulse is applied when the switch transistor is turned on, and a hold-off winding used to short the transformer flux when the outputtransistor is turned off.

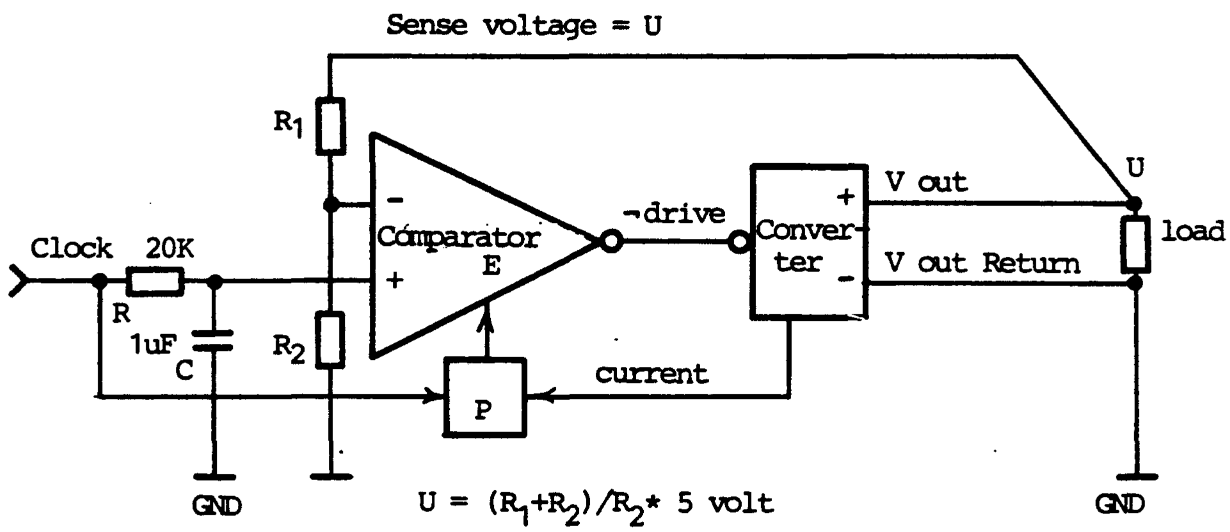
To ensure that the outputtransistor is not turned on by noise when the drive circuit has no servicepower applied, the short-circuit is formed by a FET transistor acting as a "normally on" switch (active off).

3.2.2. Voltage Regulation and Overload Protection. 3.2.2.

As pointed out in section 3.2.1., the converter operation is compleatly controlled by controlling the conduction dutycycle, hence this is the way voltage regulation is carried out.

The control module broadcasts a squarewave clock signal with 5V reference as average values, so that the converter regulation has to do is ot integrate the clocksignal (by means of an RC circuit) extracting the five volts, compare them with the modified sense voltage and use the difference for regulation of the conduction duty.

Fortunately the integration of a square-wave gives a triangular wave with a peak voltage depending on frequency and the value of the RC product. By choosing the values properly, comparison of the triangel and the modified sensevoltage directly produces a square wave with the wanted dutycycle. Figure 9 shows the circuits.



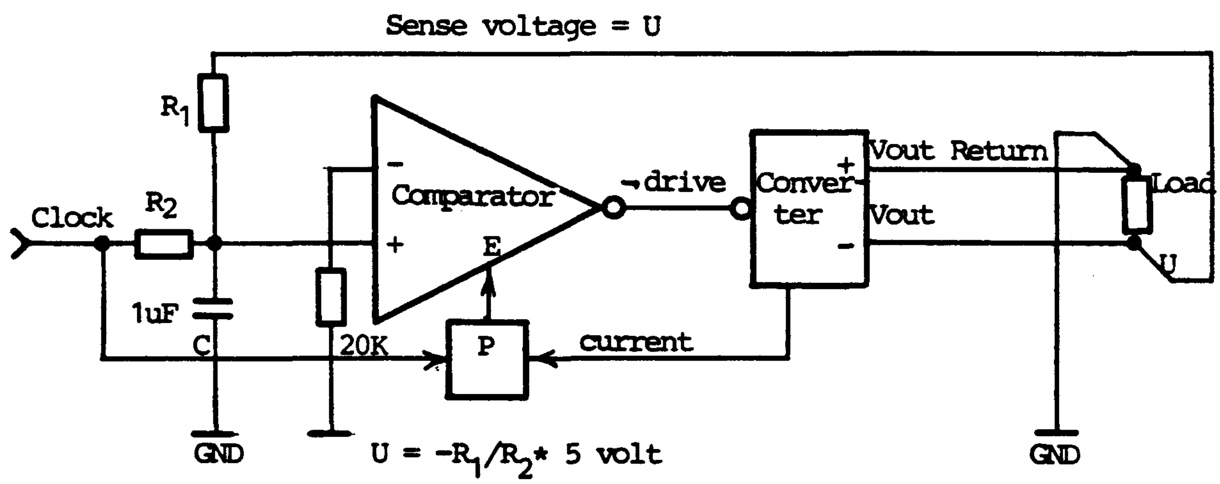


Fig. 9

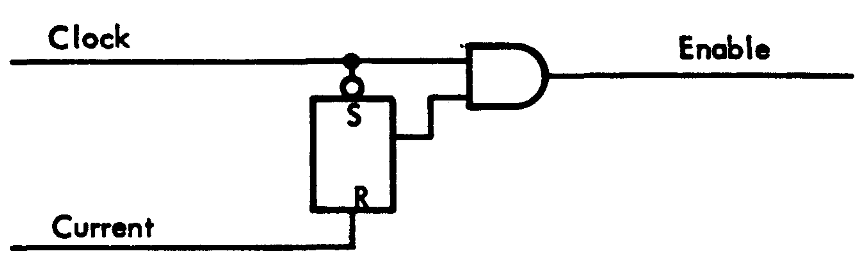


Fig. 10

As the sensevoltage is measured at the load, the circuit automatically compensates for the load dependent voltagedrop across the converter to load connections.

Figure 10 shows the logic contents of the protection circuit (block P in fig. 9). The current signal becomes true, when the converter primary current as measured over a current transformator exceeds a certain threshold (appr. 2A). This signal sets the overcurrent flipflop, which limits the converter dutycycle. As shown, the clocksignal lowlevel resets this flipflop, but inhibits the converter, limiting the maximum dutycycle.

3.2.3. Voltage Checkout. 3.2.3.

The voltage checkout circuit compares the sensevoltage with a precision zener and releases the "converters up"-signal when the voltage is found ok. The "converters up"-signal (in diagrams referred to as Volt. bus) is "wireanded" to a line from all connected converter modules to the common controle module, and here when true, used to condition the PINT and POK circuits.

3.3. Powerchassis. 3.3.

The powerchassis contains the whole powersystem. The main parts are:

- line connection
- interconnection (motherboard)
- output terminals
- fan for forced aircooling of the powersystem.

The lineconnection includes linefuse, line noise filter and mains switch.

On the motherboard is located a thermostat closing at temperatures over 65 °C, grounding the "overtemperature" signal. This starts the control module power down sequence.

4. Adjustment Procedures. 4.

In the following sections the adjustment of the potmeters on the control module and on the power module are discussed.

4.1 Voltage adjustment. 4.1

The output voltages from the different power modules are centrally adjusted from the control module. Individual adjustment of a separate voltage is not possible.

The central voltage adjustment is made possible by the fact that every power module utilizes the integrated average voltage of the clock signal as the basic reference voltage. Therefore, adjustments of the mean value of the clock influence on all the output voltages.

The use of precision resistors (1%) in the voltage dividing networks relating the output voltage to the averaged reference clock insures that all voltages are within 1% of the nominal value (if the reference clock is exact).

Consequently, the correct voltage adjustment procedure tends to insure that the reference clock mean value is 5V, rather than adjusting a specific voltage.

For adjusting the reference clock use an analog moving coil instrument. Digital multimeters normally gives a reading slightly exceeding the true value.

The reference clock is available at the front of the Powerchassis.

4.2 Current Limit Adjustment. 4.2

The maximum output power available from the power modules can be adjusted by changing the treshold level of the emitter current protection circuit. This adjustment is made at the factory, and readjustment should only be made in succession to repairs.

Note, that though it is possible to adjust the modul to supply more than 100W output power, attemp to utilize this fact should be avoided. The over-all design is only aimed at 100W and decreased life time will result at higher output power levels.

The current protection potmeter is adjusted using the following procedure:

a. Decrease the "300VDC" high voltage to 230V.

b. At 100W output power the trimmer is turned clockwise until the output voltage is no longer affected.

c. Turn the trimmer counter clockwise until the output voltage has decreased by 10%

d. Finally make a half-turn clockwise.

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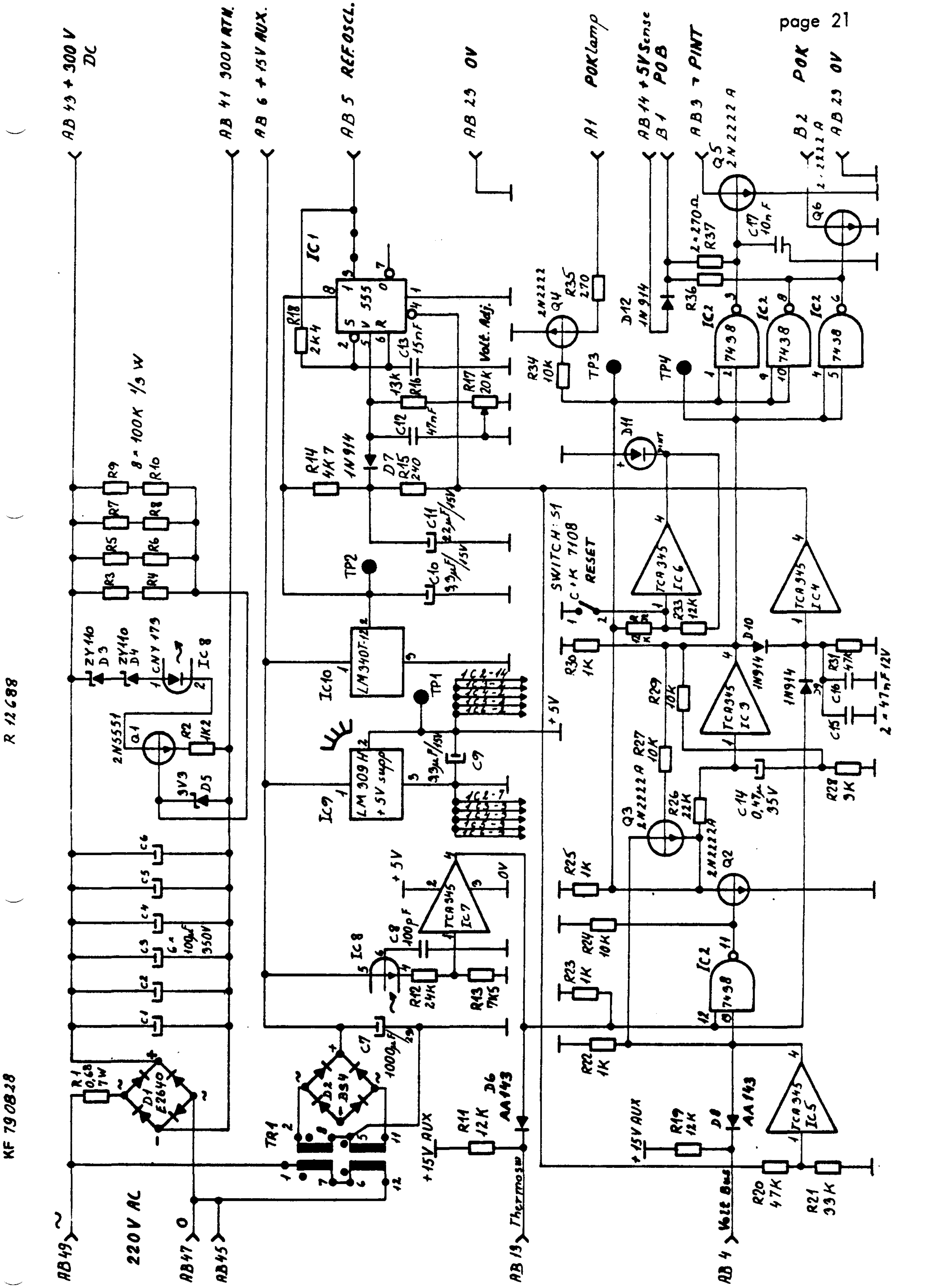

POW 728

R12742

CONTROL MODULE POW 728

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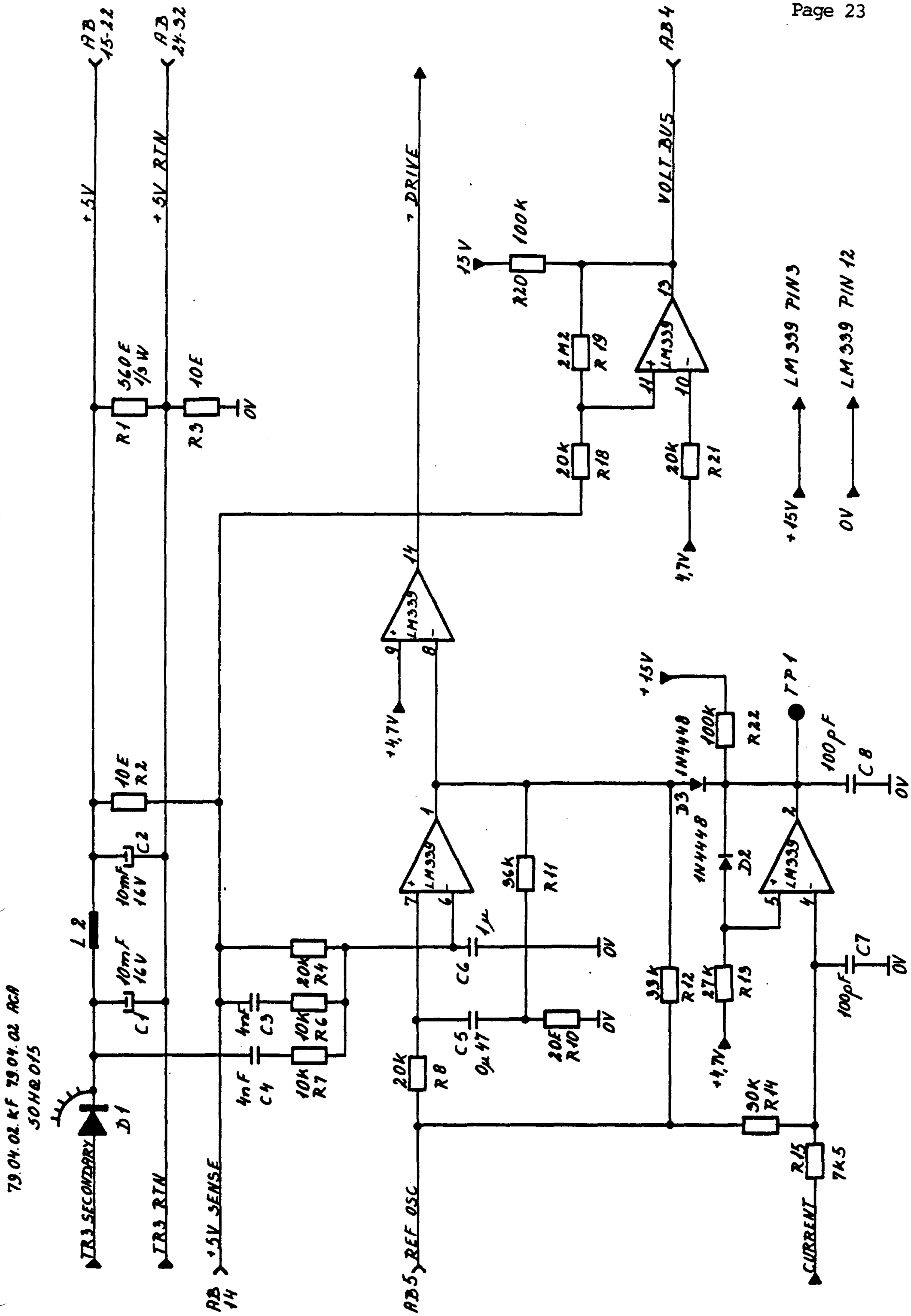

POW 729 + 5V POWER MODULE
CONTROL SECTION
CIRCUIT DIAGRAM

POW 729

R 12692

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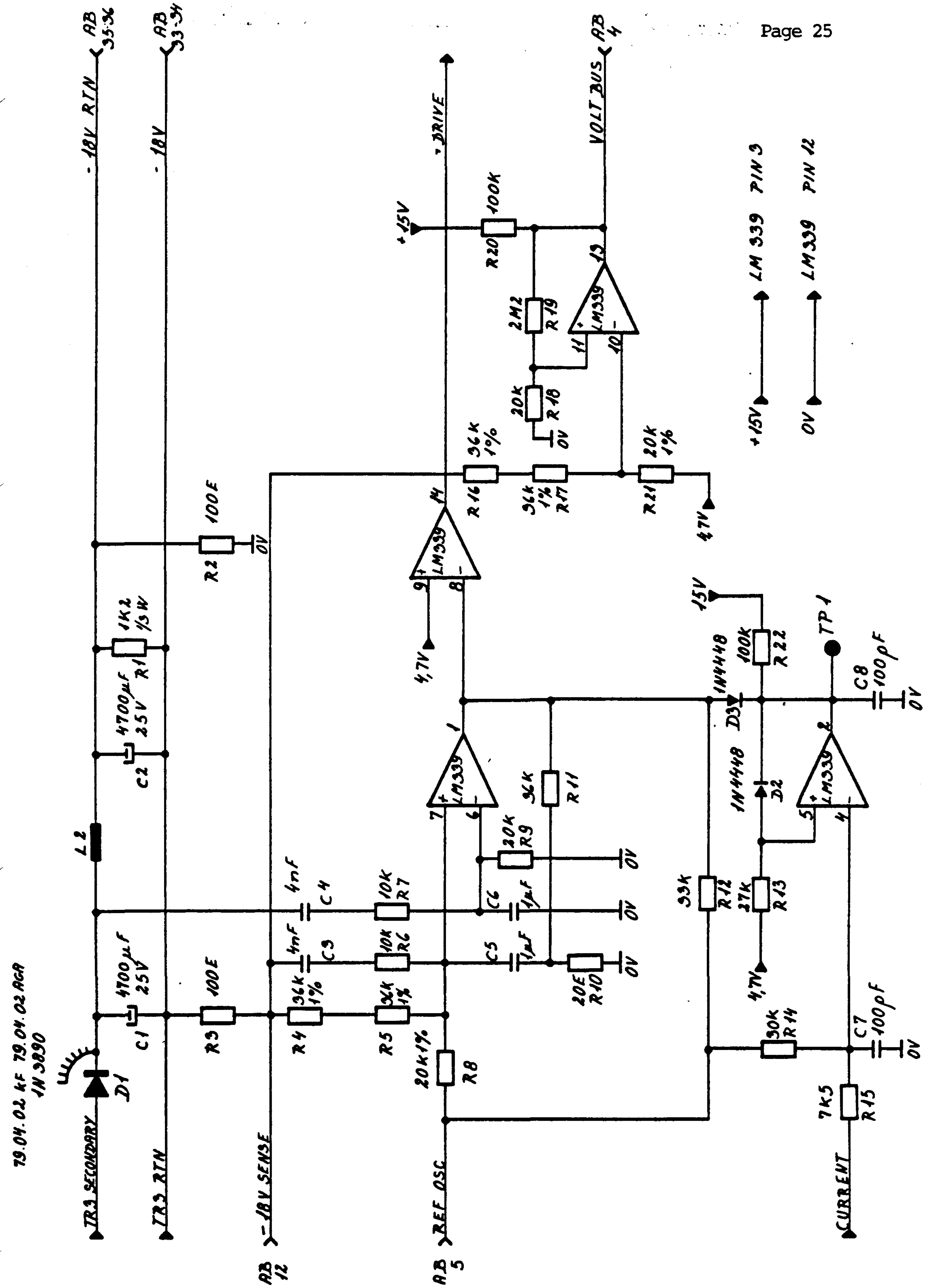

POW 730 - 18V POWER MODULE
CONTROL SECTION
CIRCUIT DIAGRAM

POW 730

R 12693

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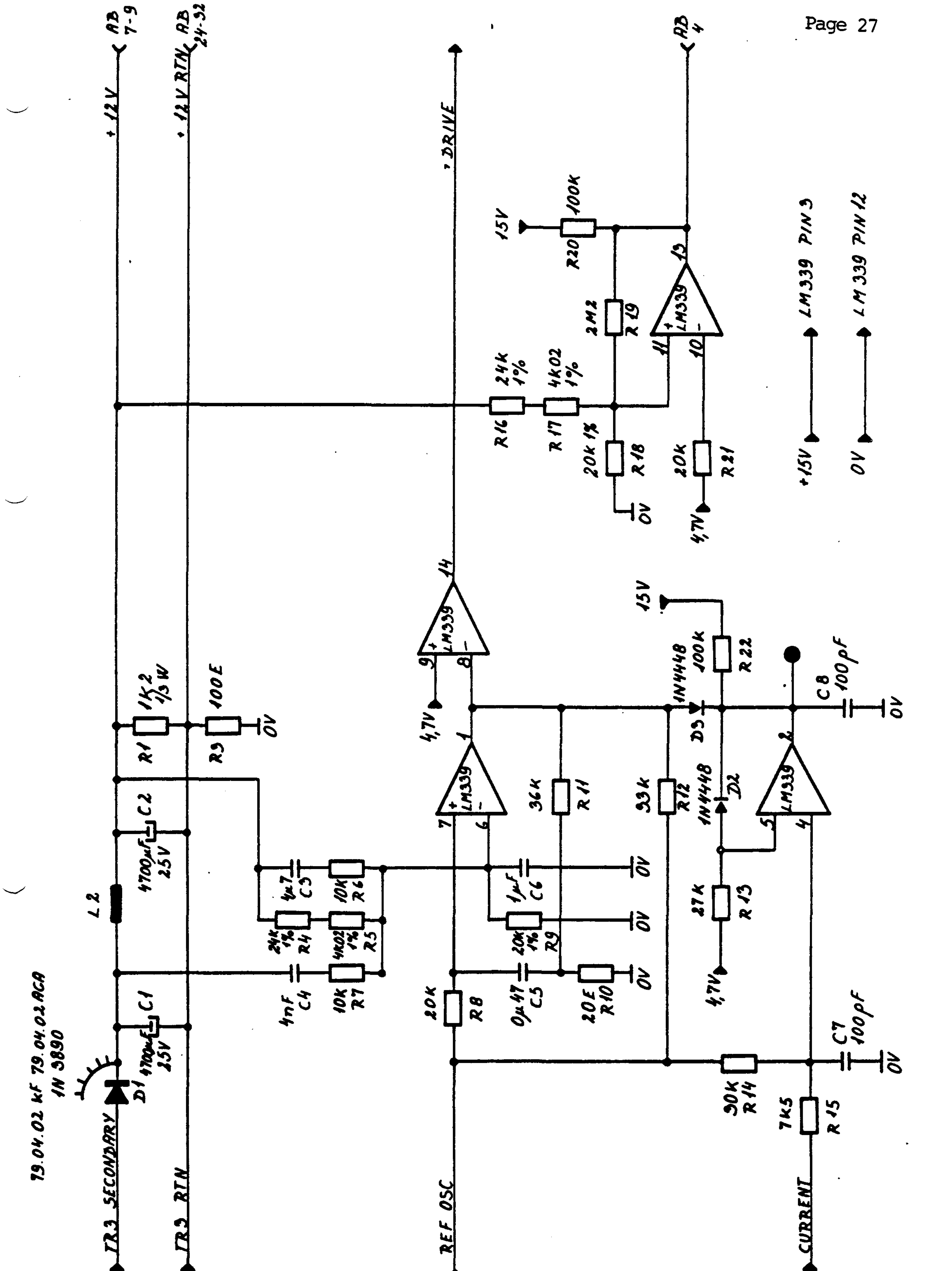

POW 731 +12V POWER MODULE
CONTROL SECTION
CIRCUIT DIAGRAM

POW 731
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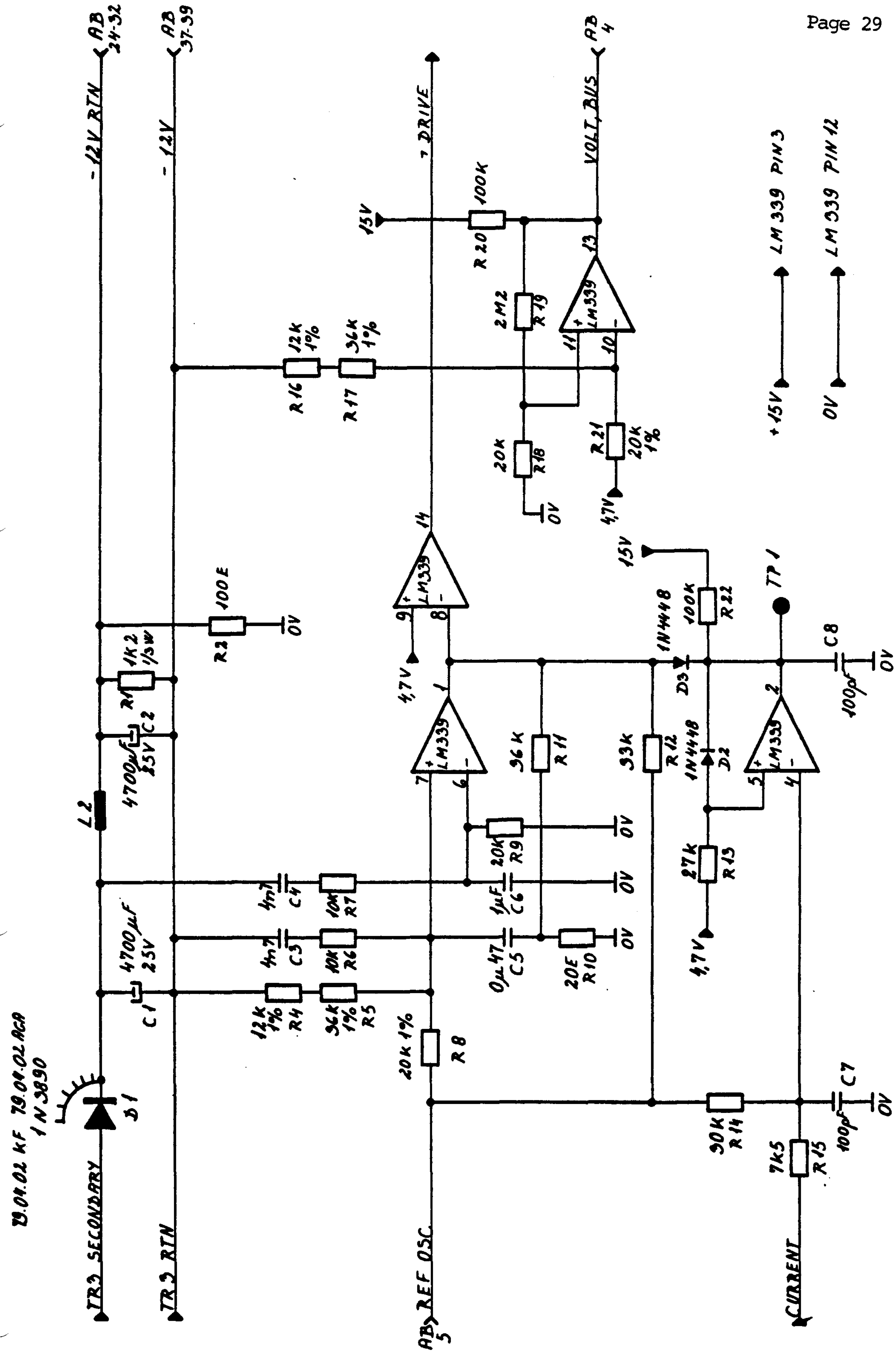

POW 732 -12V POWER MODULE
CONTROL SECTION
CIRCUIT DIAGRAM

POW 732
R 12689

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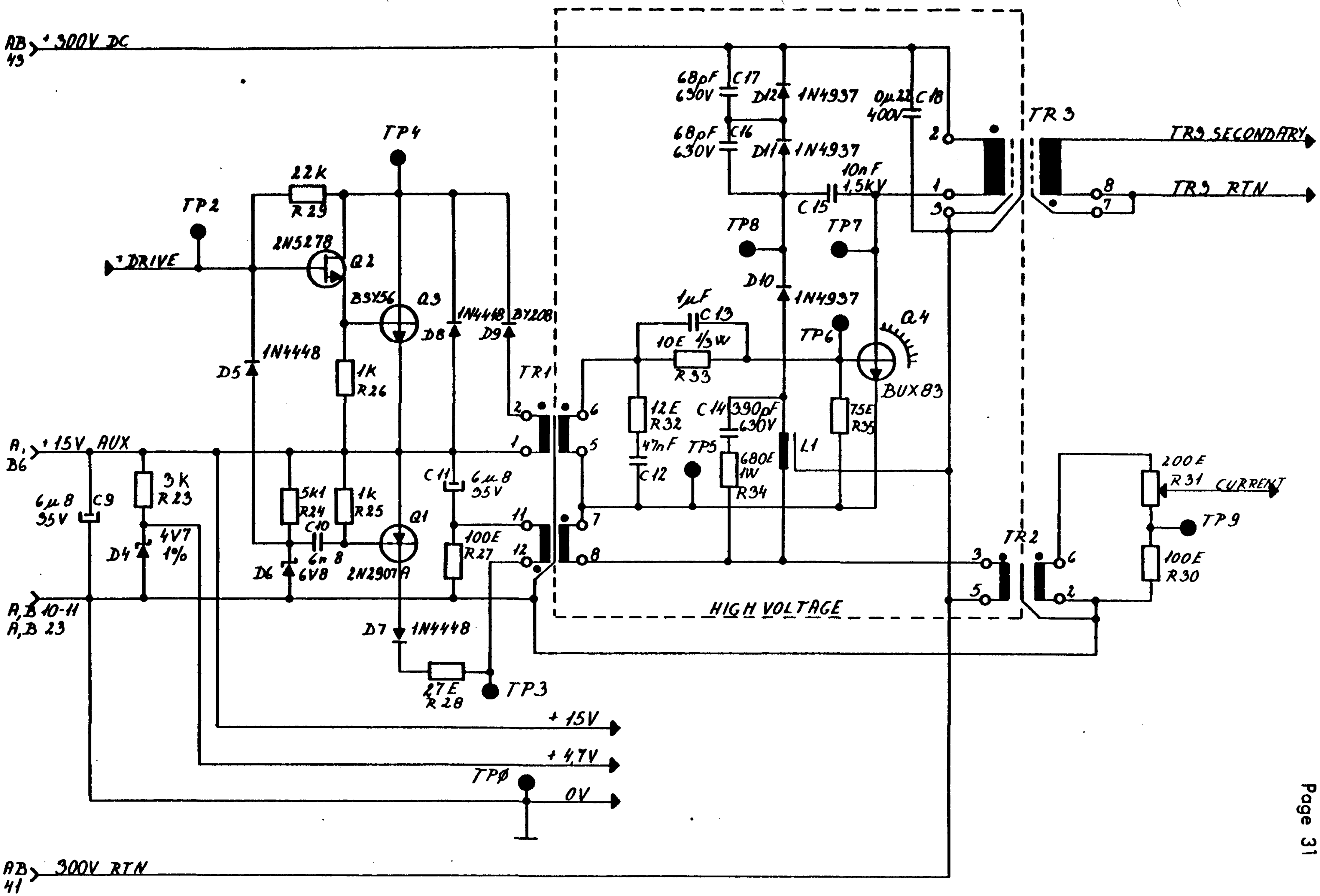

POW 729-32 POWER MODULE
POWER SWITCH SECTION
CIRCUIT DIAGRAM

POW

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PCH 701

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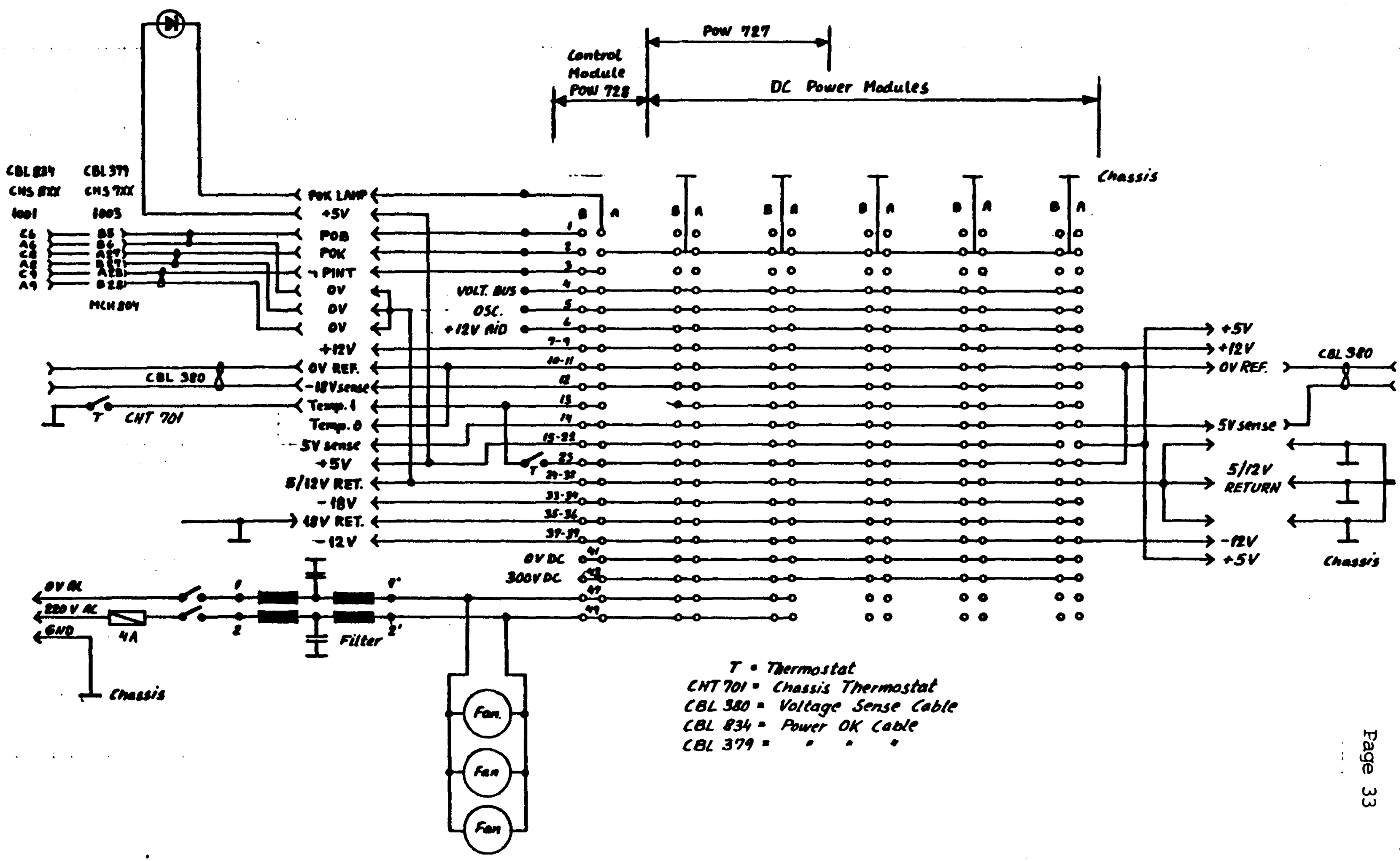

POWER CHASSIS MOTHERBOARD

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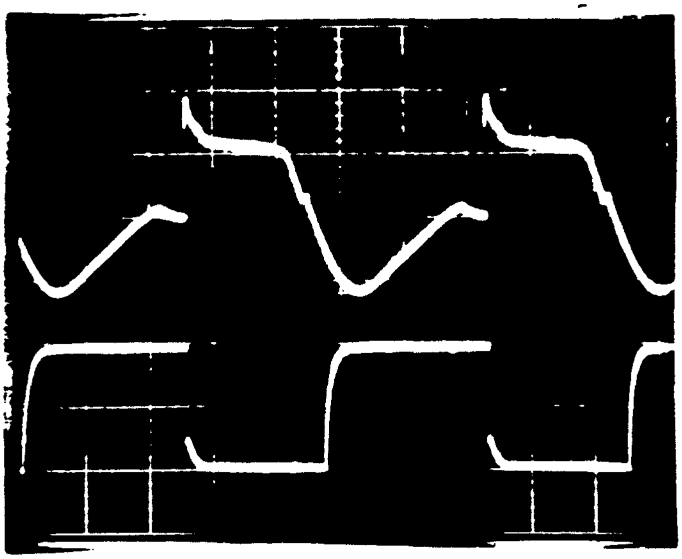
6. OSCILLOGRAMS.

The following pages contain oscillograms showing typical voltage waveforms at the different testpoints. Testpoint no. 0 (TP0) is used as signal ground reference in the low voltage section of the circuit, and testpoint no. 5 (TP5) is used in the high voltage area.

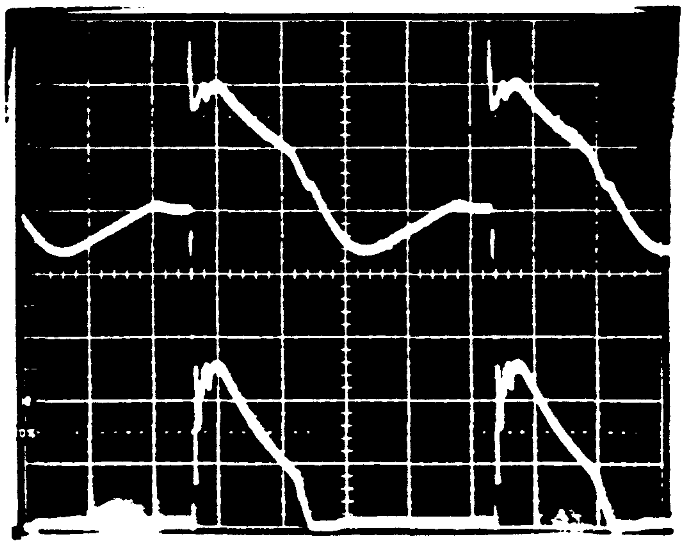
The timebase on all oscillograms is 10 µs/div.



TP6 (V_{BE}) 1V/div

300 V DC = 0V

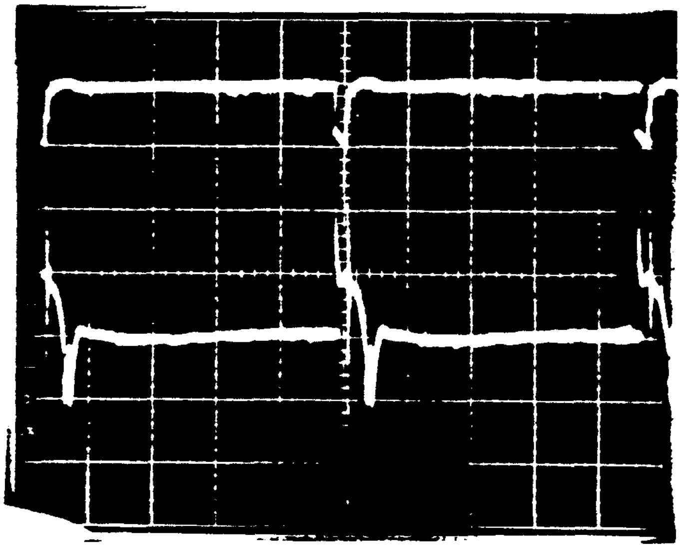
TP2 (7Drive) 10V/div



TP3 (Start) 5V/div

300 V DC = 0

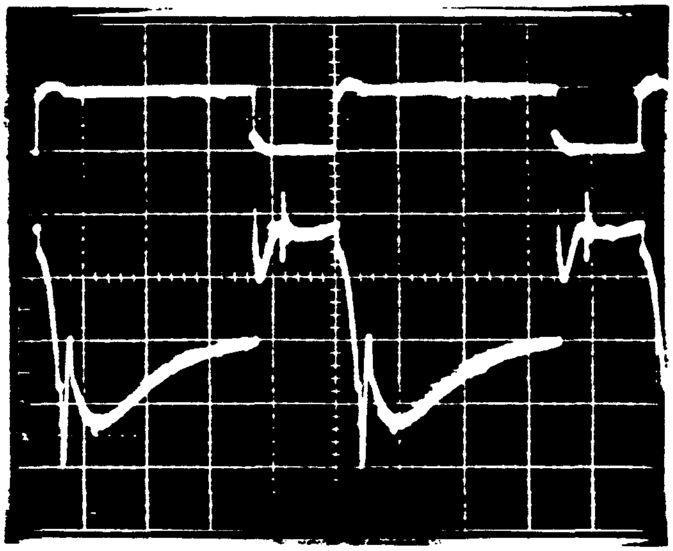
TP4 (Turn off) 10V/div



TP2 (Drive) 20V/div

Pout ≃ 0 W

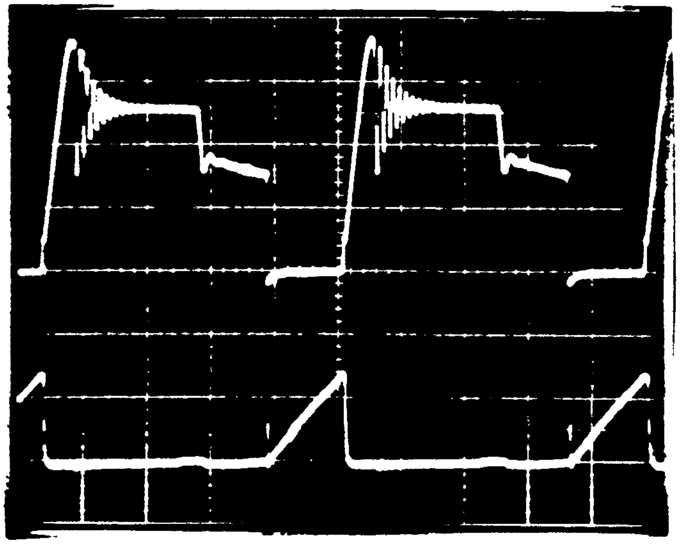
TP3 (Start) 10V/div



TP2 (¬Drive) 20V/div

Pout = 100W

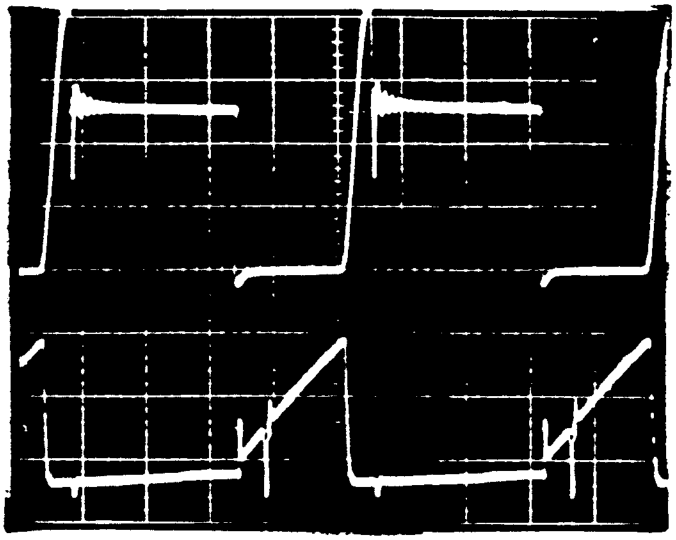
TP3 (Start) 10V/div



TP7 (V_{CE}) 200 V/div

Pout = 50W

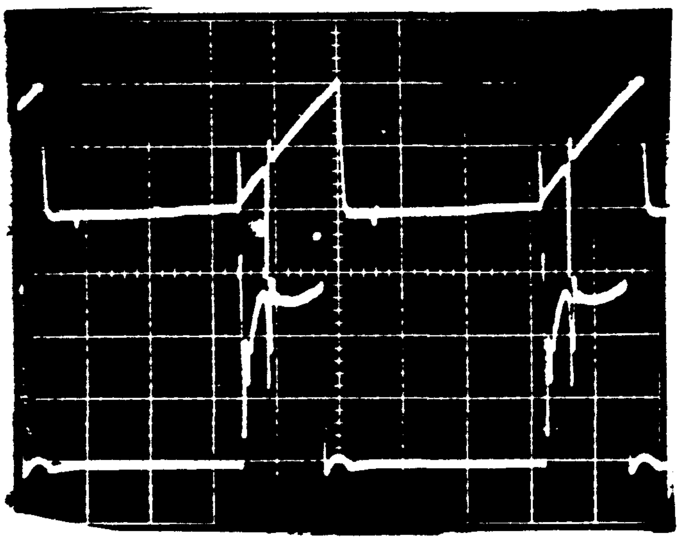
TP9 (I_C) 1 V/div



TP7 (V_{CE}) 200V/div

Pout = 100W

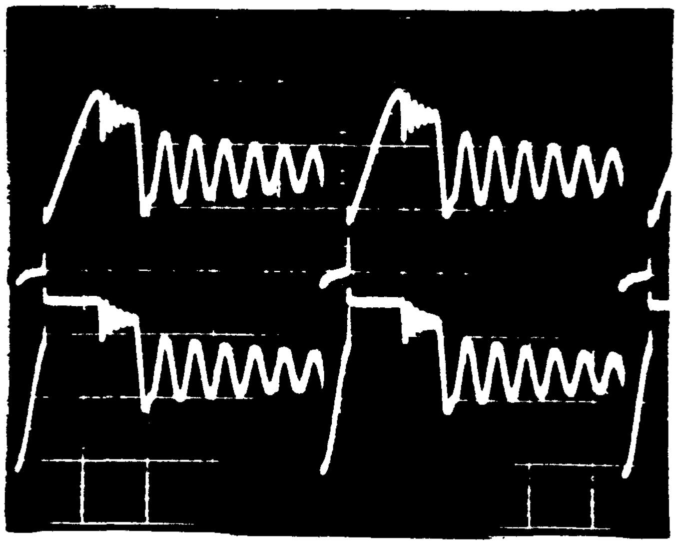
TP9 (I_C) 1V/div



TP9 (I_C) 1V/div

Pout = 80W

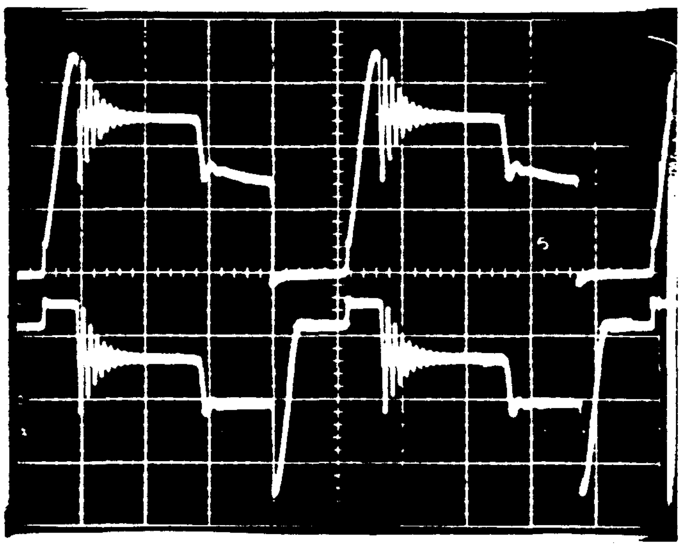
TP4 (Turn off) 20V/div



TP7 (V_{CE}) 200V/div

Pout = 10W

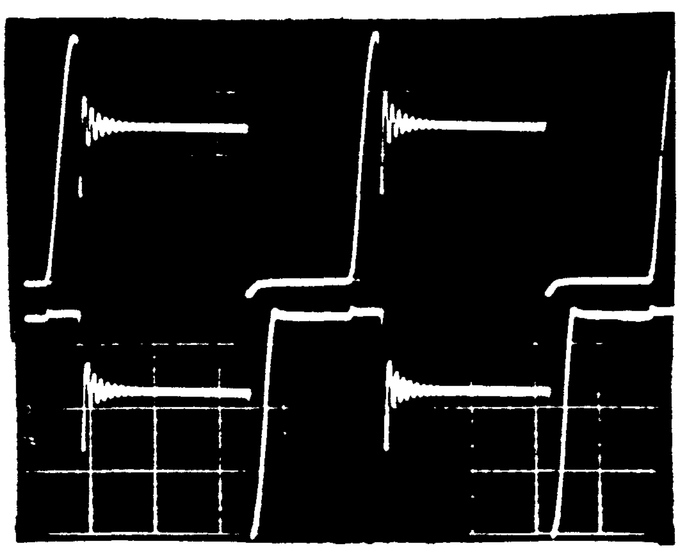
TP8 200V/div



TP7 200V/div

Pout = 50W

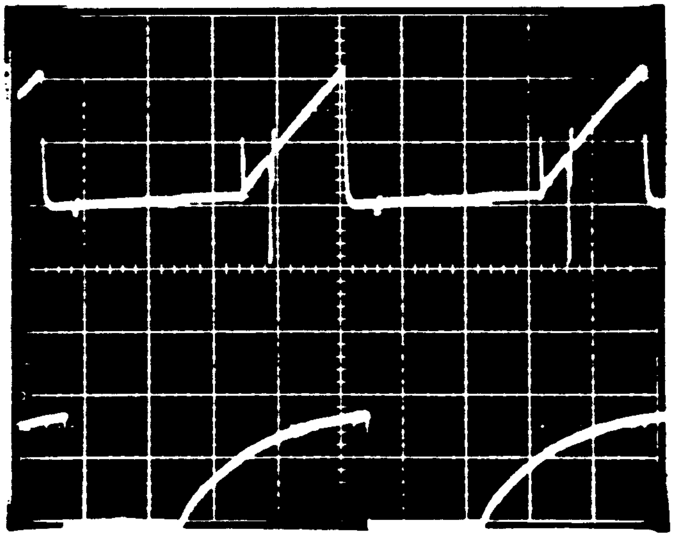
TP8 200V/div



TP7 200V/div

Pout = 100W

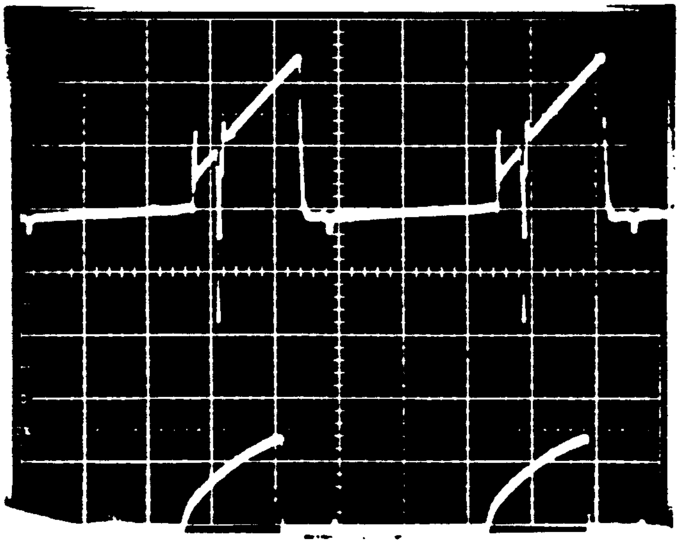
TP8 200V/div



TP9 (I_C) 1V/div

Pout = 100W

TP1 ($I_C$limit) 10V/div



TP9 (I_C) 1V/div

Pout = 135W
(current limit)

TP1 ($I_C$limit) 10V/div

7. RECOMMENTED SPAREPARTS. 7.

In the following, recommented spareparts for each of the modules POW728-32 are listed. The lists includes only electrical components.

7.1 POW 728 Partlist. 7.1

The following spareparts are applicable for the POW 728:

QTY	Description	RC partnumber.
1	Bridge rectifier	
1	" " BS4	
1	CNY17 II Photo coupler	60117
1	Light emitting Diode	
2	AA143 Diode	64510
4	1N914 Diode	11607
1	BZY88 C3V3 Diode	11604
2	ZY110 Diode	
5	2N2222A Transistor	34116
1	2N5551 Transistor	
1	SN7438N, IC	40804
1	LM309H, IC	58817
1	LM340T-12, IC	
1	LM555CN, IC	54717
5	TCA345A	63815
6	100µF/350V El-lyt	
1	1000µF/25V " "	43909
1	22µF/15V Tantal	11118
2	3,3µF/15V "	11117
1	0,47µF/35V "	41902
1	100pF/63V Condenser	11209
1	10nF/250V "	11315
1	15nF/250V "	11317
3	47nF/250V "	11406
1	E68 Resistor 6W 10%	

QTY	Description			RC partnumber.
8	100K	Resistor	1/3W 5%	16002
1	240E	"	1/8W 5%	15113
3	270E	"	"	15114
4	1K	"	"	10600
1	1K2	"	"	10602
1	2K4	"	"	10609
1	3K	"	"	10611
1	4K7	"	"	10616
1	7K	"	"	10701
4	10K	"	"	10704
4	12K	"	"	10706
1	13K	"	"	10707
1	22K	"	"	10722
1	24K	"	"	10713
1	33K	"	"	10716
2	47K	"	"	10800

7.2 POW 729-732 Shared partlist. 7.2

The following spareparts are applicable for all the power modules POW729-732.

QTY	Description	RC Partnumber.
1	RM 8 Transformer	(8462-03-059)
1	RM 6 "	(8463-03-060)
1	22x13 inductor	(8460-03-064)
1	LM339N, IC	58806
1	BUX83 transistor	64400
1	BSY56 "	64401
1	2N5278 FET transistor	63818
1	2N2907A Transistor	34114
1	BZY88 C6V8 Diode	11711
1	BZX97 4V7 1% Diode	63814
1	BY208 1000V Diode	64413
5	1N4448 Diode	64613
3	1N4937 "	64614
2	6,8µF/35V Tantal	10518
2	1µF/63V Condensor	11104
1	0.22 µF/400V Condensor	43919
1	10nF/1.5KV "	63813
1	6.8nf/250V "	11314
2	4.7nF/250V "	11311
1	47nF/250V "	11406
2	100 pF/63V "	11209
1	390 pF/630V "	11218
2	63 pF/630V "	64615
1	200E Potmeter	61215
1	680E resistor 1W 5%	10204
1	10E " 1/3W 5%	10301
1	12E " 1/8W 5%	15002
1	20E " "	15007
1	27E " "	15010
1	75E " "	15101

QTY	Description			RC Partnumber.
1	100E	Resistor	1/8W 5%	15104
1	1K	"	"	10600
1	3K	"	"	10611
1	5K1	"	"	10617
1	7K5	"	"	10701
2	10K	"	"	10704
2	20K	"	"	10711
1	22K	"	"	10712
1	27K	"	"	10714
1	30K	"	"	10715
1	33K	"	"	10716
1	36K	"	"	10717
2	100K	"	"	10808
1	2M2	"	"	(110-03-137)

7.3 POW 729 Separate Partlist. 7.3

Besides the spareparts listed in sec. 7.2 those listed below are applicable for the POW 729:

QTY	Description			RC Partnumber.
1	50x30 transformer			(8464-03-061)
1	choke			(0192-03-022)
1	50HQ015 Diode			60707
2	10000µF/16V El-lyt			43905
1	0.47µF/63V Condensor			11103
1	560E	Resistor	1/3W 5%	10405
2	10E	"	1/8W 5%	15000
2	20K	"	"	10711

7.4 POW 730 Separate Partlist. 7.4

Besides the spareparts listed in section 7.2, those listed below are applicable for the POW 730:

QTY	Description	RC partnumber.
1	50x30 transformer	(8465-03-062)
1	choke	(0191-03-021)
1	1N3890 Diode	40811
2	4700µF/25V El-lyt	64404
1	1uF/63V Capacitor	11104
2	20K resistor 1/8W 1%	45305
4	36K " "	64616
1	1K2 " 1/3W 5%	10413

7.5 POW 731 Separate Partlist 7.5

Besides the spareparts listed in section 7.2 those listed below are applicable for the POW 731:

QTY	Description	RC partnumber.
1	50x30 transformer	(8466-03-063)
1	choke	(0192-03-023)
1	1N3890 Diode	40811
2	4700µF/25V El-lyt	64404
1	0.47µF/63V Condenser	11103
2	20K Resistor 1/8W 1%	45305
2	4K02 " "	64617
2	24K " "	41805
1	1K2 " 1/3W 5%	10413

7.6 POW 732 Separate Partlist. 7.6

Besides the spareparts listed in section 7.2, those listed below are applicable for the POW 732:

QTY	Description	RC partnumber
1	50x30 transformer	(8466-03-063)
1	choke	(0192-03-023)
1	1N3890 Diode	40811
2	4700uF/25V El-lyt	64404
1	0.47uF/63V Condensor	11103
2	20K Resistor 1/8W 1%	45305
2	36K " "	64616
2	12K " "	64618
1	1K2 " 1/3W 5%	10413