
Title:

Technical Manual for
POW -728, -729, -730, -731 and -732
Powersupply for RC computers

 **REGNECENTRALEN**

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Abstract:

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

CONTENTS

PAGE

1.	GENERAL DESCRIPTION	1
2.	SPECIFICATIONS	4
3.	PRINCIPLES OF OPERATION	6
	3.1. Control Module	6
	3.1.1. Line Rectifying and Energy Store	6
	3.1.2. Service Power and Signalsource	7
	3.1.3. Control Circuit	10
	3.2. Converters	11
	3.2.1. Powertransformation	11
	3.2.2. Voltage Regulation and Overload Protection .	15
	3.2.3. Voltage Checkout	17
	3.3. Powerchassis	17
4.	DIAGRAMS	18
	POW728 Control Module R12567	18
	POW729 +5V Module R12301	19
	POW730 -18V Module R12302	20
	POW731 +12V Module R12303	21
	POW732 -12V Module R12304	22

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 makes 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.

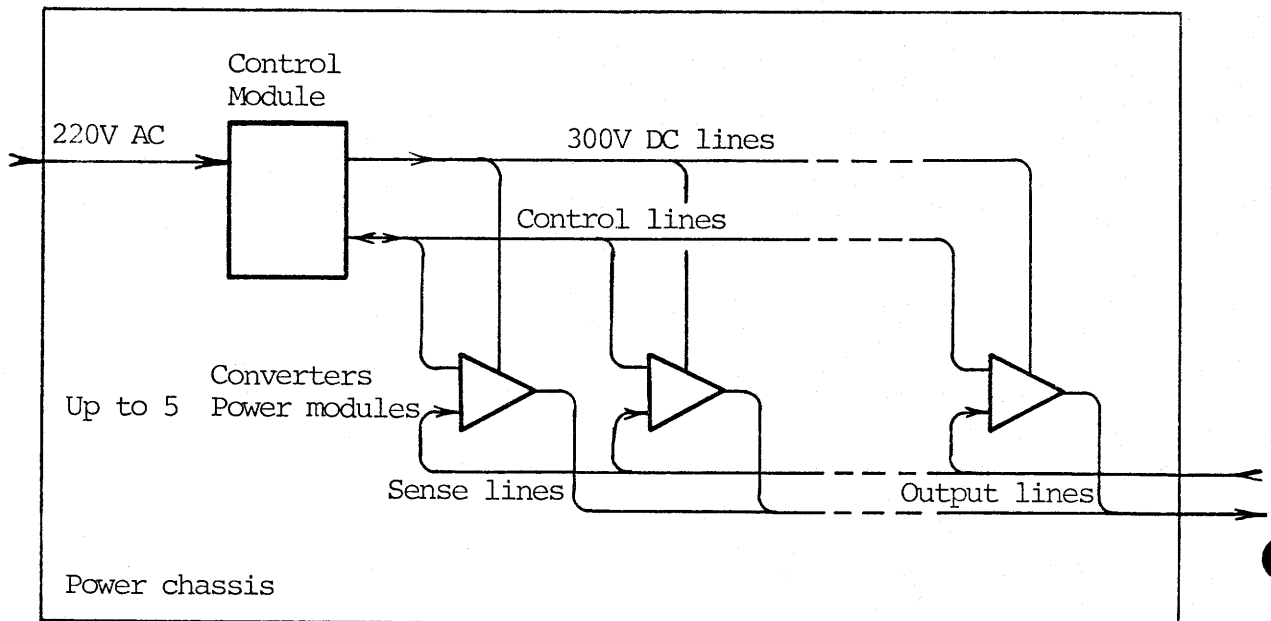


Fig. 1. Energyflow.

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 synchronizing 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 fly-back type. Through almost all the load characteristics it operates as a "ringing choke" converter, this eliminates 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 $-18/5 \times U_{ref}$ 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	49	50	-	Hz
requirements:	Voltage	200	220	240	Volt RMS
	Voltage	280	310	340	Volt peak

Performance:

Rectification: Full wave

300V DC at 600 Watt input:

Voltage	$U_{peak}-32$	$U_{peak}-2$	Volt
Ripple		30	Volt peak to peak

300V DC level activating "PINT"

	U_{pint}	213	235	Volt
Delay from PINT to POK	1,5		3	msec.
Delay from POK to PINT	1,5		3	msec.

Clock	frequency	18	20	22	KHz
Uref:	adjust-				
	ability:	4,75	5	5,25	Volt
	Stability:			1	%

All Power modules.

Ambient temperature	15		60	°C
300V DC operating	200	310	350	Volt
Input power			125	Watt
Output power		100		Watt
Output regulation				
measured at sense lines	$U_{out}-1\%$	U_{out}	$U_{out}+1\%$	

POW 729 +5 Volt module.

		min.	nom.	max.	Unit
Uout	(Iout < 20A)		Uref		
Rout	(Iout > 20A)		0,25		OHM
Voltage ok:	Uout >	4,75	4,80	4,85	Volt

POW 730 -18 Volt module.

Uout	(Iout < 5,5A)		-3,2xUref		
Rout	(Iout > 5,5A)		3		OHM
Voltage ok:	Uout <	-17,3	-17,1	-16,9	Volt

POW 731 +12 Volt module.

Uout	(Iout < 8A)		-2,4xUref		
Rout	(Iout > 8A)		1,4		OHM
Voltage ok:	Uout >	11,3	11,4	11,5	Volt

POW 732 -12 Volt module.

Uout	(Iout < 8A)		-2,4xUref		
Rout	(Iout > 8A)		1,4		OHM
Voltage ok:	Uout <	-11,5	-11,4	-11,3	Vol

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 separate electrical circuits are found on the control module board.

3.1.1. Line Rectifying and Energy Store.

This circuit consists of a Graetz 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 $U_1 = 310\text{Volt}$ 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

$$16,8 \text{ Joule} / 600\text{W} = 28 \text{ msec.}$$

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 control 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 synchronize 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.

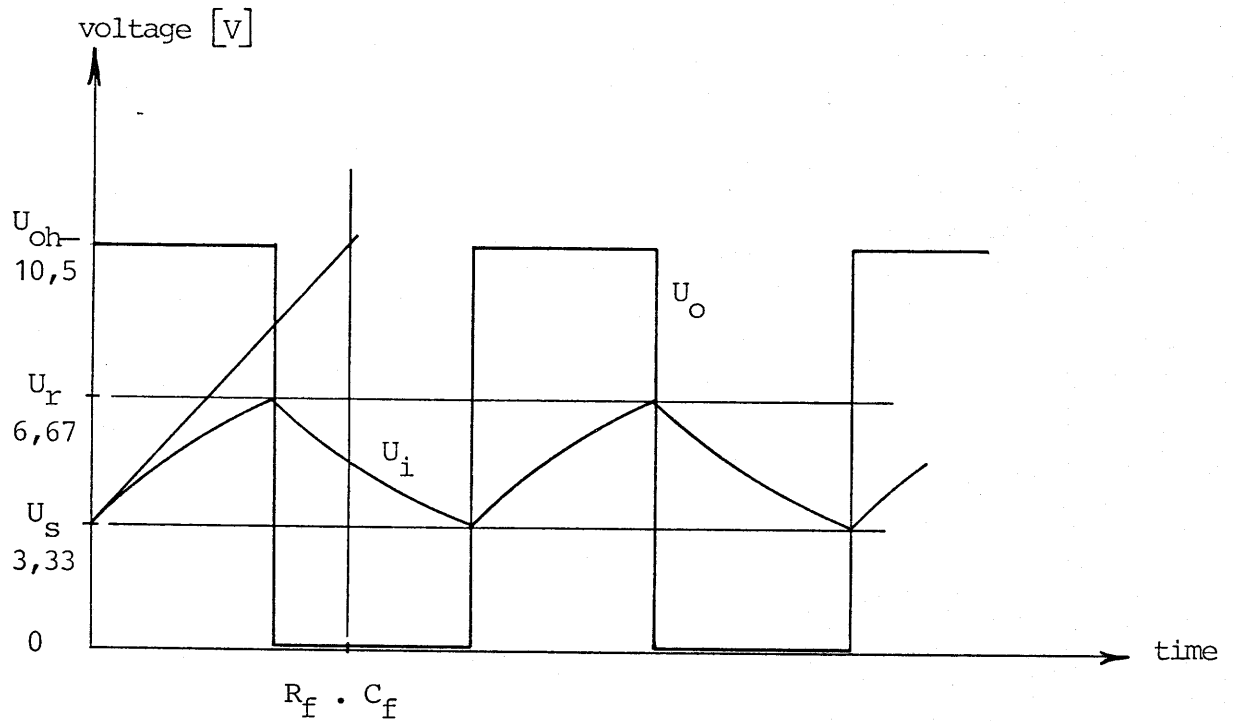


Fig. 2.

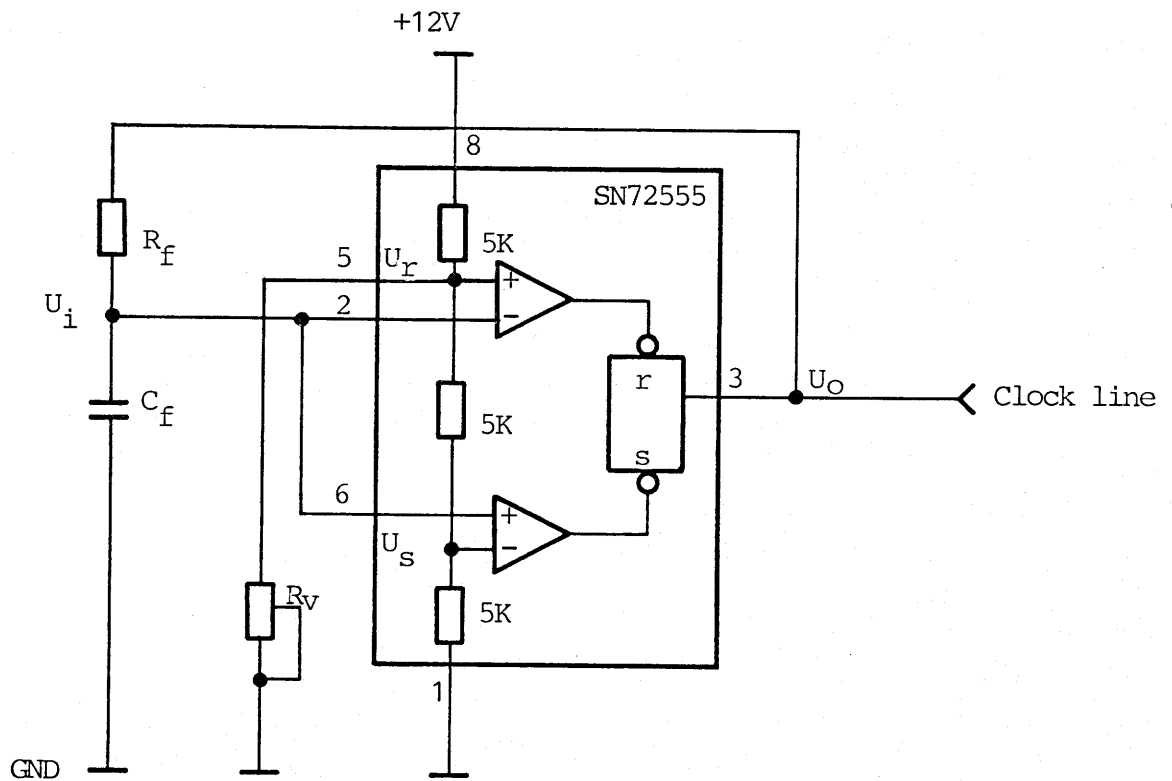


Fig. 3.

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).

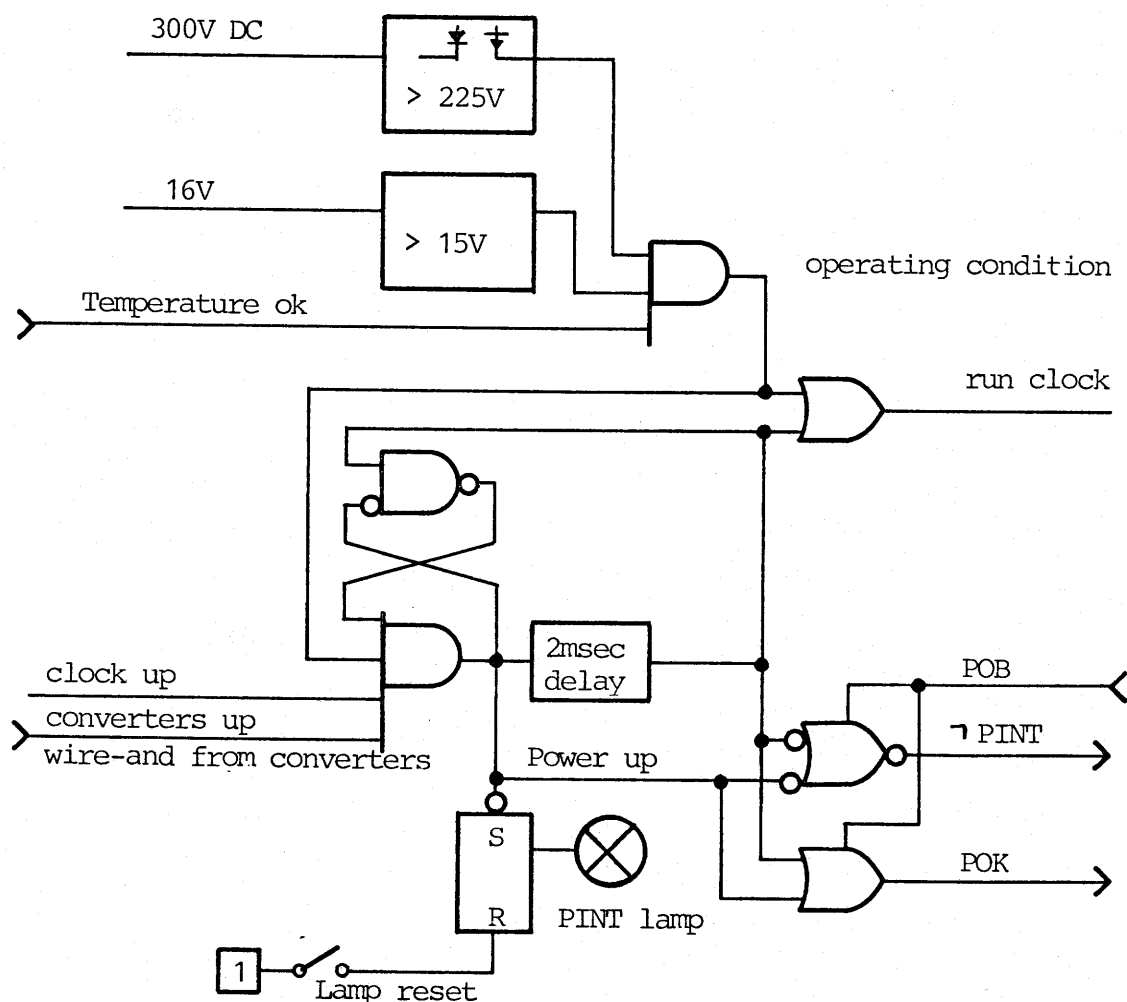


Fig. 4. Logic operation of control circuit.

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 $\pm$ 5%. The result is signalled through an optocoupler (current zero or greater than 1mA). This signal is added 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" falls and is latched low, power interrupt is set as well as the "PINT lamp" is turned on.

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. Voltage regulation
3. Overload protection (current limiting)
4. Voltage checkout

3.2.1. Power transformation.

3.2.1.

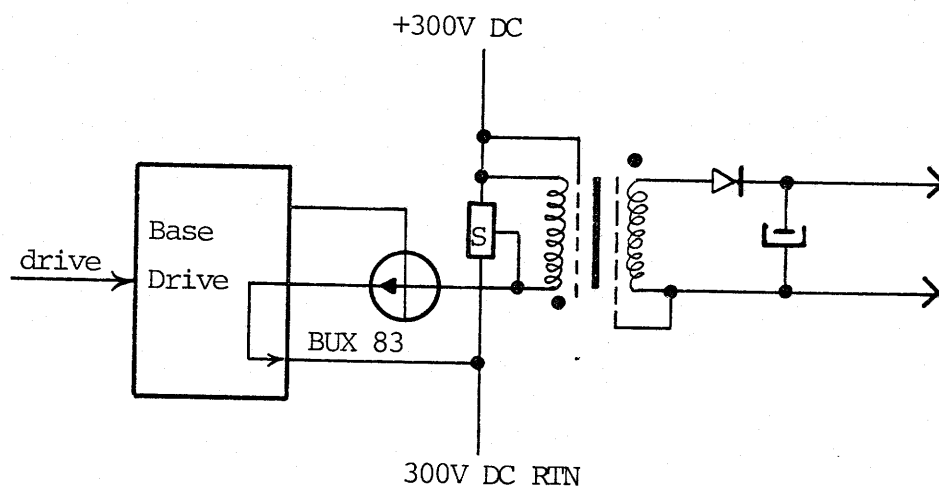


Fig. 5.

On fig. 5 the principle for power transformation 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

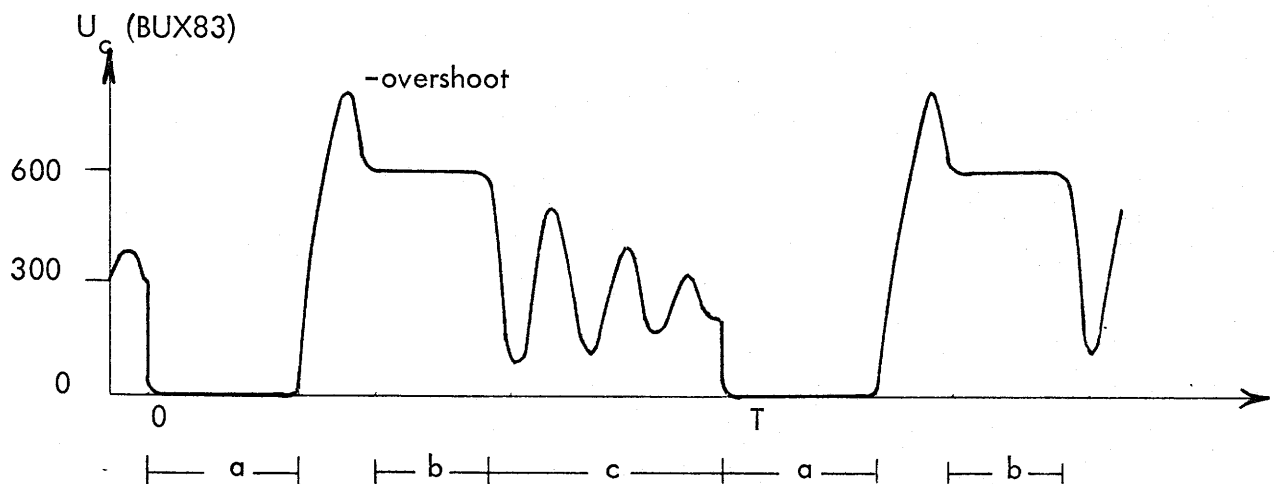


Fig. 6.

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 transformer. 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 secondary). 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 $n \times$ 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 .

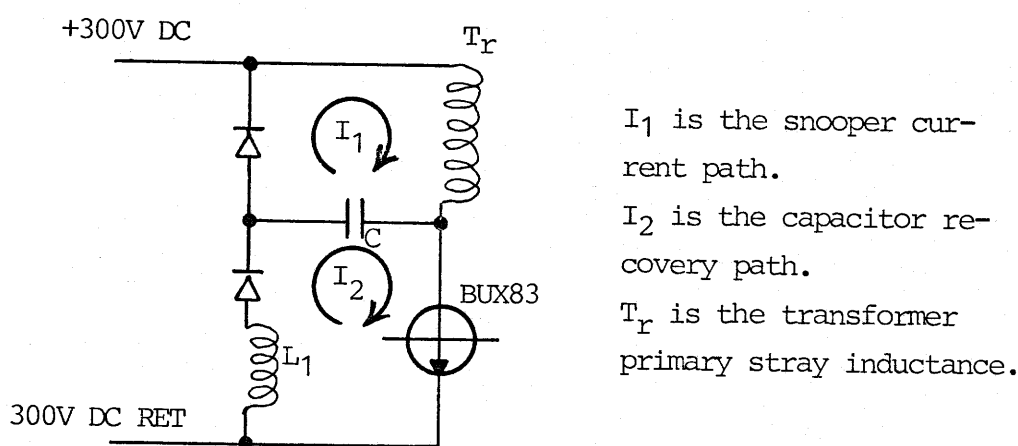
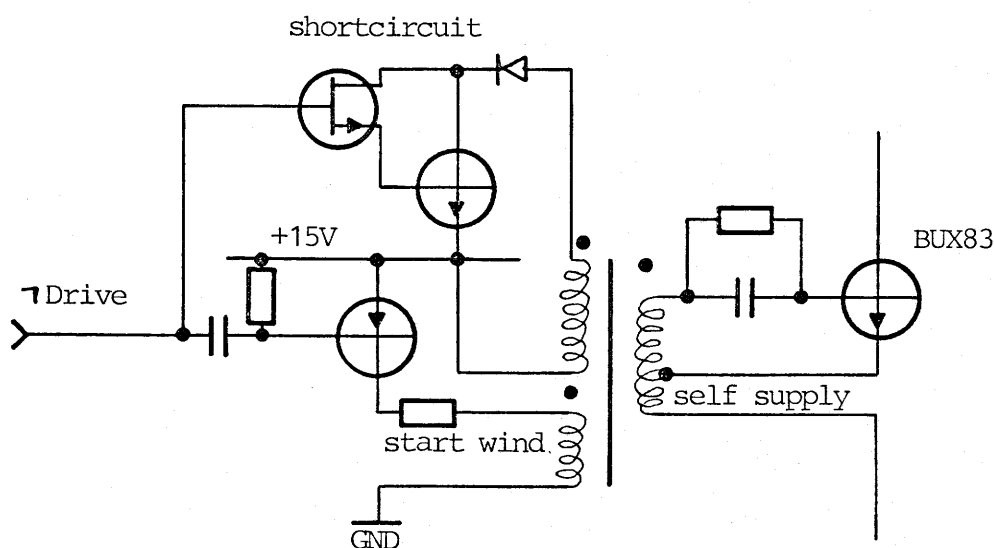


Fig. 7.

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.

The main components in this circuit are one diode and one capacitor. When the transistor turns off, the diode turns on, letting the transformer current flow through the capacitor leaving the transistor currentless, and limiting the overshoot to about 850V max. collector voltage. During this transition the energy stored in the transformer primary stray induction is converted to electrostatic energy in the capacitor. The voltage on the capacitor is reversed however and has to be reversed again before the circuit can handle a new transition of the described nature. This is done by means of another selfinduction and another diode at the start of the next conducting period. These precautions reduce collector dissipation from the switch transistor, increasing the reliability.

The two screens shown at Fig. 5 are connected to "cold" terminals at the two transformer windings, and helps reducing the converter generated RF noise to a minimum.



Base drive circuit

Fig. 8.

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 switchtransistor 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 power-source. 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 completely 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 triangle and the modified sense voltage directly produces a square wave with the wanted duty cycle. Figure 9 shows the circuits.

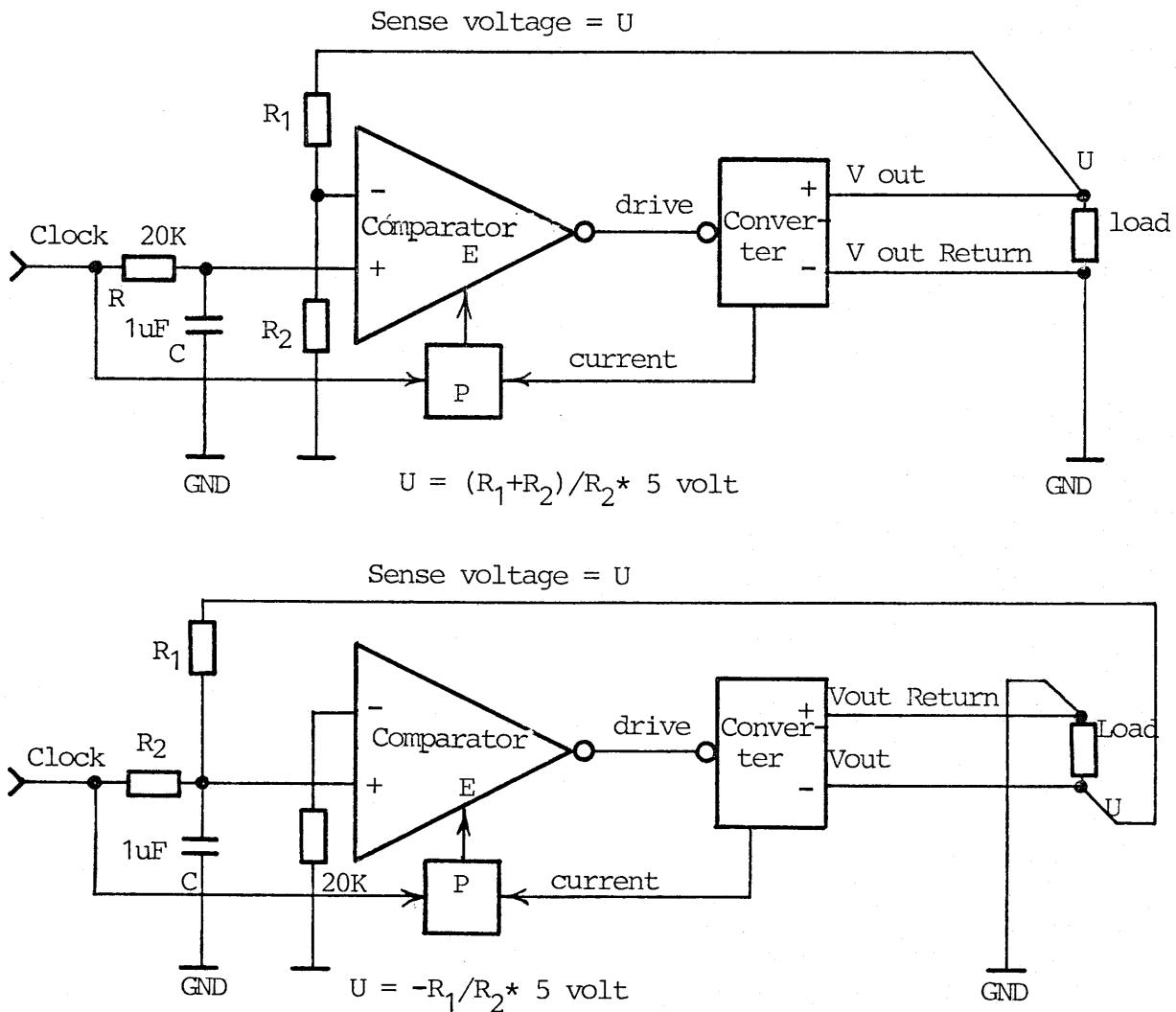


Fig. 9

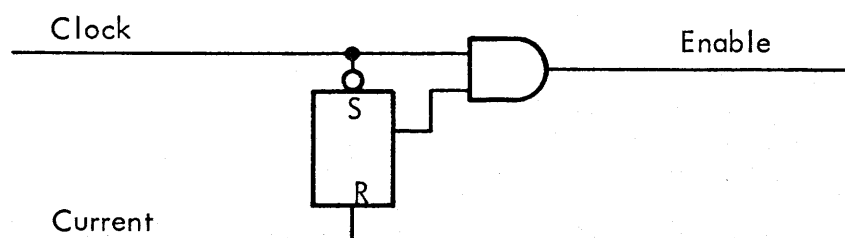


Fig. 10

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 transformer 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.

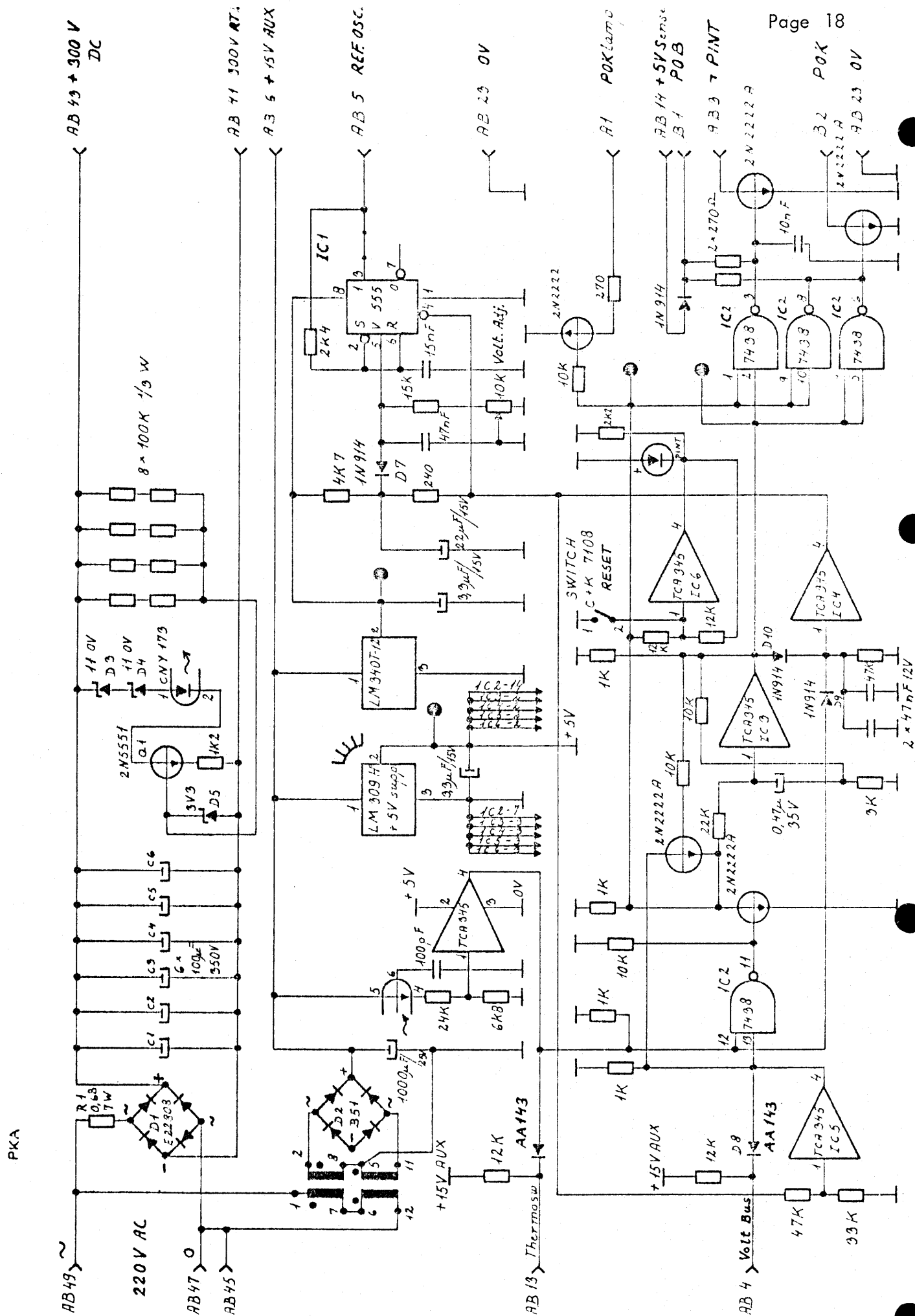
3.3.

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 "overttemperature" signal. This starts the control module power down sequence.



POW 728

R 12 567

CONTROL MODULE

POW 728

To be supplied later.

R 12301

POW 729 +5V Module.

To be supplied later.

R 12303

POW 731 +12V Module.

To be supplied later.

R 12304

POW 732 -12V Module.

