# How to repair a RWN POWER SUPPLY

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### Overview

The RWN power supply is used to generate all necessary voltages to drive a **RW 1127** TWTA (traveling wave tube amplifier) or similar tubes.
These tubes can generate up to 90 watts RF power @ 10 GHz and up to 45 watts RF power at 24 GHz !
A look at the tube's data sheet will show a TW tube, designed as a 3.5 watts TV AM transmitter. Therefore special care is necessary to prevent the tube and the original PSU (RWN 320P, RWN 322P, RWN 328P.....), because they are working under “severe” conditions.

Many radio amateurs, interested in microwave, having these tube and one or two RWN power supplies. In worst case booth supplies are damaged and nothing works.... But even, if the supply works, its hard to understand what can be done, if a failure comes up.

The tube needs excessive voltages !!!! ~4900 V for the helix; ~2600 V for collector 1, ~420 V for collector 2 and ~4800 V as the grid 2 voltage.

All voltages are generated inside the tiny RWN box and the RWN itself is driven from a 24 volt ….. 60 volt DC power supply having 10 A load capability.

The RWN PSU does **not work** without a tube connected at the HV-connector, due to the tubes internal “fail-save” bridge (INTERLOCK) at Pin 54 and 60.

### Attention:

ALLWAYS connect the PLUS or MINUS pole from the main DC power supply to the RWN PSU box. Otherwise the RWN can be destroyed !!! (refer input connector drawing)

Each RWN consists of **seven !!!** independent power-supplies; two of them are switched types.

**Be VERY careful if you work at an open RWN power supply; especially if you do not fully understand where HIGH VOLTAGES occur !!!**

**If you don't have the right tools or test equipment, take extra special care always !!!!**

# The author is not responsible for any damage or health risk !

**Preamble:** (please refer to the RWN circuit diagram enclosed)

To generate the high helix voltage close to 5000 volts, the Coll1 PSU (~2400v), the Coll 2 PSU (~420v) are “stacked” together with the Helix PSU (~2100v) to form the helix voltage. This voltage must be very stable and therefore the Helix PSU is regulated by the Helix-Control Bord #900.
The RWN PSU itself try to stabilize the Coll 1 and Coll 2 voltages under various load conditions by varying the output voltage of the Power Unit #400. Due to the stacking, the voltage of all three individual HV PSU`s varies over a wider range. This will be compensated by controlling the output of the helix PSU by monitoring the HV sum, keeping the final helix voltage very constant in a range of a few volts (at 4.88 kV !!!)

The G2 voltage is part of the helix voltage and gains from the stabilization process described above.

The DC filament voltage of 6.3 volts is formed by IC801 (TDC0723) at board #800. **Please be aware, this voltage is at cathode level of 5000 V !!!!**

1. **AUXILARY supply**

The “first” supply, the so called AUXILARY supply, is a simple series regulator, and often a source of big trouble. It is formed by T001, a BD649 or similar. This supply is necessary to “start” all internal processes of controlling partly the other supplies.
To guarantee the large allowed DC input range (at earlier commercial applications used by Deutsche Telekom) from 24 …. 60 volts the developer therefore used a simple series transistor with high E/C voltage and zener diode in a straight forward design, to generate +15 volts as a starting voltage. Any 7815 device will do the job **too**, but cannot tolerate 60 volts at their input.
Sometimes I exchanged the broken series transistor (BD 649) by a 7815 voltage regulator in series with a 24 V /1W zener diode with the similar overall result.
The reason for a shorted BD 649 mostly is a shorted (tantalum) capacitor C128 at his base or a tantalum capacitor a bit more distant, but at the AUX +15 v line.
In this case, ALL parts in the AUX power supply are destroyed, because its **NOT** safe against shorts at their output (wrong design !). If additional tantalum capacitors at the AUX line having a short, sometimes DR109/DR110 inductors burned down too !

**POWER UNIT 400**

The next very important part in the whole RWN supply is a step-up converter called POWER UNIT. The output voltage can be preset in 4 steps.
This converter is basically a “big” choke DR 001, periodically shorted to -V by the power transistor T400 (BUX 21) and a rectifier series power diode (GR400) (1N3893 / BYV30/200) to load C130/C107 to 78 volt (under idle conditions).
This unit is used to “generate” a pre-stabilized high current DC source from any DC voltage in the range of 24 – 60 V. With TWT cathode current (TX position), the output voltage of the power unit can be raise up to 105....110 V DC.
If the power transistor fails, no more DC output is present. Even if there are no drive signal

at the PWM input (X1/21), generated by MODULATOR #300, no DC output at X1/18 is present !

**MODULATOR 300** and **REGULATOR 200**

The power transistor T400 uses a transformer as regulator input, coupled to their base, and driven by board 300 (PWM) Modulator and controlled by board 200 Regulator.

Two different versions of board #300 exists:
**Version 1** contains a MC3520L PWM controller chip and the regulator board contains all additional error amplifier for voltage and current regulation.

**Version 2** contain a UC 1550 AJ PWM IC with **in build** error amplifiers. Therefore his board 200 is VERY simple and contains a voltage divider from Vs (+78V) and a 120V “OVERVOLTAGE” clamp zener diode only. This is a protection for much to high voltages, generated by the power unit.

Both versions driving T301 (board 300) for 12 volt PMW pulses from connector X3/2 to X1/21.

All what is described above is necessary to keep a constant voltage of **78 Volt** at C130/C107, regardless any variations of the input DC voltage (in a range from 24V … 60V). A second function of board 200 is to monitor the current needed by the tube (R141/ 20 Ohm) and raise this primary voltage up to **112 Volt** under heavy load current to compensate for transformer and rectifier losses. As pointed out before, the 120V Zener diode clamp prevent from over-voltage.

Errors in the Power Unit are very seldom – but at board 200 and 300 sometimes trouble happen. Mostly the tantalum C's at the 12 volt line having shorts and they can damage DR109 / DR 110 on the main board due to excessive current.
Other errors can be introduced by altering ohmic values of resistors.
Having a nonfunctional RWN at the bench, its a good idea to remove Inverter-board #500 and/or the Collector 1 and Collector 2 board #600 first, **to prevent from any other shorts** !!!
This can be done without influences of the functionality of the remaining power-supplies. In this case Collector 1, Collector 2, G2, Helix-voltage and filament voltage are NOT present.

**INVERTER 500**

The inverter board contains two different parts: the half-bridge inverter itself and a +12 Volt and a -12 volt power supply to feed the Helix-Control-Board #900.

This half-bridge inverter oscillates with help of a saturation transformer TR501 and two power transistors BUW51 a bit higher than 28 kHz and uses the 78 volts primary DC voltage Vs(named Intermediate Voltage) to “feed” transformers TR101 and TR102 at the main board and transformer TR801 and TR802 at the Helix-Voltage board #800 with a rectangular voltage of half the DC input voltage Vs.
This transformer technique decouples all further power-supplies in the RWN from the outside world. (C1, C2, Helix and Filament)

The half bridge inverter contains the TR50 transformer, two power transistors T104 and T

105 (both BUW51), some diodes, a thermo cutoff switch and T503 to switch HV on and off.

This inverter board also contain a small +12V and a small -12V power supply (nominal values / higher in reality) – always a source of trouble. The tantalum capacitors used, are often shorted due to the sharp rise and fall times of the input signal (from transformer T102) and damaged other parts easily, including rectifier diodes from GR103, GR106, and sometimes the transformer itself !!!!!

It might be a good idea to change immediately ALL capacitors close to IC501 (TBD7812 T) and T502 (2N2904) against modern LOW ESR capacitors.
This is necessary for the +15V line at the Control Unit board #1000 too and at the Helix-Voltage transformer and HV-rectifier (with heater circuitry) at board 800 too !!!

A very important thing is the HV “security” blocking at the inverter board pin X5/6 (HV-) and pin X5/7 (HV+). These pins are connected (via X10/6 – X10/7) to the contacts of Relays 1000 (at board 1000) and the opto-coupler T1003 (BCY79) close by.

Normally the contacts are closed and saturate T503 (BF391). This transistor shorten, with help from GR505 …. GR 508, pin 1 and 12 of the saturation transformer T501 on board 500. The inverter is blocked and cannot start. Connect a push button between Pin 3 (+RESET) and 5 (+15 AUX voltage) of the input connector. This is necessary to RESET the PSU if the error counter blocks the HV start !
*Do not forget to connect Pin 6 (-Ub) to Pin 10, 11, 12 (for DC return).*
*At the same time a LED in series with a 1.5kOhm resistor can be connected to Pin 2 (+IND) of the input connector and to Pin 5 (+AUX) to watch out the ALARM (Pin 4 ) condition (meaning HV off). A PTT switch at Pin 4 (STBY/TRANS) to Pin 4 switches the PSU into the TX condition.*

As pointed out before, connecting a tube will short the “fail safe” loop ( INTERLOCK) by connecting X10/3 with X10/9 and activate Rel 1000 at the Control Board #1000. The contact open, T 501 open and the transformer TR501 at board #500 is not longer more blocked.
Diode GR 102 (1N4935) and trigger diode GR122 (BR100/03) immediately starts the inverter at board #500 to generate a alternating voltage for several transformer. The transformer are connected to the switched voltage between the summing point of C110/C111 and via DR104 (15uH) to X5/11; the collector of T505 power transistor.

**Collector 1 and Collector 2 voltage #600 (rectifiers/filter board) with current indicator**

Its a good practice to connect NOW a 100uA panel-meter with series resistor between Pin 9 (Ik) and Pin 8 (GND) to watch out the cathode current in TX setting.
Also a 100 uA panel-meter with a series resistor should be connected between Pin 1(Ih) and Pin 8 to monitor the very important helix current !
I cathode monitor: 10 V at 100mA Ik, 15 V at 150mA Ik (max. 130 mA)
I helix monitor: 1V at 1 mA Ih, 3V at 3mA Ih (max. 2.8mA !!)

The #600 board rectifies the rectangular voltages generated by the main transformer TR101 (secondary winding C1 and C2). C1 feeds a HV full wave bridge, formed by X40FG diodes GR600....GR603.
The output (green) wire passes another HV X40FG diode (prevent of reverse voltage), is feed through IC1 Overload Switch Off Circuitry and end up at the HV connector Pin 51

(COLLECTOR 1 voltage). C1 is present between collector and cathode.

If heavy overload or over voltage (bad regulated Inverter #400 / Vs > 110V) or sparks having occurred, sometimes GR604....GR607 diodes are damaged (UF4007 / fast switching model !! for lower power dissipation at rise and fall times).
Very seldom GR600 ….. GR603 are damaged, if happen – than mostly from sparks or excessive collector 1 overload over longer times. I never had failed HV capacitors or damaged resistors at board #600.

*This Overload Switch (limits C1 @ 31+/-2 mA) must be disconnected for HAM-usage. This can be done by disconnecting the orange wire from Helix-Control board #900 !!*

Winding C2 of transformer TR101 on main board generates the C2 voltage. The corresponding AC inputs at board #600 are X6/3 and X6/4. In series with this input the cathode current telemetry monitor is formed by the current/voltage converter TR601 and bridge rectifiers GR104/105 and GR126/127. A current up to 150mA can be monitored.
At the output line of the C2 power supply a current indicator (R441) monitors the demand of cathode current (the Collector 2 current is part of the cathode current) and transfers the result by the red (Y) and blue(Z) wire to the regulator circuitry on board #200.

With increasing C1 current (increasing RF input !!) the pre-regulated DC output is increased from 78V......110V to overcome ohmic losses from HV transformers and HV rectifiers to keep the resulting HV voltages constant or shift the to the values needed !

The voltage C2 is connected between cathode and collector 2.

**Voltage Limiter**

The blue block close to the board #600 contains a stack of six high voltage zener diodes ( 6 x 440 volts) and the 5kV reverse blocking diode X40FG and is often a source of error. This block is mounted at the basic PCB and mechanical very close to the ground potential. Sometimes the bad insulation of this block occur sparks to ground and damaged their internal diodes. Its hard to measure them, because the zener voltage is in 2.7 kV region. But at HAM usage its possible to reject the blue block totally by connecting and insulating carefully the remaining colored wires !

**G2 voltage 700**

This board contains a transistorized stacked combined voltage divider (output yellow wire) acting as current amplifiers and is used to set the G2 voltage and therefore the control of the cathode current. (red knob at front side)
The G2 voltage is temperature compensated using a NTC-resistor build in in all tubes and prevent from Ik drift at different tube temperatures.

The only known failure is a potentiometer slider failure. Ask JA4BLC how to repair this VERY seldom failure !

**Helix-Voltage 800**

This board contains the **Helix** power supply and the **Filament** power supply. **BE AWARE:**

the 6.45 volts filament supply is located at **cathode level of minus 4880 volts.**
One CANNOT measure very easy the filament voltage, because of presence of the **5 kV** helix voltage anytime, even if the board #600 (C1/C2 voltage) is NOT present !!!!
A save way to measure the filament voltage is to disconnect board #600 and delta H from Helix-Voltage board #800.

Be careful !!!! A part of the helix voltage ( 2500 V) made by transformer TR802 is still present at board #800 !!!! Use caution using meter clips or wires !

**Helix-Control 900**

This control unit contains 2 parts:

The low voltage part and a medium voltage part with the power transistor T003; both parts separated by a OC900 (SFH601) optocoupler.
As pointed out before, the **Helix Voltage** must be extreme stable. Therefore this voltage must must controlled and regulated according to the various load conditions.

R142 monitors the actual value, the set point of the error amplifier can be changed in steps according to the various tube data. The calculated delta data are transferred to T 003. This high current transistor influences the energy density in TR 802 at board #800.

R120 monitors, with help of the helix-control electronic, the helix current. This error signal is evaluated by two comperator and one integrator. Comp #1 changed his output, if a dangerous level of helix current is exceeded and trigger Pre-Alarm, Comp #2 is triggered at the max. level of Ih and immediately switch on the integrator which follows.
This integrator calculates the current/time product and cut off HV if a certain charge amount of the thin helix is reached.

**Control Unit 1000**

This unit contains:

- A Block System, to prevent from HV if no tube is connected
- The pre-heating timer, preventing from HV before 60 sec and TX on. If HV is switched of < 5sec by any fail save circuit, this timer is NOT activated again. HV off time > 5sec starts the timer again and blocked HV for 60 sec.
- Prevent from rising G2 at the same time as Uh (Helix voltage) to omit unstable overload conditions.
- A counter counting multiple overload conditions. After 8 automatic Resets the RWN would be completed switched off.
  The last automated Reset (#8) triggers the INDICATOR, shown at output (Pin 10 / input connector)
- Generates every two hours an automated reset of the error counter, erasing earlier counted errors.

  This board contains a lot of tantalum capacitors, which should be all exchanged by low ESR capacitors. Shorted devices will affect and damage the AUX power supply.

No other failures from board #1000 are known.....

**IC1 Overload Switch Off Circuitry**

As pointed out before: This circuitry can omitted by disconnecting the orange wire from #900. No other failure known.....

*The following text in German language is a description how to proceed, if the Half-Bridge Inverter at board #500 doesn't work, but electronic parts seems to be all OK.*
*In this specific case of a*

**Power-Supply Siemens RWN 320P # 001376** *(DL7YC spare part)*

*the switched Inverter does* ***NOT*** *work properly (as in other PSU`s of the same type) starting with Vs voltages > 65 V at C107/C130.*

*Dieses Netzteil dient in erster Näherung als Ersatz, wobei der INVERTER nicht voll funktionfähig ist !!!*

***ACHTUNG !!!***

***Nur OFFEN und unter Beobachtung mittels Oszillograph an der Anode von GR400 (BYV30/200) betreiben. Die Platine #300 Modulator "pulst" und erzeugt teiweise gefährliche hohe Vs Spannungen (> 120 Volt), die dann Überschläge in anderen Netzteil-Abschnitten zur Folge haben !***

**Der Hauptfehler besteht in einem schlecht schwingenden Inverter-Board #500**. Der Inverter schwingt erst bei Eingangsspannungen Vs > 105 Volt an. Um diese relativ hohe Spannung (Regelfall Voll-Last) schon im Idle-Fall zu erreichen und ein Anschwingen des Half-Bridge Inverters zu ermöglichen, wurden folgende Maßnahmen ergriffen:

Board **#200** (PWM Erzeuger mit MC3520L und 741 Error-Amp): Die Strom-(I) und Spannung-(U) Regelkreise wurden an GR202 und GR205 an ihrem Summenpunkt Ureg unterbrochen. Eine weitere 1N 4148 wurde an diesem Punkt zur Fremdeinspeisung Ureg angelötet. Der MC 3520 wurde mittels Spannungseinspeisung getestet (ca.6V) und durchläuft seinen gesamten Pulsbreiten-Einstellbereich (Totzeit) einwandfrei. Die eingestellte Totzeit bestimmt später die Höhe von Vs.

Die Referenzspannung auf **#300** wurde mit P300 exakt auf 5.0V eingestellt. Der PWM-Totzeit-Regler P301 wurde genau so (nahe Rechtsanschlag) eingestellt, daß der Inverter #500 gerade anschwingt.
Die erzeugte Vs Spannung liegt dann (temperaturabhängig !!) bei ca. 108.5 Volt. Das ist ohne Belastung des Netzteil gefährlich hoch !!!, weil nach Tranformation durch T101 und T102 SEHR hohe Spannungen an den Sekundärwicklungen der Trafos T101 unf T102 entstehen.

Die Netzteile HELIX (Bord #900), C1 und C2 (beide auf Board #500) sind hintereinander geschaltet, wobei +Helix Massepotential und -C2 Kathodenpotential hat.

Um diese Summenspannung OHNE Belastung (im Reparaturfall) nicht auf Spannungen >

5000 Volt ansteigen zu lassen, wurde die BR600 im C1 Netzteil geöffnet. Damit fehlt die (auch zu große) C1 Spannung im “Helix-Stack” ohne die physische Primär-Kette der Netzteile zu unterbrechen. *Erinnerung: Das Netzteil ist primär nicht geregelt !!!!*

Board #200, #300 höchstwahrscheinlich in Ordnung. Um eine Fehlfunktion des Power-Netzteils #400 (Erzeugung von Vs) auszuschließen, wurde der Leistungstransistor vorrübergehend gegen einen BUW52 ausgetauscht. Die Mechanik ist nur provisorisch !

Das Inverter-board #500 muss ausfühlich untersucht und repariert werden, damit es ab ca. > 65 Volt Vs einwandfrei anschwingt !

Das C1/C2 Board **#600** arbeitet einwandfrei. Nach Reparatur des Inverters #500 muss die Brücke BR 600 wieder geschlossen werden. Bei ca. 109 Volt Vs wird eine C2 Spannung von ca 950 V (anstatt 400 V) erzeugt. C1 wird mit ca. 800V angezeigt (durch Limiter durchgeschleift von C2 ???). Bei abgezogenem schwarzen Stecker (delta H) wird an delta H -4,2 kV gegen Massepotential angezeigt.

Das Board **#700** ist von der geregelten Helix-Spannung abhängig, arbeitet einwandfrei und läßt sich über den gewünschten Bereich einstellen.

Das Board **#800** trägt das Heiznetzteil und den ungeregelten Teil des Helix-Netzteils und läuft einwandfrei.

Auf dem Helix-Control Board **#900** wurde zu Testzwecken zwischen dem Ausgang des OP MC1747 (IC901) und dem Widerstand R915 (604 Ohm) eine gelbe, auftrennbare Brücke zur Fremdeinspeisung der NEGATIVEN Helix Regelspannung *temporär* eingefügt.
Diese Spannung wird mit dem LINKEN 10-Gang Wendel-Poti eingestellt (Href)
Speist man nun ca. 2.5 V (bei offener gelber Brücke) In den R915 ein, muß sich die Helix-Spannung ändern. Unter 2.0 Volt beträgt die Helixspannung ca. 2kV und kann mittels der, vor dem 600 Ohm, eingespeisten Spannung, auf bis zu 4.5kV erhöht werden !!

Die Helix-Spannung wird bei geschlossenem Regelkreis (alle Netzteile I.O. / Spannung an RM ca. 0.1 Volt) durch Vergleich von Uref und der Spannung an RM 50M Ohm / ca. 61K Ohm (Netzwerk-Summen-R) als Differenzregelgröße gebildet. Dabei kompensiert +6.0V Uref die -6.0V an RM und die Regeldifferenz wird in den Error-Verstärker IC901 eingespeist, der die Helix-U so regelt, daß an RM 0 (null) Volt entsteht.

Der Fehler besteht demnach mit hoher Wahscheinlichkeit weiterhin auf dem Half-bridge Inverter board !!!!!

**Erst nach erfolgter Reparatur von #500 (Inverter) kann man die Helix-Regelung incl. Power-Transistor testen. (#800 aber erfolgreich repariert)**