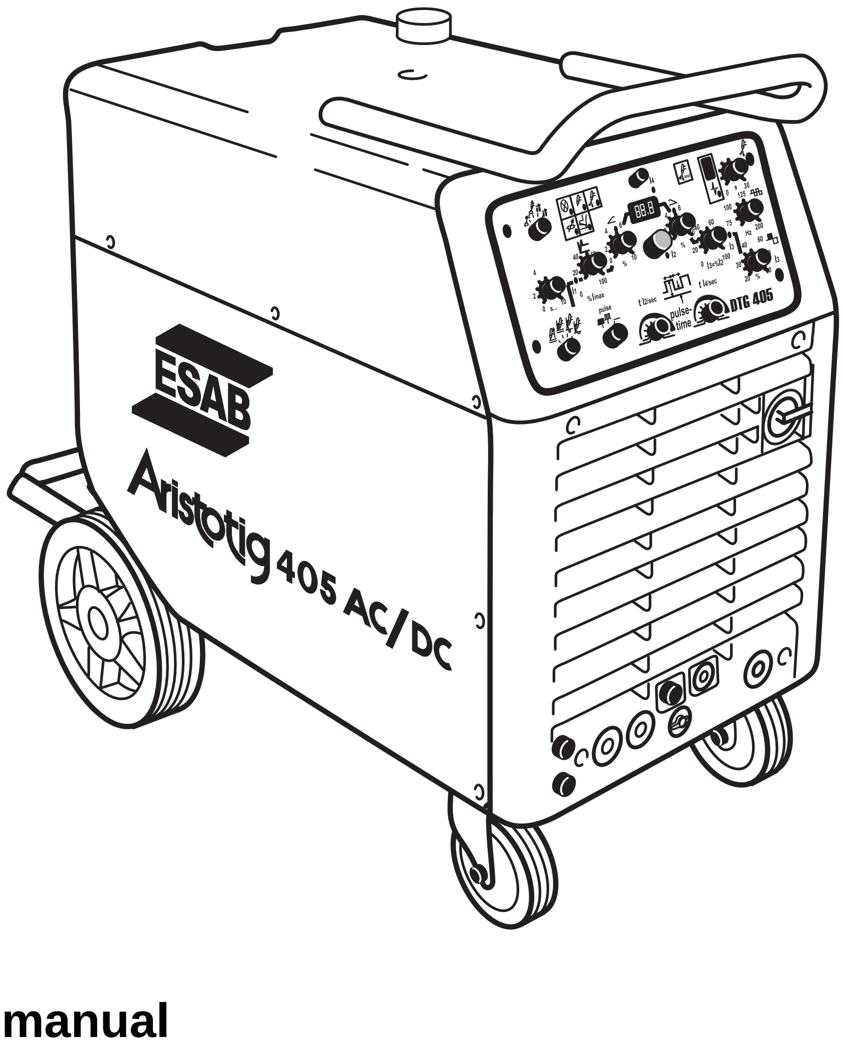
DTG 405

Aristotig 405 AC/DC

Welding rectifier



Service manual

0458 165 002 9910

CONTENTS

READ THIS FIRST

Maintenance and repair work should be performed by an experienced person, and electrical work only by a trained electrician. Use only recommended replacement parts.

This service manual is intended for use by technicians with electrical/electronic training for help in connection with fault tracing and repair.

Use the connection diagram as a form of index for the operation description and the component description. The circuit board is divided into numbered blocks, which are described individually in more detail in the operation description. All important component names in the connection diagram are listed in the component description.

This manual contains details of all designs that have been made up to and including August 1999. Rights reserved to alter specifications without notice.

NOTE! All warranty undertakings given by the supplier cease to apply if the customer attempts to rectify any faults on the machine during the warranty period.

THE DTG 405 IS DESIGNED AND TESTED IN ACCORDANCE WITH INTERNATIONAL STANDARD EN 60 974-1 (IEC 974-1).
ON COMPLETION OF SERVICE OR REPAIR WORK, IT IS THE RESPONSIBILITY OF THE PERSON(S) ETC. PERFORMING THE WORK TO ENSURE THAT THE PRODUCT DOES NOT DEPART FROM THE REQUIREMENTS OF THE ABOVE STANDARD.

NOTES:

SAFETY

Users of ESAB welding equipments are responsible for ensuring that all persons working directly with the machine or standing in its vicinity are complying with all valid safety requirements.

The Safety requirements have to be in accordance with those for the particular welding equipment.

In addition to the Standard workplace instructions, the following directives should be observed

The operating of the equipment must be performed by trained personnel who are well-acquainted with its functions.

Inadequate use of the equipment may create dangerous situations for the operator or cause damage to the equipment.

1. The operator of the welding machine must be well-acquainted with:
   - the handling
   - the functions
   - the valid safety instructions
   - the welds.
2. The operator must ensure:
   - that no unauthorized persons are situated in the working area while switching on the device.
   - that all persons near the ignited arc are wearing adequate protection equipment.
3. The workplace should be:
   - adequate for any need
   - free of draught.
4. Personal protection equipment:
   - Do always wear the corresponding personal protection equipment such as for example safety glasses, fireproof clothing and protection gloves.
   - Do not wear loose-fitting objects such as belts, bracelets, rings etc., which could get caught or cause burns.
5. Miscellanous:

- Ensure that the corresponding return conduction is well connected.
- Works on high voltage equipment **must only be done by trained personnel**.
- Appropriate fire extinguishers must be clearly visible and easily accessible.
- Greasing and maintenance of the welding equipment must not be performed while operating.

WARNING

ARC WELDING AND CUTTING CAN BE INJURIOUS TO YOURSELF AND OTHERS. TAKE PRECAUTIONS WHEN WELDING. ASK FOR YOUR EMPLOYER'S SAFETY PRACTICES WHICH SHOULD BE BASED ON MANUFACTURERS HAZARD DATA.

ELECTRIC SHOCK - Can kill
- Install and earth the welding unit in accordance with applicable standards.
- Do not touch live electrical parts or electrodes with bare skin, wet gloves or wet clothing.
- Insulate yourself from earth and the workpiece.
- Ensure your working stance is safe.

FUMES AND GASES - Can be dangerous to health
- Keep your head out of the fumes.
- Use ventilation, extraction at the arc, or both, to keep fumes and gases from your breathing zone and the general area.

ARC RAYS - Can injure eyes and burn skin
- Protect your eyes and body. Use the correct welding screen and filter lens and wear protective clothing.
- Protect bystanders with suitable screens or curtains.

FIRE HAZARD
- Sparks (spatter) can cause fire. Make sure therefore that there are no inflammable materials nearby.

NOISE - Excessive noise can damage hearing
- Protect your ears. Use ear defenders or other hearing protection.
- Warn bystanders of the risk.

MALFUNCTION - Call for expert assistance in the event of malfunction.

READ AND UNDERSTAND THE OPERATING MANUAL BEFORE INSTALLING OR OPERATING.

PROTECT YOURSELF AND OTHERS!

WARNING

This product is intended for industrial use. In a domestic environment this product may cause radio interference. It is the users responsibility to take adequate precautions.

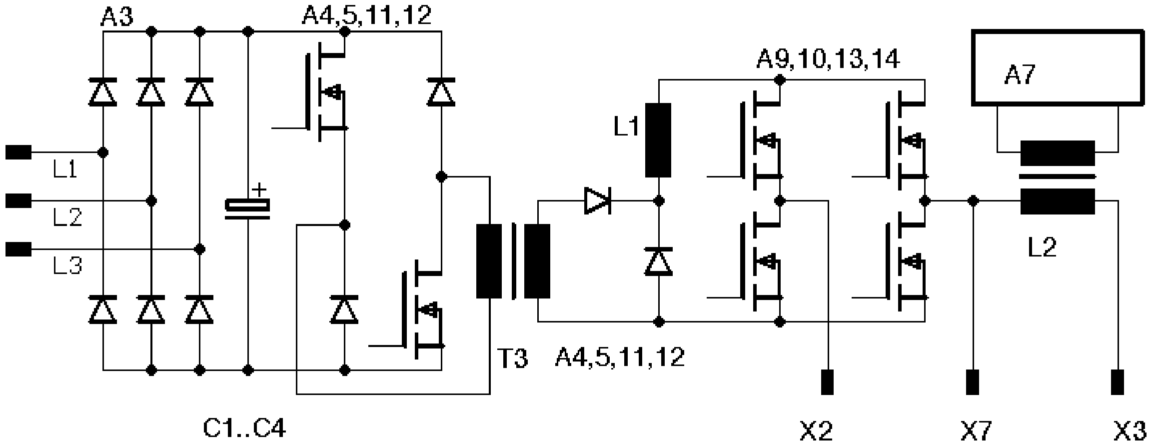
PRINCIPAL DIAGRAM DTG 405

The **DTG 405** is a primary-switched power unit, using a forward asymmetrical half-bridge switched mode power supply (A4, A5, A11, A12). A high frequency transformer (T3) isolates the mains potential (L1, L2, L3) from the welding potential. After high frequency rectification (A4, A5, A11, A12) the polarity of the output current is controlled by an AC converter (A9, A10, A13, A14, full-bridge topology). Inductor L1 smooths the current and stores switching energy.

The primary switching frequency is about 66 kHz (pulse-width-modulation, PWM). The frequency of the welding current while AC-welding is controlled from 50 Hz to 200 Hz by the AC converter. The AC converter has four MOSFET switches. If no control signal is applied, all switches are turned off. No output current is possible. During normal operation there are control signals in either forward polarity (two switches are on and two are off) or in reverse polarity.

A high voltage ignition unit (A7) is used for ignition and stabilising the arc while welding.

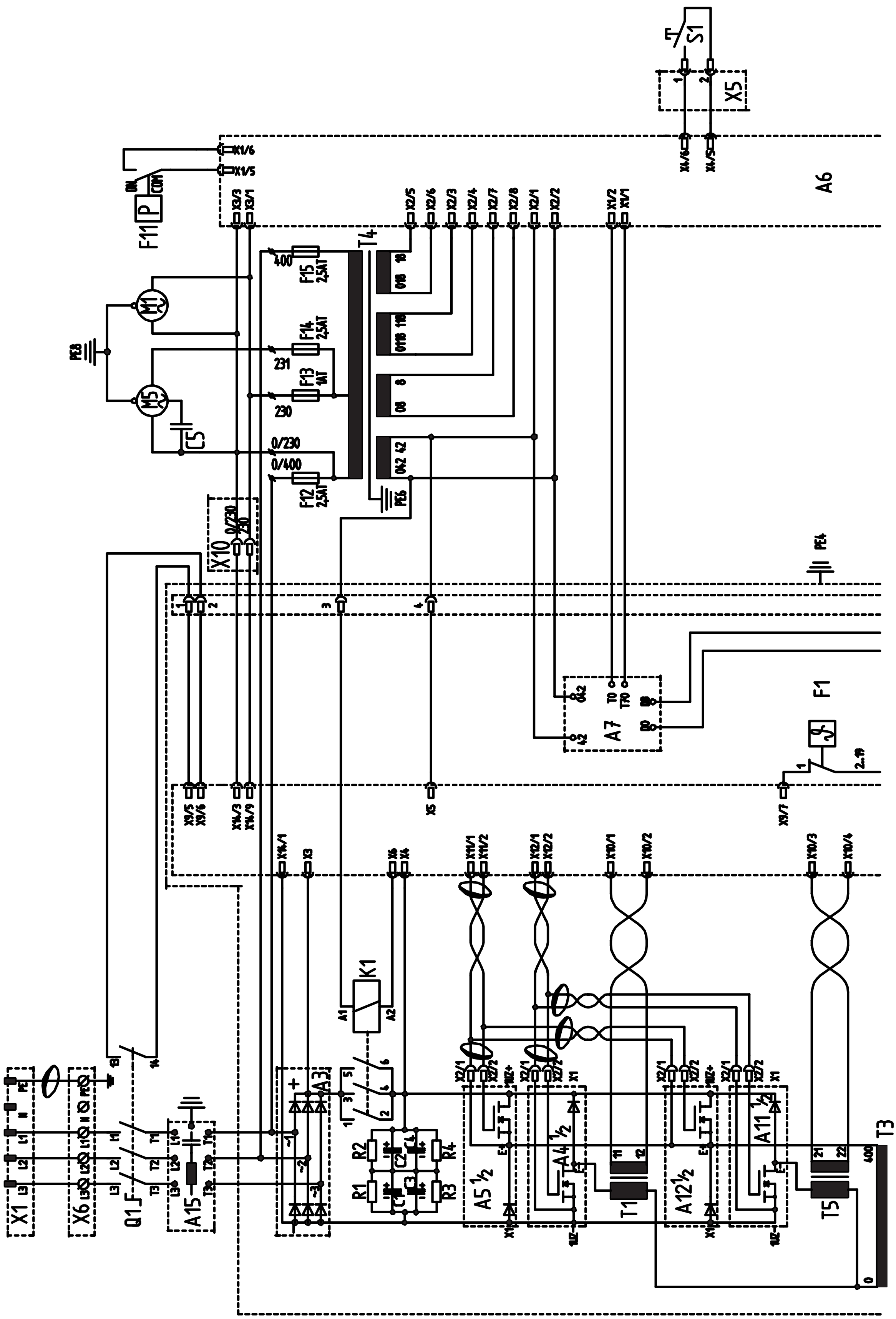
DTG 405f.pcx

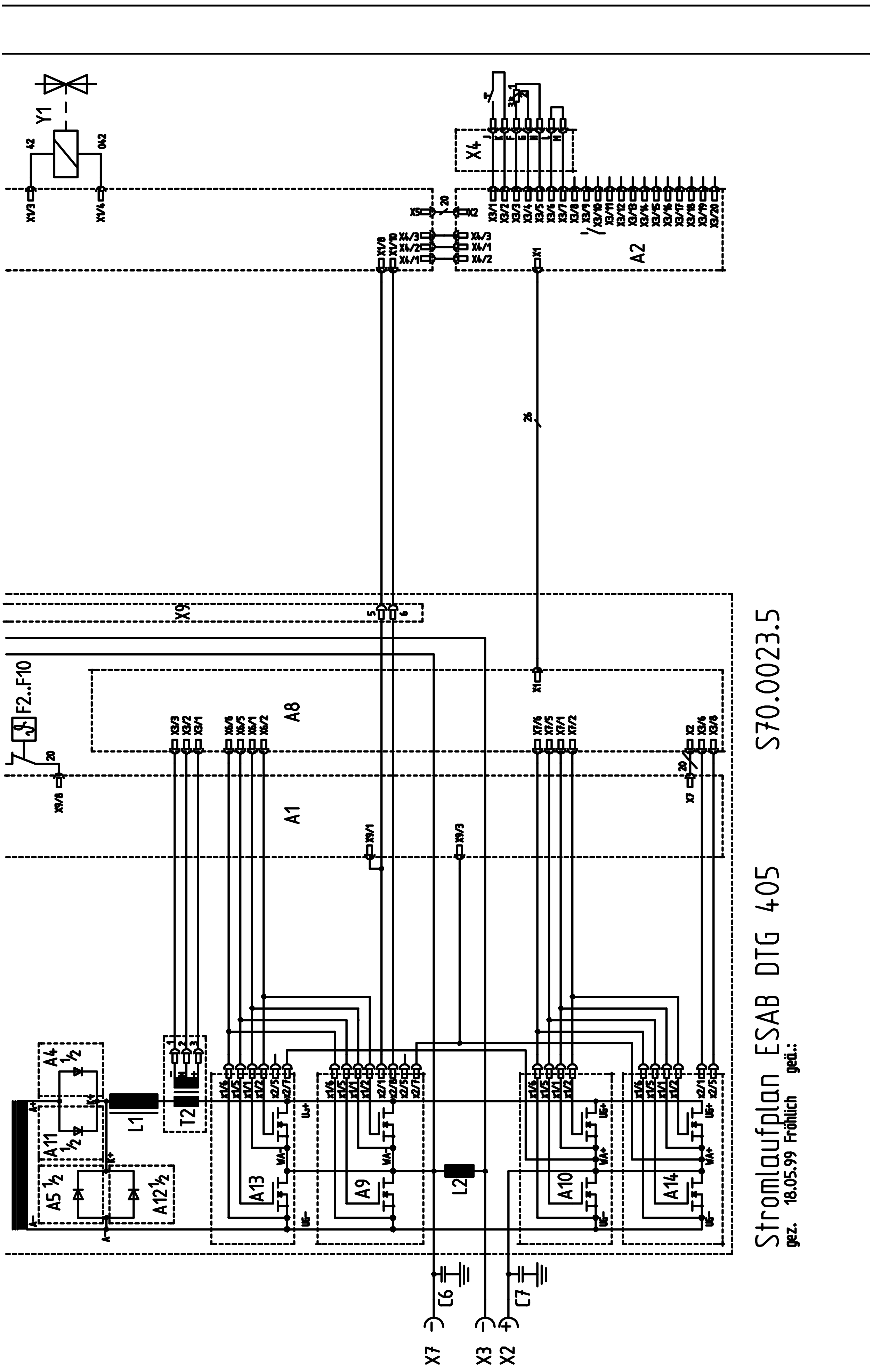


X3 is connector to TIG-torch, X7 is connector to stick holder, X2 is connector for workpiece cable.

NOTES:

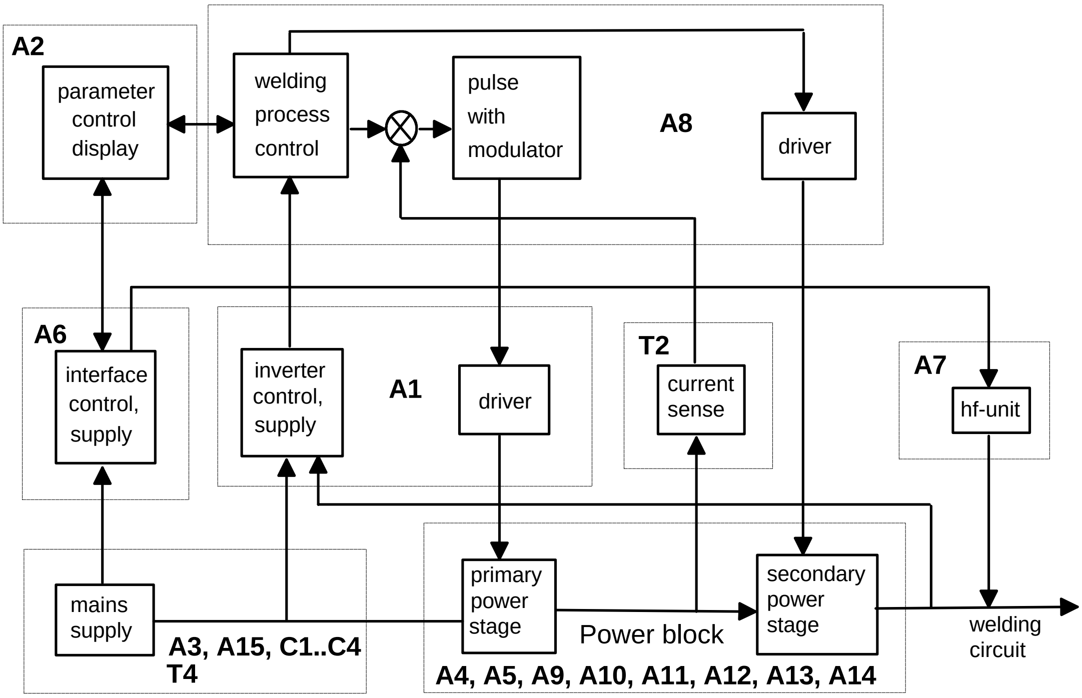
CONNECTION DIAGRAM DTG 405





Stromlaufplan ESAB DTG 405
S70.0023.5
gez. 18.05.99 Fröhlich
gez.:
Y1
X4
A2
X9
F2..F10
A8
A1
A4
A11
A5
A12
L1
T2
A13
A9
L2
A10
A14
C6
C7
X7
X3
X2

FUNCTION DIAGRAM DTG 405



COMPONENT DESCRIPTION

This component description refers to the block diagram on the following pages.

A1	Designed to ensure the basic primary inverter control, monitoring and protective functions. It comprises: • start-up circuit • primary switch mode power supply for internal supply • power supply for A8 • potential separation, primary MOSFET-drivers for A5, A12, • security logic and control for primary inverter • thermal switch monitoring
A2	Designed to ensure and manage the advanced operating parameters and mode control. It comprises: • (A2-1) input for remote control • (A2-1) sequencer control • (A2-1) current value and current slope control • (A2-1) solenoid valve control • (A2-1) HF ignition control • (A2-2) front panel analogue and digital settings • (A2-2) front panel displays
A3	Mains rectifier 75A/1200V

A4, A11	Primary power modules, low-side MOSFET, secondary rectifier, comprising: • Interconnection of MOSFET modules • Voltage suppression • Gate circuits • Secondary rectifier with suppression circuits
A5, A12	Primary power modules, high-side MOSFET, secondary rectifier, containing: • Interconnection of MOSFET modules • Voltage suppression • Gate circuits • Secondary rectifier with suppression circuits
A6	It comprises: • Supply for A2 and A6 • Potential separated torch button sense • Solenoid valve driver • High-voltage ignition control and driver
A7	HF ignition device
A8	Designed to ensure the more sophisticated primary and secondary inverter functions. Control primary and secondary inverter; it comprises: • Security of logic and control for secondary inverter • Current and voltage welding process control • Potential separation, secondary MOSFET-drivers for A9, A13, A10, A14 • Arc current and arc voltage monitoring
A9, A13, A10, A14	Secondary power MOSFET modules, full bridge AC converter, containing: • Interconnection of MOSFET modules • Voltage suppression • Gate circuits
A15	E-Assembly, power filter, interference suppression circuit board, connector to mains voltage cable
C1, C2, C3, C4	Mains buffer capacitors. Comprising 4 series/parallel-connected capacitors with symmetric resistors
C5	Capacitor for pump M5
C6, C7	Interference suppression capacitors to protective conductor
F1.. F10	Thermal switches, opening, see section A1-4 "TEMPERATURE MONITORING"
F11	Pressure switch for coolant circuit
L1	Smoothing inductor
L2	Choke, HF coupling and suppression inductor
M1	Fan, 230V AC
M5	Pump, 230V AC
Power block	A4, A5, A9, A10, A11, A12, A13, A14: Comprising the high-current / high-voltage section with forced cooling
Q1	Main switch 0/1 DTG 405
T1, T5	Current sensor transformer 200:1 for overcurrent shutdown

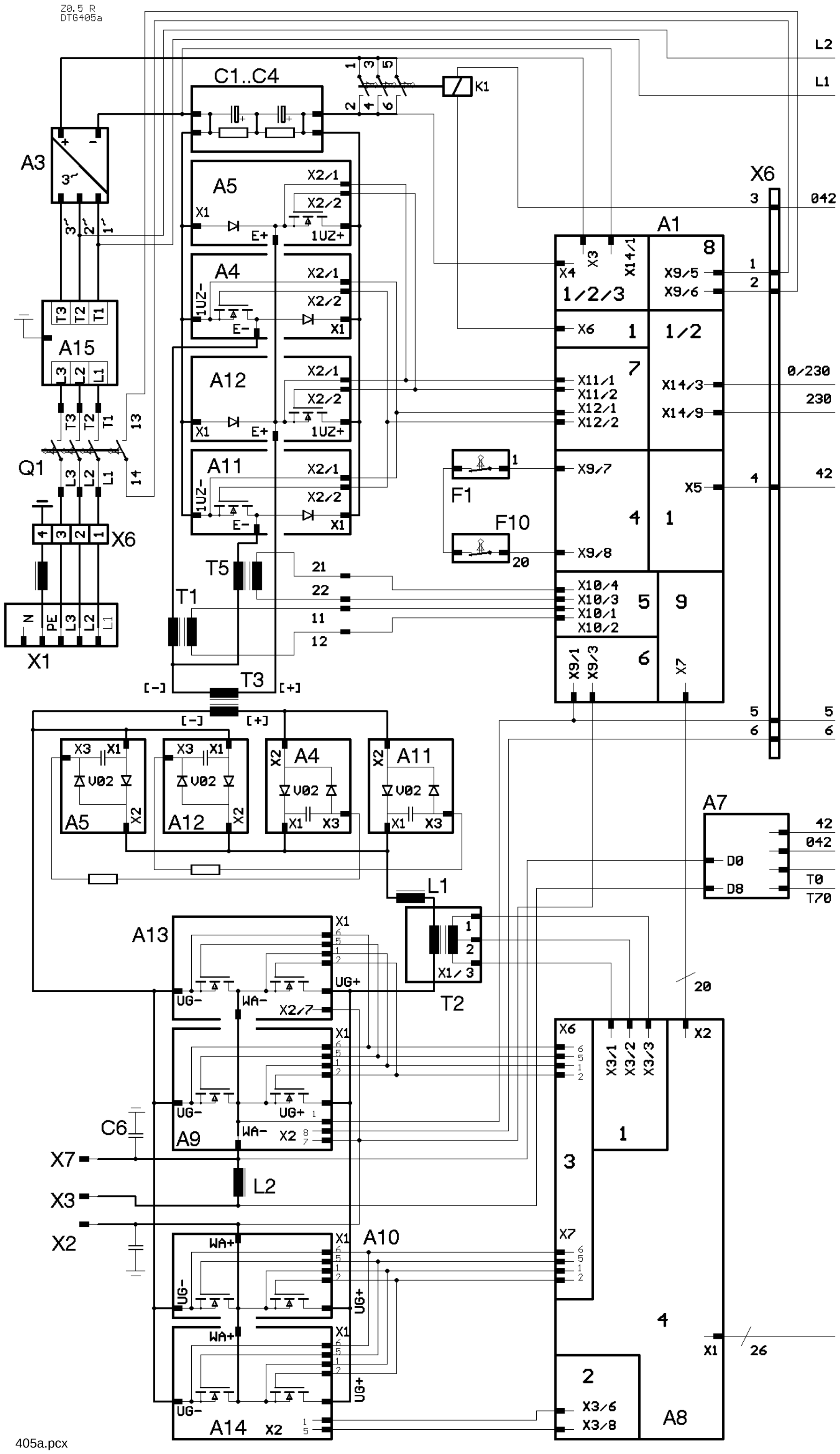
T2	DC sense transformer 2000:1
T3	High-frequency inverter main transformer
T4	Mains supply transformer, supply: • A2 • A6 • 230V AC (fans, pump) • 42V AC (solenoid valve, main contactor, HF ignition device)
X...	Connectors
X1	Mains cable
X2, X3, X7	Socket for workpiece cable, TIG torch, MMA stick holder
X4	Connector for remote control
X5	TIG torch control connector for torch button
X9	Interconnection to power block
X10	Interconnection 230V AC
Y01	solenoid valve, 42V AC

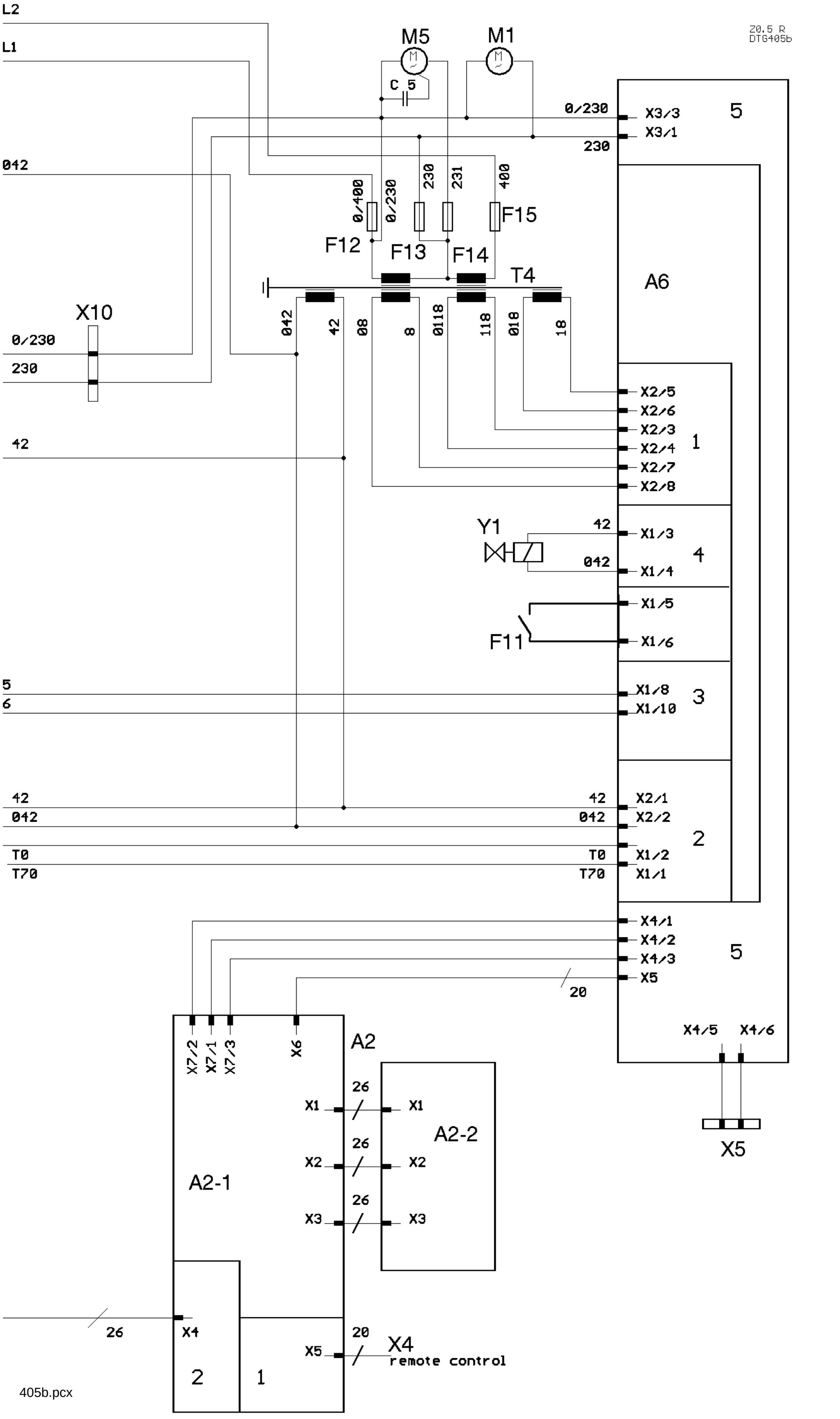
Introduction to the block diagram

Some of the circuit board components are divided into function blocks which are described in the descriptions of operation. These function blocks are shown in the following block diagram.

NOTES:

BLOCK DIAGRAM DTG 405





Warning! Some parts of this circuit are connected to mains voltage potential.

GENERAL DESCRIPTION

1 CONNECTIONS

The DTG405 unit is powered by 400 V 3-phase AC via X1; the neutral conductor is not required. For TIG welding, shielding gas is also needed and is supplied via a pressure reducer.

The welding-current sockets are designated in the circuit diagram as X2; X3 and X7. Usually, the earth conductor is connected to X2, and the TIG torch is connected to X3.

X3 contains the gas connection. The "cold side" of the HF reactor is routed externally via X7. Provision is made there to connect an electrode holder. In electrode mode, no HF ignition pulses are generated. During welding, however, no-load voltage or weld voltage is applied to the torch not in use.

If welding is carried out with electrodes tied to the positive pole, the earth conductor should be connected to X7, and the electrode conductor to X2.

Foot or hand remote regulators can be connected to the remote-regulator connector X5.

2 POWER ELECTRONICS ENERGY FLOW

The mains voltage is first routed to the mains switch Q1. When ON, the mains voltage is connected through to the power rectifier A3 via interference filter A15. Rectified mains voltage (+UZ and -UZ) is applied to the output of A3. -UZ is connected direct to the link capacitors C1, C2, C3, C4 and the primary switches A4, A5, A11, A12. At unit POWER ON, the start-up contactor K1 is open. Current flows through the start-up resistor which is installed in electronic module A1, and charges the link capacitors. (Refer to section A1-1 "START-UP CIRCUIT").

The contactor is closed after a time lag of about 1 second, thus connecting +UZ to link capacitors C1, C2, C3, C4 and primary switches A4, A5, A11, A12. At 400 V ± 10% conductor voltage, the link voltage UZ = +UZ-(-UZ) is in the range from 510 V to 620 V. When the unit is loaded, the link voltage decreases somewhat and it becomes wavy.

Primary switches A4, A5, A11, A12 switch the DC voltage at approx. 66 kHz, producing a high-frequency square wave AC voltage that is applied to the primary of the power transformer T3. Current from the two primary switch-mode modules, which are connected in parallel, is monitored through toroidal-core current transformers T1, T5.

At primary overcurrent, the control pulses on module A1 are disabled (see section A1-5). This prevents or minimises consequential damage in many cases if faults occur in the primary switches A4, A5, A11, A12, on the control boards A1, A8, in the secondary rectifiers A4, A5, A11, A12, or on power transformer T3.

Similarly, the voltage on the secondary of power transformer T3 is a high-frequency AC voltage; the frequency is identical to the primary, except that the voltage is approx. 100 V and is floating, i.e. it is no longer linked to the mains voltage.

The next stage is referred to as secondary rectifier and is physically located on A4, A5, A11, A12. It converts the high-frequency AC voltage to a high-frequency DC voltage. Because of the high frequency, the weld current can be satisfactorily smoothed by reactor L1 with a relatively small inductance.

The current then flows through the transformer shunt T2. T2 produces a floating image of the current which is smaller by a factor of 2,000 and acts as a control function on A8 (see section A8-1).

The inverter A9, A13, A10, A14 consists of a full bridge circuit with four MOSFET switches. It is capable of reversing the polarity of the DC voltage applied to its input, and it can generate at the output a DC voltage of any polarity or, in case of cyclic changeover, an AC voltage. In principle, any AC frequency can be chosen. For the DTG405 it can be adjusted in the range from 50Hz to 200Hz.

Arranged integral with the inverter module are RC elements. They serve to attenuate the high-frequency voltage pulses from power transformer T3 and block off the HF-pulses.

Moreover, high-voltage starting pulses are required so as to permit non-contact starting of the arc and stabilising the arc in AC welding. These pulses are generated in pulser A7 and fed into the HF reactor L2.

The HF reactor L2 is also referred to as a pulse gating reactor. It prevents a drop in high-voltage pulses in the inverter A9, A13, A10, A14.

3 FUNCTION OF CONTROL AND ADJUSTMENT

The welder usually starts the power supply by pressing the Torch button S1. The Torch button signal to X5 is processed on module A6 and passed on in floating mode to the control unit A2 (see section A6-5). Previously, the welder enters the settings for the welding process sequence, i.e. to control the timings of the gas valve, pulser and inverter. The weld current setting is shown on an LED display. Light-emitting diodes display whether or not the inverter has been started, which current is selected or is applied, whether the gas valve is switched, or a fault has occurred. The electronic signals used to control the gas valve and the pulser are routed to the supply and control bus to module A6 where they control the associated relays (see section A6-2 and section A6-4).

All the signals required to control the inverter are transferred over the inverter control bus from A2-1 to module A8. These include Start, Mode (DC+, DC-, AC), current reference, frequency reference, and balance reference. From A8, fault signals as well as actual current and voltage levels are reported back to the control panel over this bus.

So setpoints (references) are fed to A8 from the control panel A2. The current actual value is reported to A8 via the transformer shunt T2 (see section A8-1). The output voltage is tapped at the inverter A9, A13, A10, A14 (see section A8-2). These references and actual values are used by A8 to generate the associated control pulses for primary switches A4, A5, A11, A12 and inverter A9, A13, A10, A14 via control and regulation circuits. The control signals of the four transistors of the inverter A9, A13, A10, A14 are generated on A8 in floating mode.

The control signal for the primary switches A4, A5, A11, A12 runs over the supply bus to module A1. The two drives for the primary switches A5, A12 and A4, A11 are located there (see section A1-7).

As indicated in the schematic diagram, the primary switch and the inverter power sections each comprise two power sections connected in parallel, i.e. they are directly connected in parallel on both power and control sides.

The DTG405 is a water-cooled system. The water cooling unit comprises a water pump, a cooler, and a LOW WATER switch F11 via X1-5, X1-6. If no water pressure is built up, the LOW WATER switch sends a signal (contact opens) to the control A6 (see section A6-6). The inverter is shut down and the fault is displayed on A2. This prevents water-cooled torches from operated without adequate cooling.

The power electronics components of the primary switch, the secondary rectifier (A4, A5, A11, A12) and the inverter (A9, A10, A13, A14) are cooled by heat sinks consisting of aluminium sections. Each heat sink, as well as the transformer and the reactor, are fitted with a thermal switch F1 to F10. The contacts of the thermal switches are all connected in series. When one thermal switch opens because of high temperature, the chain of temperature switches opens. This is detected on module A1 (see section A1-4) and signalled to module A8 via the supply bus. This trips the inverter and signals overtemperature to the control unit A2 which displays the event.

4 PROTECTION AGAINST EXCESSIVE OUTPUT VOLTAGE

The DTG405 is designed for welding operations where higher-than-normal electric hazards exist.

Usually, only no-load DC voltages of about 90 V are applied to the output of the DTG405. The maximum permitted no-load DC voltage as per the relevant standard is 113 V.

No-load AC voltages cannot occur at the output unless a fault has occurred. When the weld current is interrupted, the unit promptly changes to the positive and attempts to initiate positive starting.

This complies with the hazard-minimisation features described in regulation EN60974-1.

Irrespective of this, the electronics module A1 comprises an additional safety circuit (see section A1-6). Two separate cables convey the output voltages to the connectors X9-1 and X9-3. The safety circuit is activated at zero current and monitors whether an excessive positive, excessive negative, or excessive AC voltage is applied to the output. If any of these cases occurs, a memory signal is set. It disconnects the complete inverter supply.

As a result, there is no supply to A1 and A8 and conductive control of the primary switch and the inverter power sections is disabled. This interrupts energy flow from the mains to the outputs of the power supply.

This status can only be cancelled by turning the unit OFF and back ON again.

This complies with the stipulation for "Safe Failure" described in regulation EN60974-1.

5 PATH OF THE START-UP SIGNALS

The Torch button signal passes through X4/5,6 to the module A6, where it is transferred from X4 on A6 to X7 of module A2-1 via a potential-isolated relay.

In addition, the start-up signal is generated independently on A2-1 in MMA mode. The start-up signal, together with all necessary references, passes from X4 on A2-1 to X1 on A8.

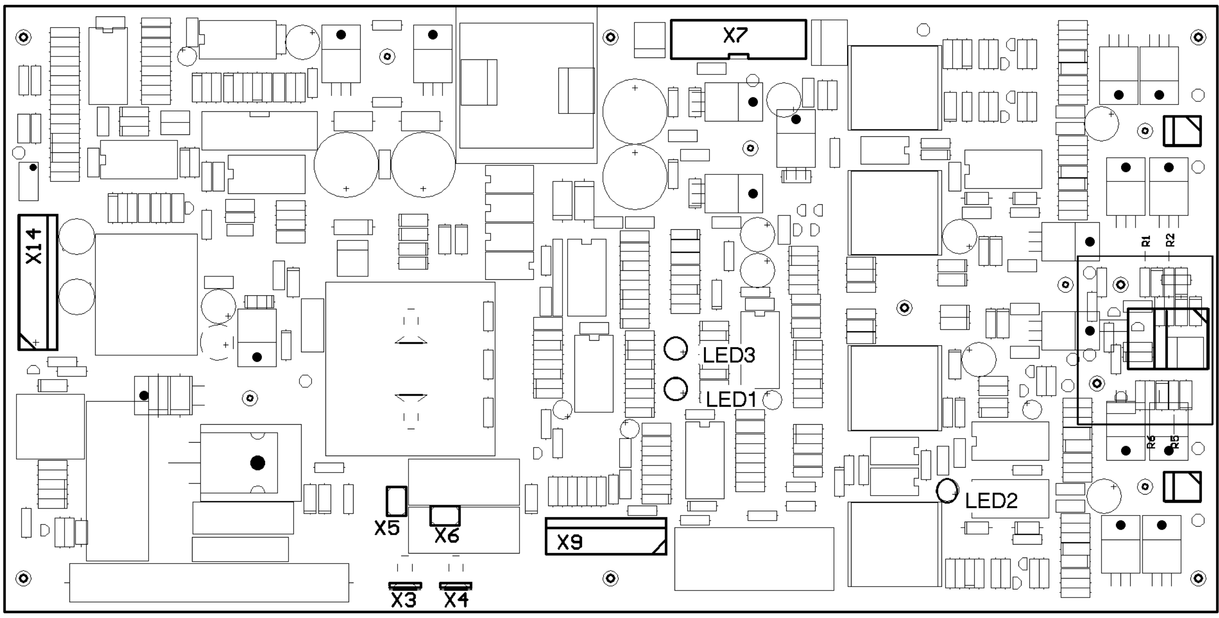
On A8, the start signal is further processed, and a PWM clock signal is generated as a function of all current and voltage references and actual values. The clock signal passes from X2 on A8 to X7 on A1. On A1, the cycle signal is potential-isolated and then amplified in the MOSFET driver stages. The control signals for the MOSFETs pass from X11 and X12 on A1 to X2 on A4, A5, A11, A12.

The MOSFETs on A4, A5, A11, A12 control the power transformer T3 as a function of the PWM clock signal.

In addition, signals for the AC converter are generated on A8. The driver signals generated for the AC converter are transferred from X6 and X7 on A8 to X1 on A9, A13 and A10, A14.

The MOSFETs on A9, A13 and AP013 control the polarity of the machine's output voltage as a function of the control signal from A8.

A1 COMPONENT POSITIONS



a1b.pcx

Warning! The circuit and its parts are connected to mains voltage potential.

Key to the LEDs on A1:

LED1, red:	Comes on when the temperature switch chain is interrupted = overtemperature.
LED2, red:	Comes on when primary overcurrent relay trips.
LED3, amber:	Comes on when the mains switch contacts 13, 14 on Q1 are open.

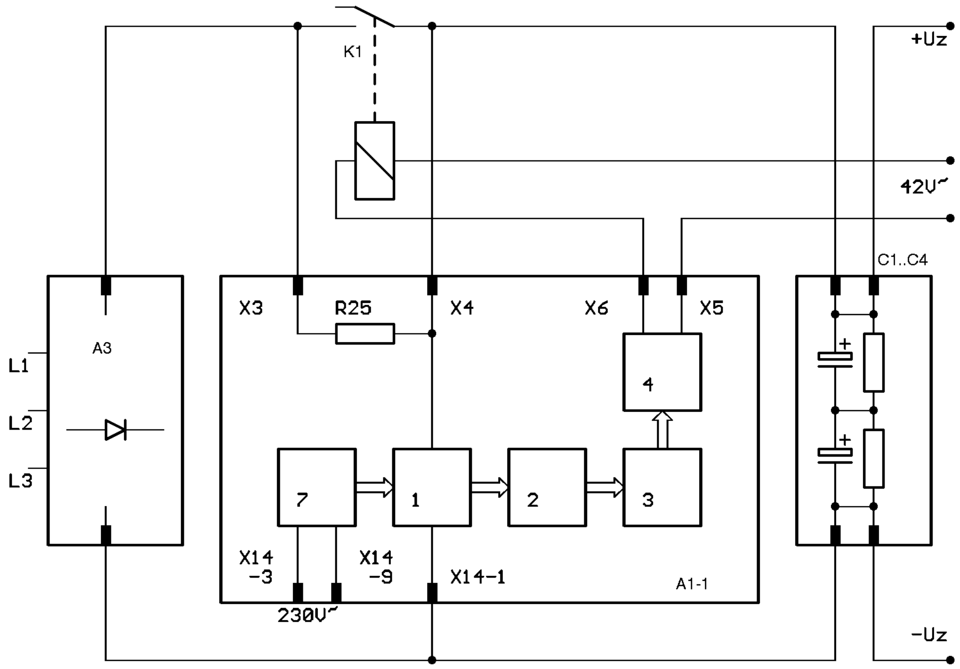
A1 DESCRIPTION OF OPERATION

The description refers to the BLOCK DIAGRAM DTG 405 and to A1 COMPONENT POSITIONS.

Only those items that are connected to the inputs and outputs of the circuit board are described here.

If there is a fault on the circuit board, the whole circuit board must be replaced. After replacing the board, the machine must soft-started as described on STARTING UP.

A1-1 START-UP CIRCUIT

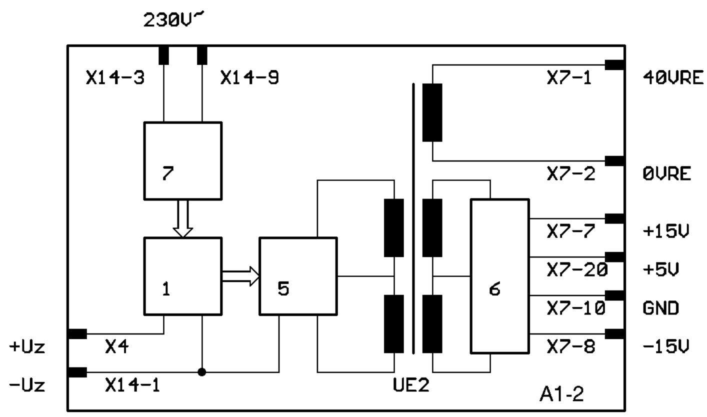


a1-1.pcx

Warning! The circuit and its parts are connected to mains voltage potential.

The voltage supplied by rectifier A3 charges the link buffer capacitors C1 to C4 to link voltage (UZ) via the charging resistor R25. A start-up circuit 7 initially powers the primary supply 1. Then, starting at a link voltage of about 40 V, the primary supply begins to work on its own. Once all the internal supply voltages have reached their setpoints, the comparator circuit 2 provides the start-up signal for a timing stage 3. After time-out of a delay of about 1 second, the main contactor K1 is closed via a switching stage 4. At the same time, the drive circuits for the inverter are enabled (see section A1-5 and section A1-7).

A1-2 SUPPLY INVERTER

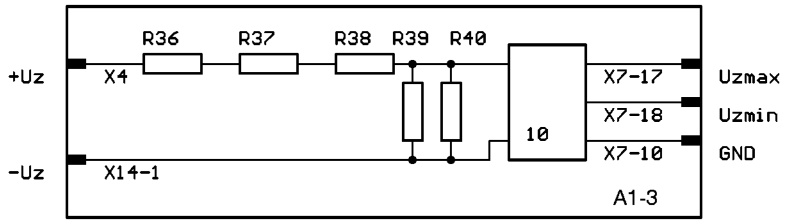


a1-2.pcx

Warning! The circuit and its parts are connected to mains voltage potential.

The start-up supply 7 is powered with 230 V AC. It starts the primary supply 1. The primary supply 1 generates a stabilised voltage of approx. 40 V. Inverter 5 in conjunction with transformer UE2 generate a potential-isolated square-wave AC voltage of 40 V amplitude acting as a potential-isolated supply for the MOSFET driver circuits on A1 and A8. A rectifier and stabiliser 6 generate potential-isolated voltages of +15 V, 5 V, and -15V for A1 and A8.

A1-3 MAINS VOLTAGE MONITORING



A1-3.pcx

Warning! The circuit and its parts are connected to mains voltage potential.

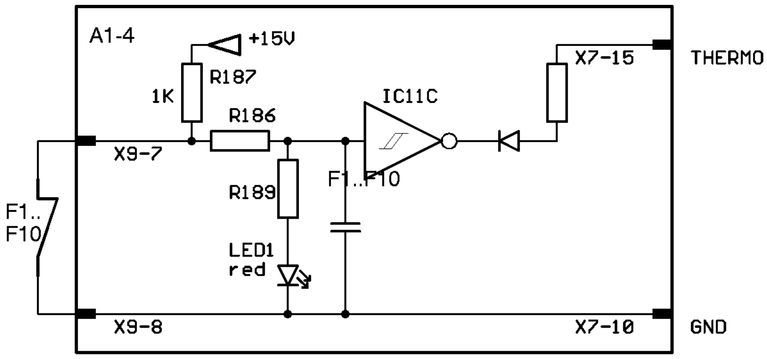
The voltage divider comprising R36 to R40 divides the link voltage UZ at a ratio of about 200:1. This voltage is evaluated by a comparator circuit 10. When the maximum allowed link voltage of 660 V DC (equivalent to a mains voltage of approx. 460 V AC) is exceeded, the signal on X7-17 is L-activated (UZmax). When the link voltage drops below the minimum of 420 V DC (equivalent to a mains voltage of approx. 300 V AC), the signal on X7-18 is L-activated (UZmin). Signals from the mains voltage potential to the potential of the control are transferred in 10 via an opto-coupler.

- Response of the unit in the event of mains overvoltage: Inverter is tripped; Error Code 3 on front panel.
- Response of the unit in the event of mains undervoltage: Inverter is tripped; Error Code 2 on front panel.

NOTE! If a minor mains undervoltage occurs, the power of the unit may decrease even if Error Code 2 is not displayed.

NOTE! If an excessive mains voltage > 500 V AC occurs starting with a link voltage UZ of about 730 V DC, the supply of A1 and A8 attempts to protect itself by performing a complete shut-down. In this case, the front display shows Error Code 5, provided the supply on A6 is not defective.

A1-4 TEMPERATURE MONITORING



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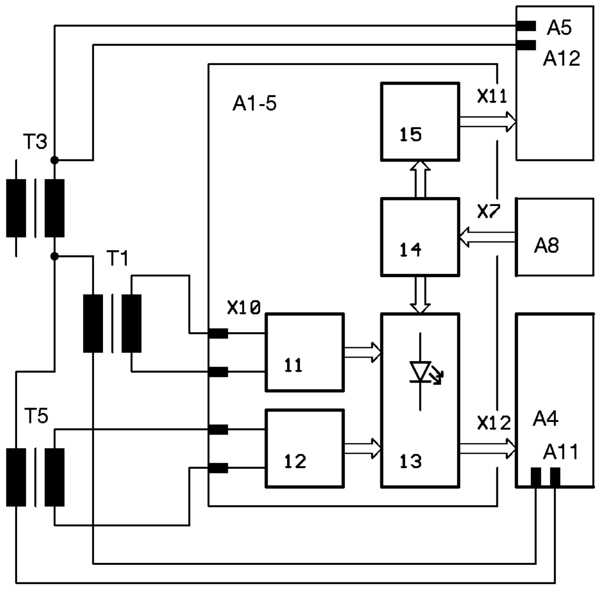
A 'chain' of thermal switches F1 to F10 is provided to monitor the temperature of key components in the system. A current of approx. 15 mA flows through the chain of thermal switches. When the temperature of a thermal switch exceeds the monitored temperature, the chain of thermal switches is interrupted. In this case LED1 on A1 comes on. The signal to X7-15 is L-activated.

A8 then interrupts the weld current and Error Code 4 is displayed on the front panel. Once the thermal switch has sufficiently cooled down, the thermal switch chain closes again. The error message is reset and welding can be resumed.

The thermal switches have different temperature limits:

- F9, F10: power transformer T3, smoothing reactor L1: 130 °C
- F5, F6, F7, F8: heat sink A5, A12, A4, A11: 90 °C
- F1, F2, F3, F4: heat sink A9, A13, A10, A14: 80 °C

A1-5 PRIMARY OVERCURRENT SHUTDOWN



a1-5.pcx

Warning! The circuit and its parts are connected to mains voltage potential.

T1 and T5 monitor the primary current of power transformer T3. When it exceeds a threshold critical for the MOSFETs on A5, A12 and A4, A11, the monitoring circuit 8 trips the Low side of the inverter half-bridge A4, A11, and the red LED2 on A1 comes on. A8 and A2 are notified of this status by the L-active signal to X7-16. Error Code 1 is displayed on the front panel. In the event of major electro-magnetic interference, the circuit will activate in some cases without any hardware fault, e.g. HF starting directly on the machine frame, etc.

But usually, a primary overcurrent trip is only initiated by a hardware fault, e.g. fault on A5, A12, A4, A11, AP10, AP11. The machine remains in tripped status until the unit is re-connected to the mains. Proceed as follows:

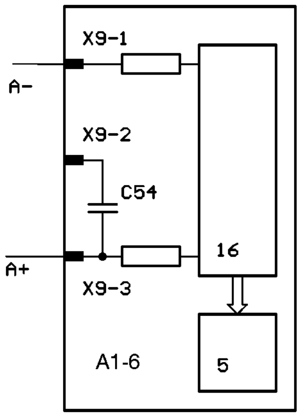
Switch off the mains switch Q1. Wait 30 seconds. Switch on mains switch again.

If the error fault is repeated continuously, check the modules in the following order: AP11, AP10, A5, A12, A4, A11, T3. Also check the electrical connections on the current transformers T1 and T5.

Cf. section "ERROR CODE 1: PRIMARY OVERCURRENT".

NOTE! T1 and T5 must never be operated with an open-circuit secondary (output). This could destroy it by flashover between the windings.

A1-6 DC-OUTPUT VOLTAGE BUFFER AND OVERVOLTAGE PROTECTION

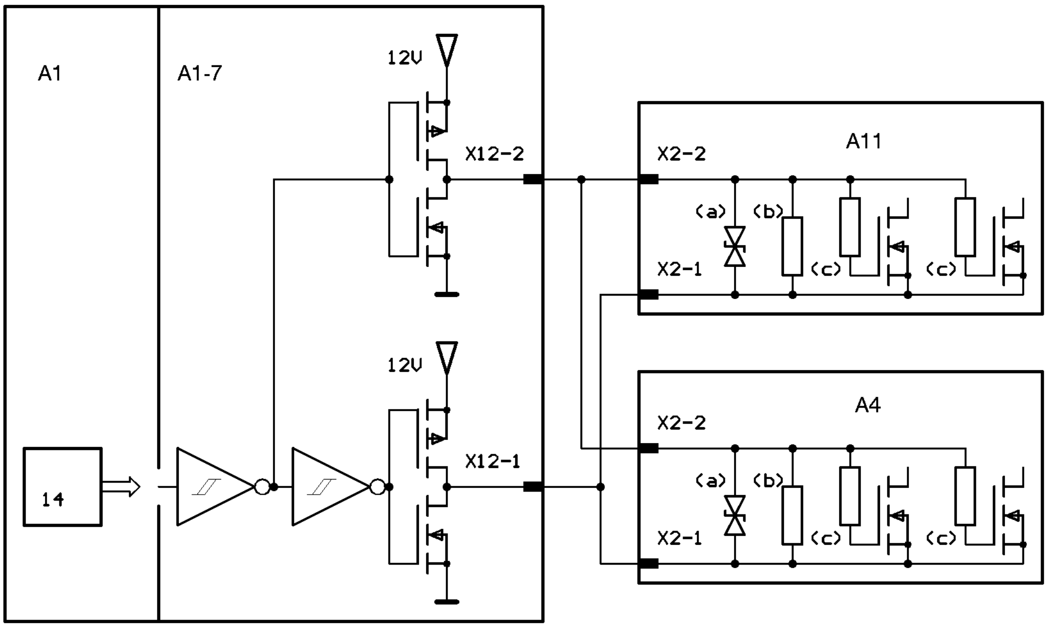


a1-6.pcx

Two separate cables convey the output voltages to connectors X9-1 and X9-3. The safety circuit 16 monitors whether an excessive positive, an excessive negative, or an excessive AC voltage is applied to the output. If any of these cases occurs, a memory signal 5 is set. It switches off the complete inverter supply.

Cf. GENERAL DESCRIPTION, 4 Protection against Excessive Output Voltage.

A1-7 PRIMARY MOSFET DRIVER



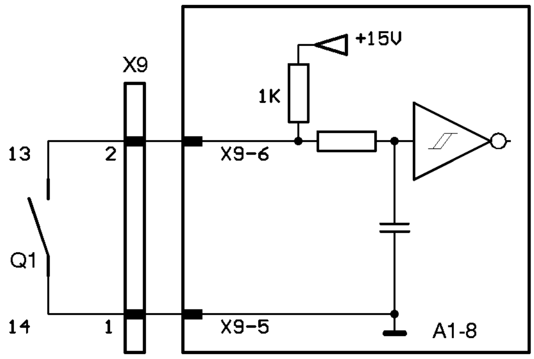
a1-7.pcx

Warning! The circuit and its parts are connected to mains voltage potential.

The Figure only shows the Low side; the High side is controlled in a similar way.

The PWM clock signal is sent from A8 to A1. A1 causes potential isolation 14 and amplifies the control signal for the MOSFETs (A5, A12, A4, A11). In the event of a MOSFET defect, also perform a function test for the driver stage A1-7 after repair on A5, A12, A4, A11 is complete. The suppressor diode (a) protects the MOSFET inputs from high voltages, and the driver stages from pulse overload in case of faulty MOSFETs. The resistor (b) provides 1 kΩ for each MOSFET group. The gate series resistors (c) have a value of 8.2 Ω for each MOSFET.

A1-8   MAINS SWITCH MONITORING

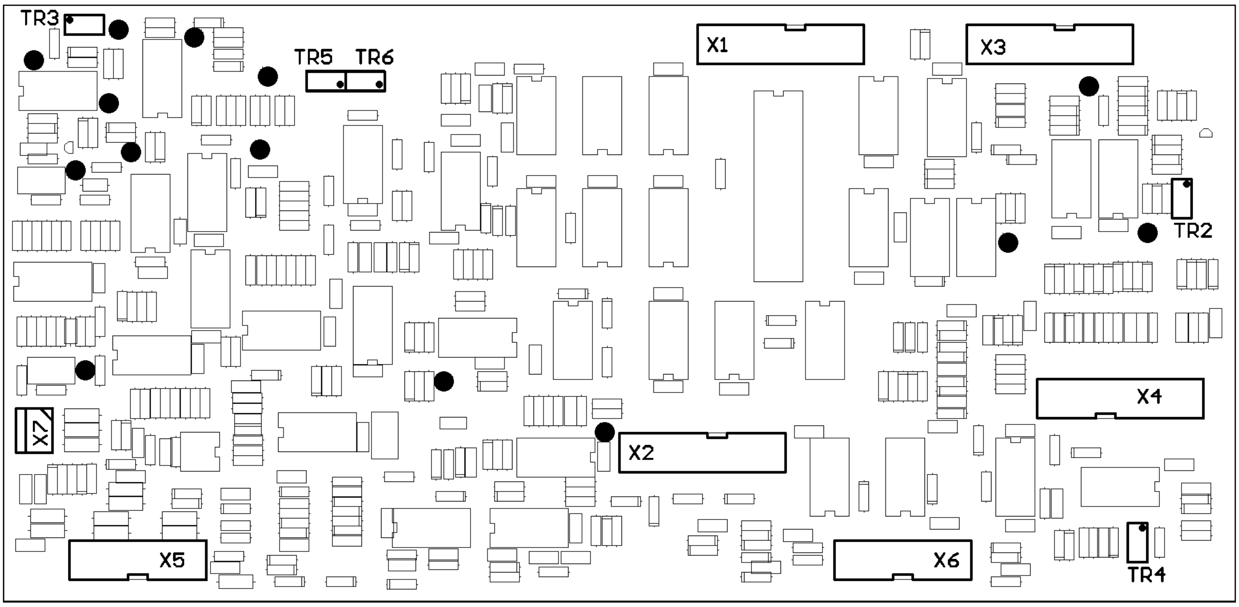


a1-8.pcx

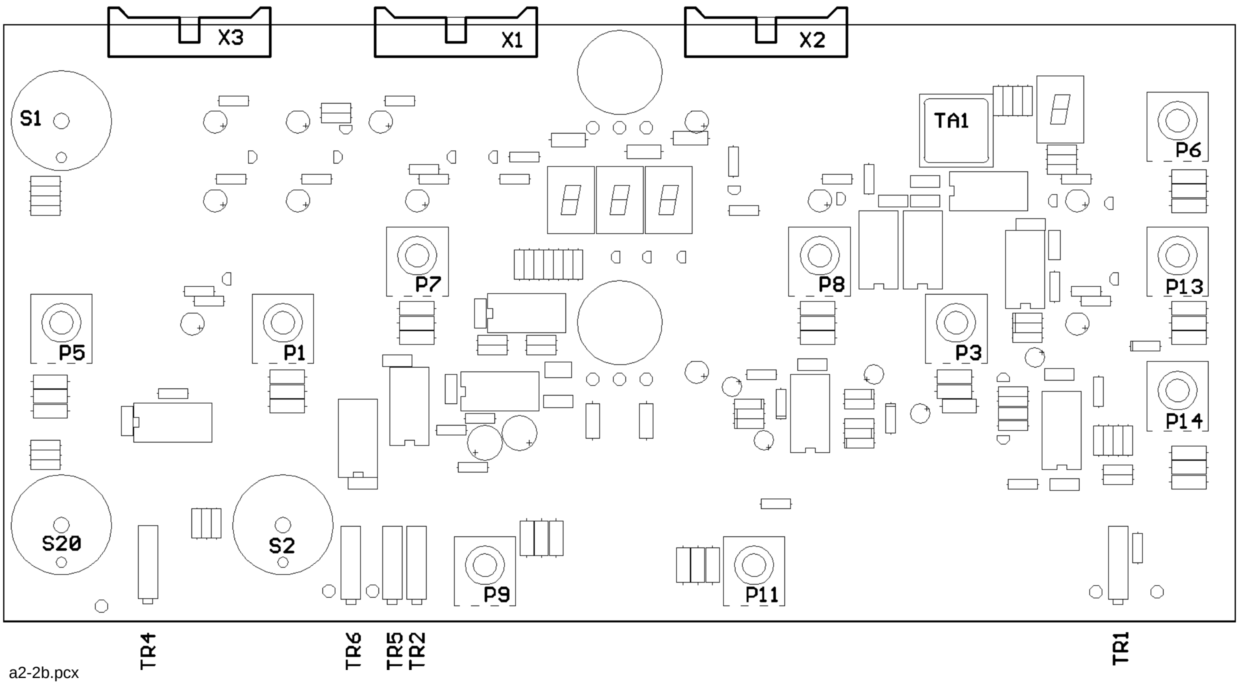
To ensure a defined ON/OFF sequence for the system, the position of the mains switch Q1 is evaluated via a contact on 13,14. The unit does not start unless the contact is closed. Then a fault indication (amber LED comes on) is displayed on the front panel with no display message (blank display). LED3 on A1 comes on.

NOTES:

A2 COMPONENT POSITIONS



a2-1b.pcx



a2-2b.pcx

A2 DESCRIPTION OF OPERATION

GENERAL FUNCTION

The functions of A2 are very complex. An arrangement of analogue and digital circuits that characterise the control function of certain welding modes is included on the board. All functions are controlled by a EPROM sequence control.

The power supply to A2 comes from A6.

A2 provides the following default values for A8:

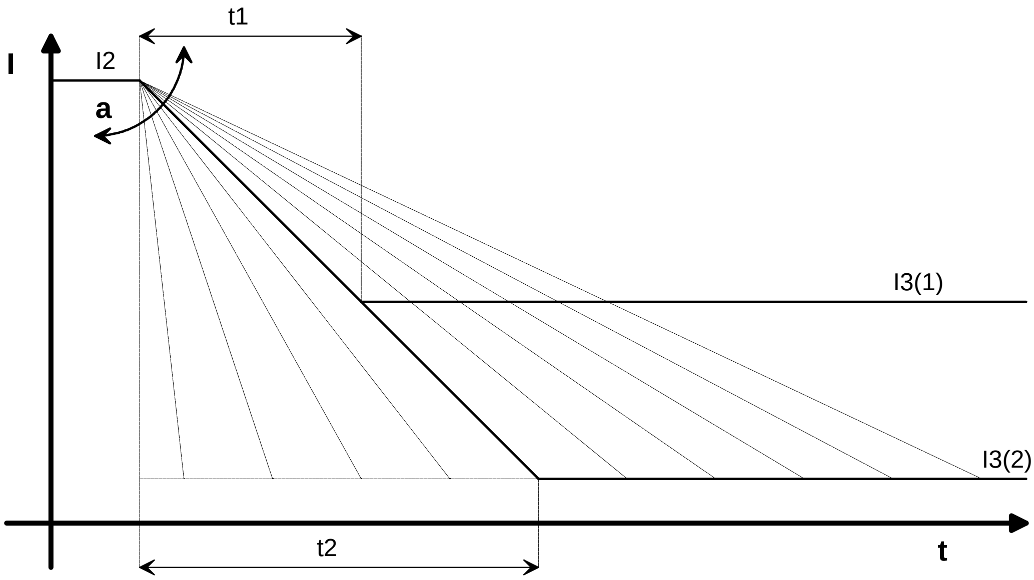
- Output current
- AC current frequency
- AC current balance
- Type of AC current curve
- DC or AC mode
- DC polarity
- Start/Stop signals

A2 and A6 control gas management, hf-ignition management, remote control connection.
All analogue and digital settings comes from A2-2 (front panel).

NOTE! The jumpers on A2 must not be re-located; otherwise A2 will produce functions other than those intended for the DTG405.

DOWN SLOPE RAMP FUNCTION

The potentiometer provided on the front panel for adjusting the downslope ramp governs the dynamics of current change, i.e. the number of amperes per unit of time the current changes during the downslope. In geometric terms, this is equivalent to the change in angle of the downslope ramp. It can be seen from the Figure that the absolute time of the downslope ramp (t1, t2), while depending on the change in angle (a) of the downslope, is a function of the starting-point and end-point values of the current (the differential of the current values I2 and I3 between which there is a downslope). For high I2 and small I3 (2) (large differential of current values), the downslope time (t2) is longer compared with a smaller I2 or a greater I3 (1) (t1, the current value differential is smaller).



For the maximum current differential I2, I3, the minimum downslope time (knob at „0“) is 0.5 seconds and the maximum downslope time (knob at „10“) is 20 seconds.

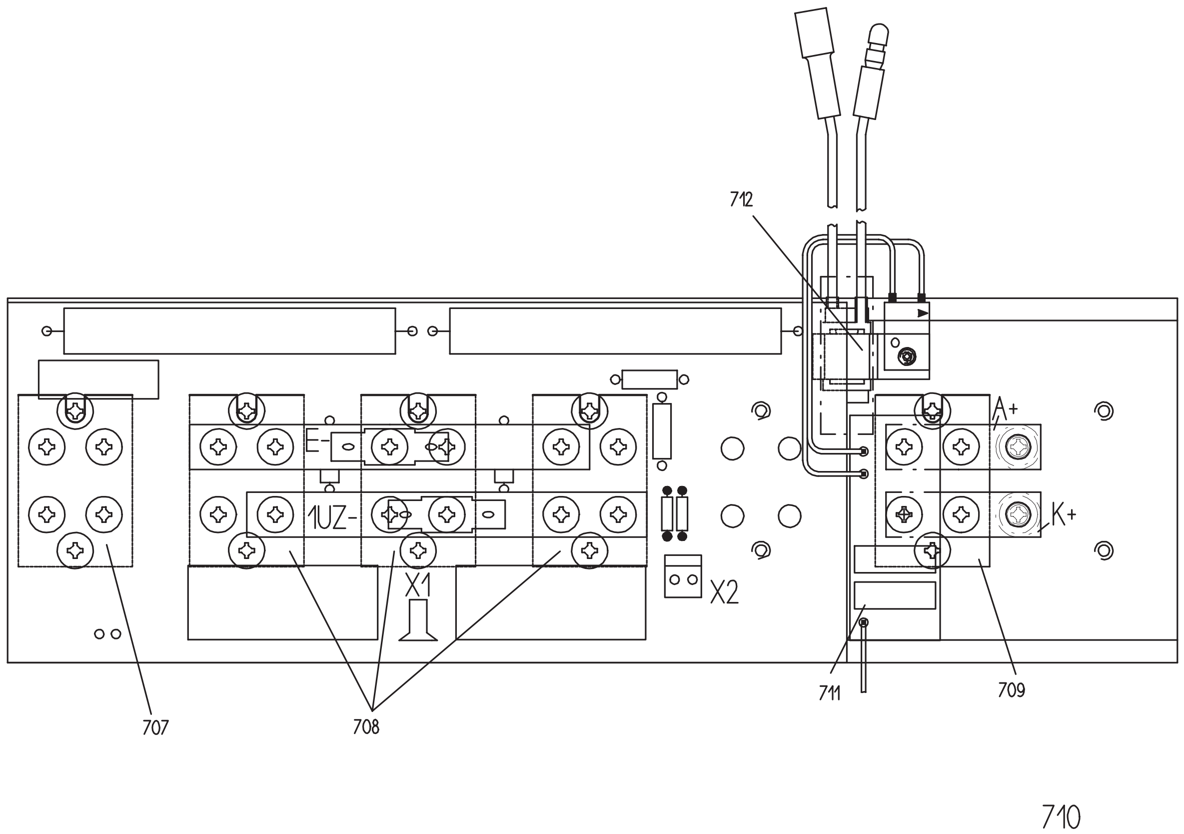
The upslope function is similar.

SIGNAL DESCRIPTION X4

Control bus to inverter X1 from A8, to X4 from A2-1

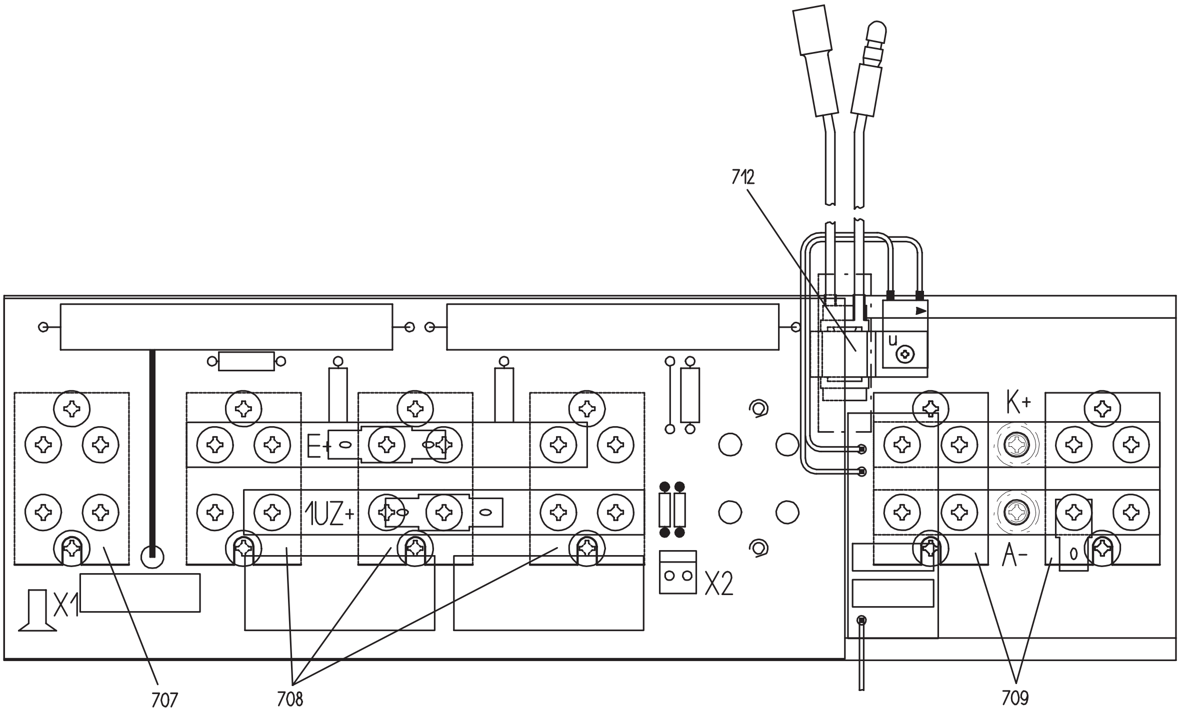
Pin No.	Signal Source	Level	Description
1	A8	+15 V	Error: thermal overload of power stage, low active
2	A8	+15 V	Error: mains overvoltage, low active
3	A8	+15 V	Error: mains undervoltage, low active
4	A8	+15 V	Error: primary overcurrent, shut down of power stage, low active
5	A8	+15 V	Error: error interrupt (group fault), low active
6	A8	+15 V	I>0, high active
7	GND	GND	Logic Ground
8	A8	0-10 V	Current value (Strom Istwert)
9	A2	0-10 V	Current set value (Strom Solllwert)
10	A2	+15 V	Start / Stop of power stage
11	A2	0-10 V	AC welding current frequency
12	A2	0-10 V	AC welding current balance
13	A2	+15 V	DC mode / AC mode (high active for AC)
14	A2	+15 V	Positive polarity for DC in MMA mode, high active
15	A2	+15 V	Positive polarity start-up time for AC mode, low active
16			Not relevant for the DTG 405
17			Not relevant for the DTG 405
18			Not relevant for the DTG 405
19	A2	+5 V	address Bit 1 for AC current wave shape
20	A2	+5 V	address Bit 2 for AC current wave shape
21	A2	+5 V	address Bit 3 for AC current wave shape
22			Not relevant for the DTG 405
23			Not relevant for the DTG 405
24			Not relevant for the DTG 405
25	A2	+15 V	MMA mode low active / TIG mode high active
26	A8	+15 V	3-phase mains supply identification, high active

A4, A11 COMPONENT POSITIONS



Warning! The circuit and its parts are connected to mains voltage potential.

A5, A12 COMPONENT POSITIONS



706

Warning! The circuit and its parts are connected to mains voltage potential.

TESTING MODULES A4, A5, A11, A12

MEASUREMENTS ON AN ENCLOSED POWER BLOCK

CHECKING WITH TESTER IT01

Disconnect Molex control lead X11, X12 on A1 and connect to IT01. Switch position 1. Both generator LEDs must blink, or the particular MOSFET group defective.

CHECKING WITH MULTIMETER

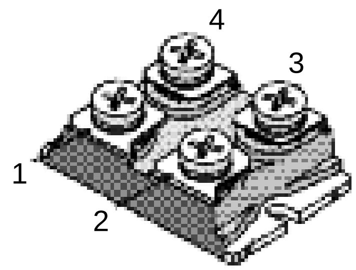
Disconnect Molex control lead X11, X12 on A1. Use the multimeter to measure the ohmic resistance between pins 1 and 2 of X11 (and X12). If the MOSFETs are OK, the reading should be approx. 500 Ω. Lower figures indicate a defective MOSFET group.

MEASUREMENTS ON AN OPEN POWER BLOCK

CHECKING THE MOSFETS AND DIODES

Use a multimeter to measure in the diode test mode. Test in the reverse and the forward directions of the diodes and MOSFETs. IMPORTANT REMINDER: Measurements must be made on cold modules. On hot modules, the measurement can be affected by residual current.

Figure: Locations of connections on MOSFET and diodes.



Pin assignment	Pin 1	Pin 2	Pin 3	Pin 4
Mosfetmodul N-200V 100A	Source	Gate	Drain	Source
Mosfetmodul N-900V 26A	Source	Gate	Drain	Source
Rectifiermodul B200 P400	K1	A1	A2	K2
Rectifiermodul B23 P10	K2	A1	K1	A2

CHECKING THE GATE PULSES

CHECKING WITH TESTER IT01

Turn off the machine.

Disconnect the cables used to transfer driver signals to modules A5, A12 and A4, A11.

Using the auxiliary cable, connect the IT01 in succession to X11 and X12 of module A1.

Turn on the machine. Select the TIG 2 Cycle Lift-Arc mode, and press the Torch button.

If the gate pulses are OK, both the red and the green LEDs come on.

Cf. Procedure of "TEST PROCEDURE WITH IT01".

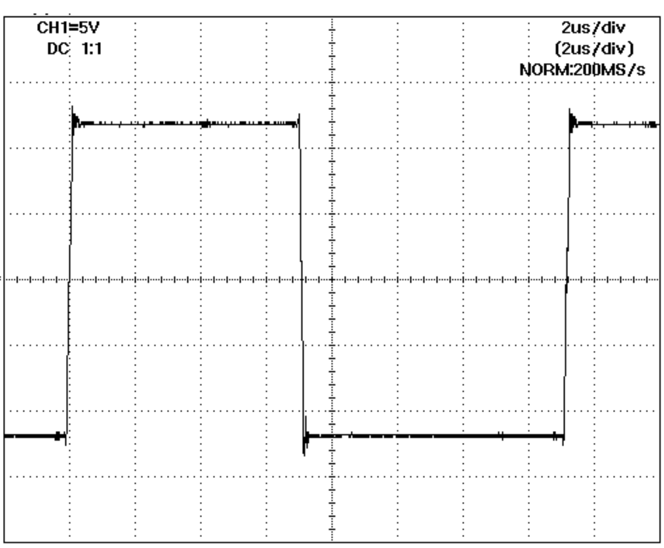
CHECKING WITH OSCILLOSCOPE

Turn off the machine.

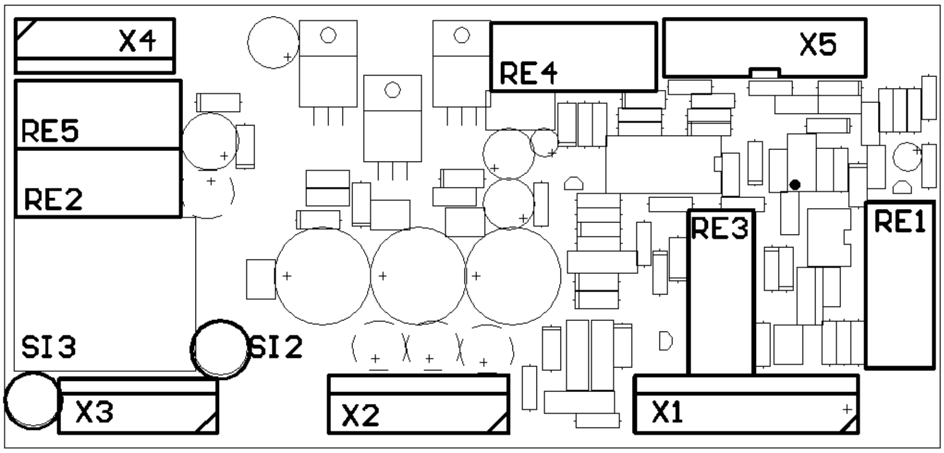
Disconnect the cables used to transfer driver signals to modules A5, A12 and A4, A11.

Connect the GND of the oscilloscope to X11-1 (and X12-1) of module A1. Connect the sample probe to X11-2 (and X12-2).

Turn on the machine. Select the TIG 2 Cycle Lift-Arc mode, and press the Torch button. The figure below shows the correct waveform of the gate pulses at no load.



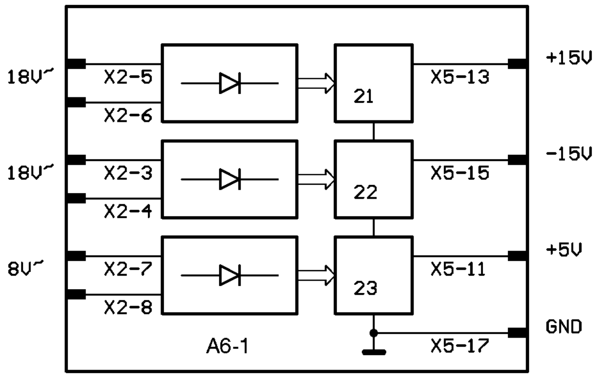
A6 COMPONENT POSITIONS



a6b.pcx

A6 DESCRIPTION OF OPERATION

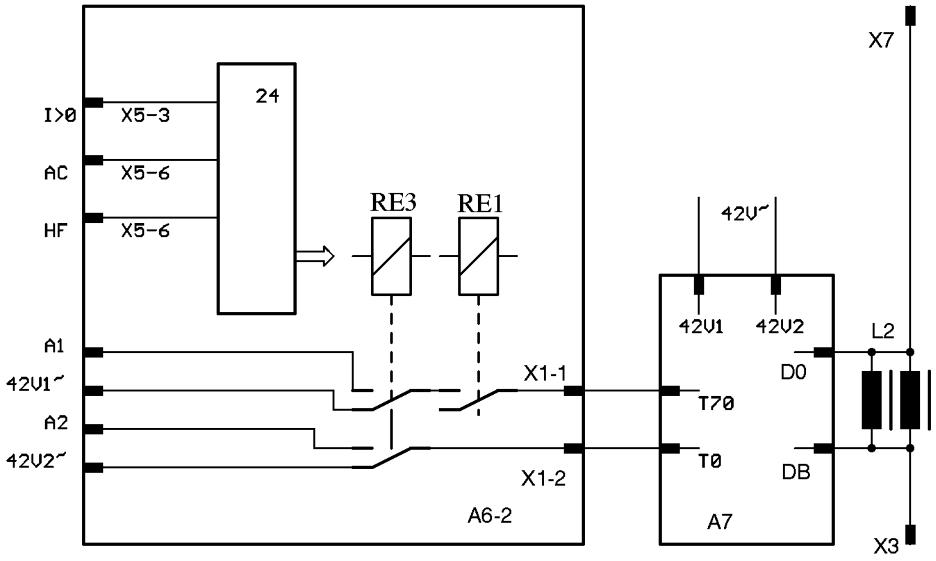
A6-1 SUPPLY A2, A6



a6-1.pcx

Transformer T4 supplies AC voltages to X2. When rectified, they are stabilised in voltage regulators 21, 22, 23 and transferred to A2 via X5. The power supply to A2 and A6 is independent of the supply to A1 and A8.

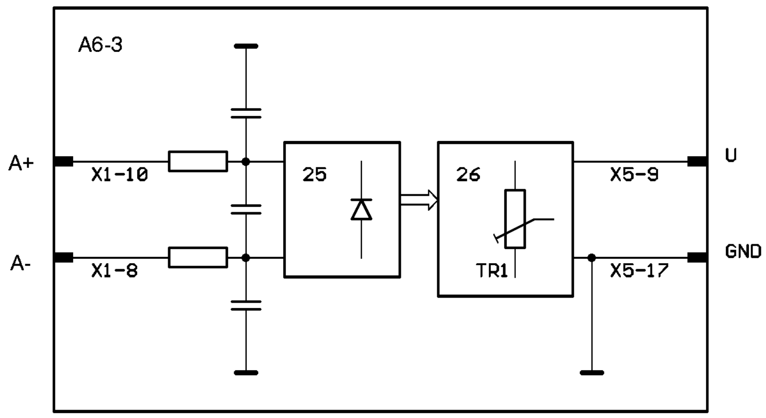
A6-2 CONTROL HF-IGNITION UNIT



a6-2.pcx

The supply voltage is 42 V. HF pulses are generated via L2. The signals at T70 and T0 govern the triggering of starter A7. For HF starting from no-load conditions (HF, /I > 0), an AC voltage of 42 V is applied to the trigger leads T0/T70. The starter then generates starting pulses of alternating polarity of about 50 Hz. During AC welding (I > 0, AC), the relay RE3 is energised, so the starter detects the necessity of HF pulses via the weld voltage on A1/A2. On discontinuation of the arc, the starter generates a starting pulse of the polarity desired.

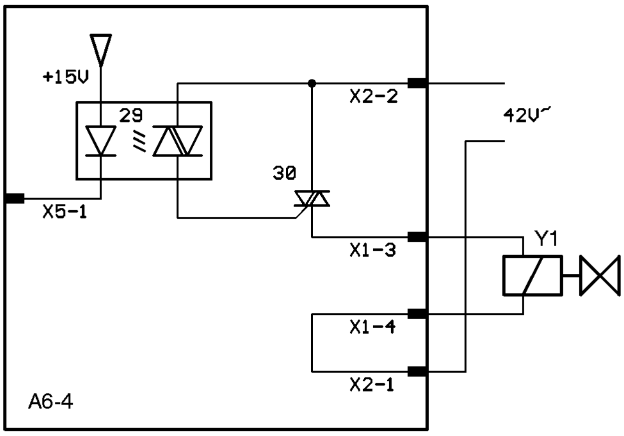
A6-3 ARC-VOLTAGE SENSE



a6-3.pcx

The arc voltage is determined on X1-9,10. After buffering and rectification (25) the voltage signal goes to a comparator circuit 26. When the voltage has reached a specific level, the signal is transferred to the control A2 via X5-9. TR1 is used to set the threshold of comparator stage 26. The signal's function is to detect short circuits and arcs for Lift-Arc starting.

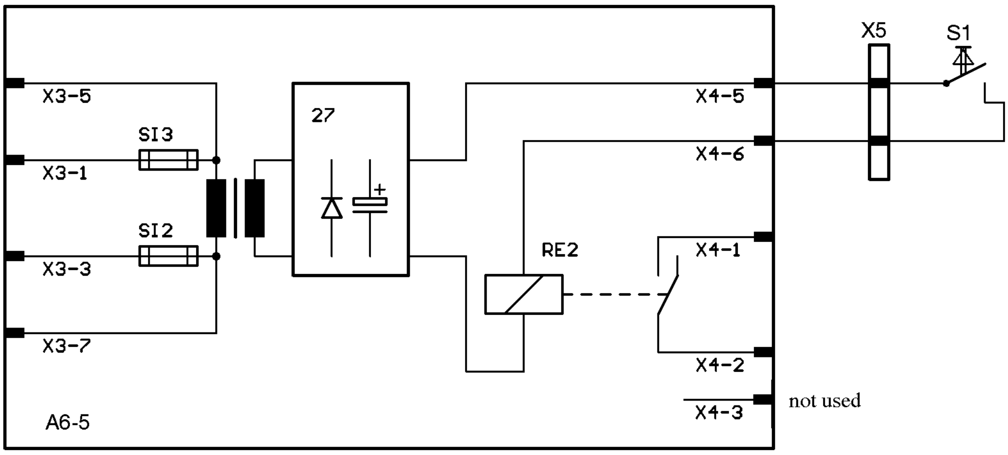
A6-4 SOLENOID VALVE CONTROL



a6-4.pcx

The gas valve is controlled from A2 via X5-1. Easy test of the gas valve: Make short circuit between X2-2 and X1-3.

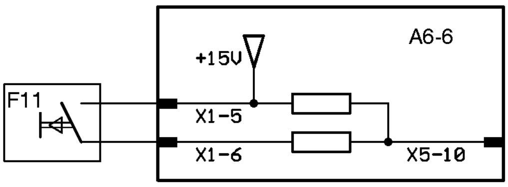
A6-5 TORCH BUTTON MONITORING



a6-5.pcx

The Torch button signal S1 is potential-isolated by RE2 and is transferred via X4-1,2 to A2. The supply voltage to X3 is 230 V; a transformer and 27 are used to provide a potential-isolated auxiliary voltage supply to RE2.

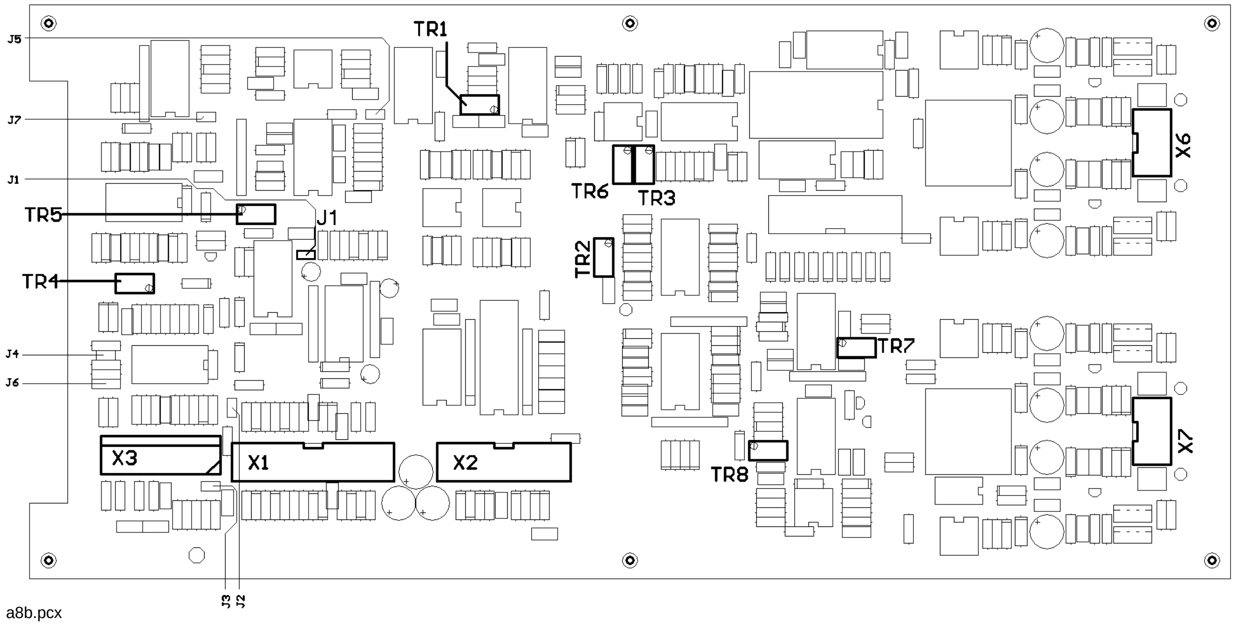
A6-6 MONITORING THE COOLING CIRCUIT



a6-6.pcx

A pressure switch F11 monitors the pressure in the cooling circuit. When pressure is applied, the pressure switch is closed. A pressure drop resulting from a defective cooling unit is reported to A2 via X5-10 by means of an L signal. A2 then displays Error Code 5.

A8 COMPONENT POSITIONS



a8b.pcx

A8 DESCRIPTION OF OPERATION

A8 PRINCIPAL FUNCTION

The functions of A8 are very complex. An arrangement of analogue and digital circuits that characterise the control function of certain welding modes is included on the board. All functions are controlled by a PLD (programmable logic device) on the board.

The power supply to A8 comes from A1 (See section A1-2).

Front panel A2 provides the following default values for A8:

- Output current
- AC current frequency
- AC current balance
- Type of AC current curve
- DC or AC mode
- DC polarity
- Start/Stop signals

A8 determines the actual output current (A8-1), actual output voltage (A8-2) and all status messages of A1.

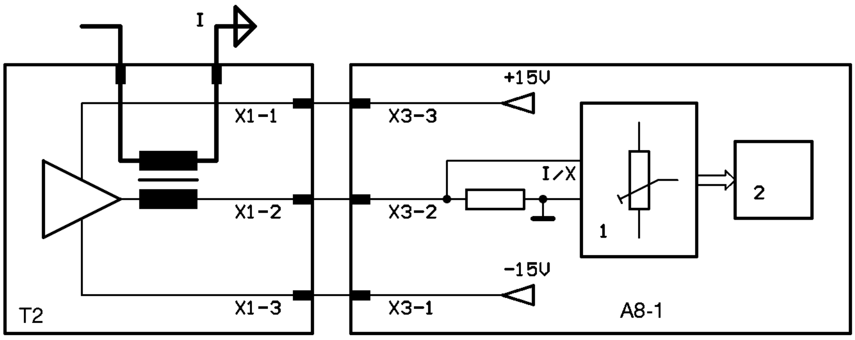
A8 ensures the following limits:

- No-load voltage
- Minimum DC output current (TR3)
- Minimum AC output current (TR6)
- Maximum output current (TR4)
- Limits of AC and DC output voltage
- Minimum inverter frequency (TR1)
- Maximum inverter frequency (TR2)
- Maximum short-circuit time of the load circuit before current reduction (can be switched off by J1);

A8 generates the following control signals:

- Pulse-width-modulated (PWM) inverter clock control signals for A1
- Control signals for A9, A13 and A10, A14 (A8-3)
- Status feedback signals to A2

A8-1 SECONDARY CURRENT MONITORING

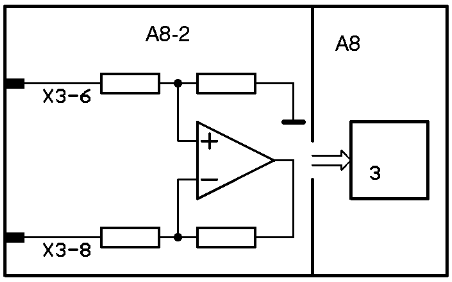


a8-1.pcx

T2 is a floating DC current transformer. The current signal I/X images 1/2000th of the weld current. In 1, the level for the maximum output current is set to 5 V by TR4 and transferred to the following stages 2.

NOTE! The signal I/X at X3-2 is only intended for internal use to control the unit. This signal must not be tapped for other purposes, e.g. for additional displays or current evaluation. In the worst case, tapping this signal could destroy the AC converter!

A8-2 ARC VOLTAGE SENSING

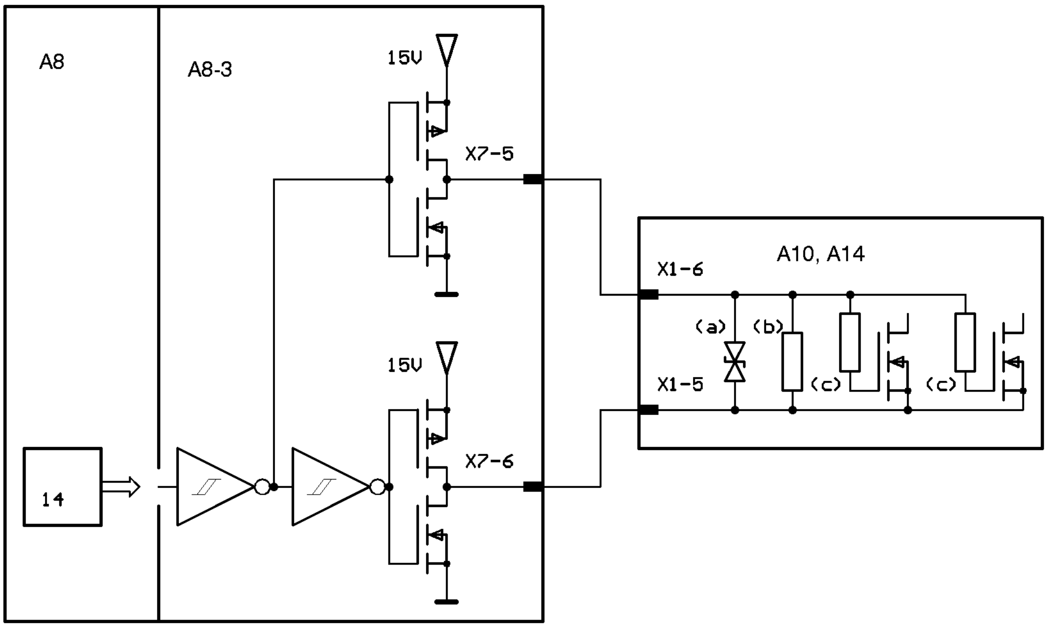


a8-2.pcx

The secondary output voltage is detected on X3-6 and X3-8 and sent to the voltage limitation circuit and short-circuit evaluation circuit 3.

NOTE! The internal voltage signal is only intended for internal use to control the unit. This signal must not be tapped on the control A8 for other purposes, e.g. for additional displays.

A8-3 SECONDARY MOSFET DRIVER



a8-3.pcx

The control signals for the secondary inverter are generated on A8 and transferred to the driver stage A03-3 potential-isolated by an opto-coupler (14). This is where the driver signals are generated for the power MOSFETs on A9, A10, A13, A14. In the event of a defect in the power MOSFETs, the control signals should also be tested.

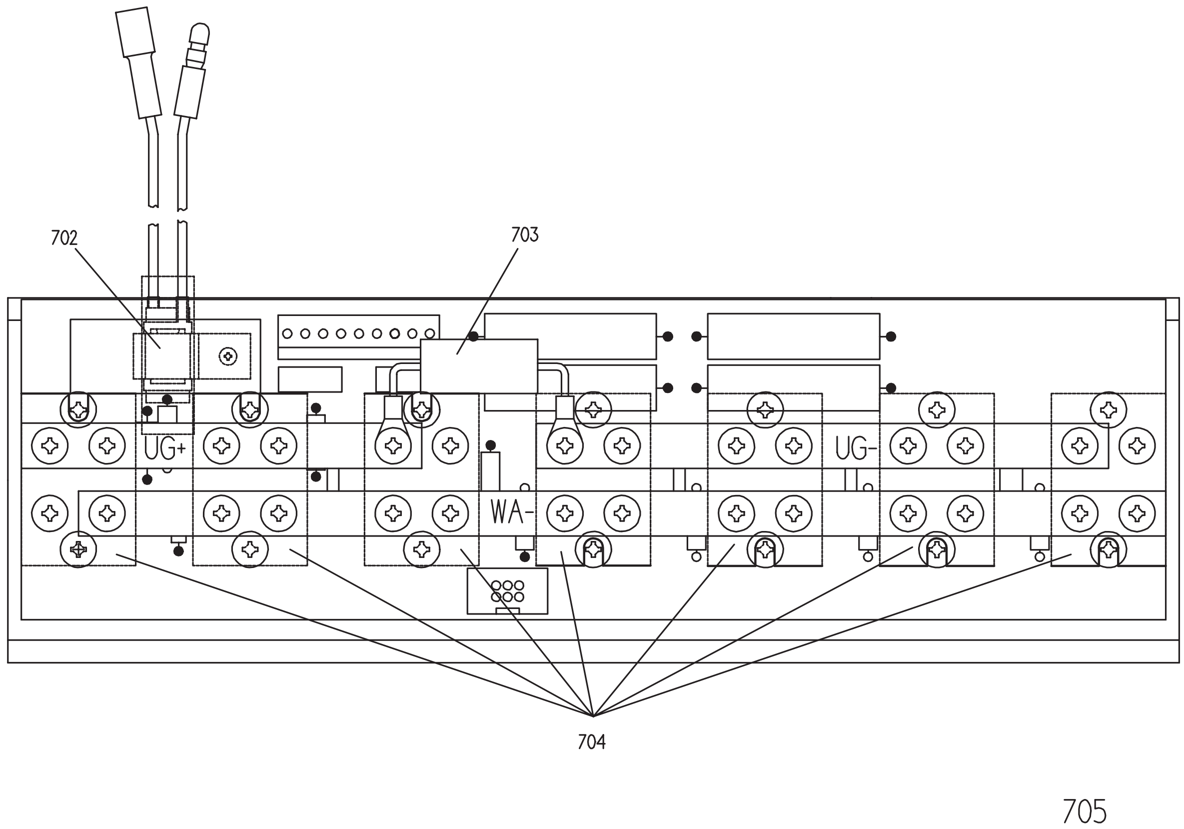
Cf. TESTING WITH TESTER IT01.

SIGNAL DESCRIPTION OF X2

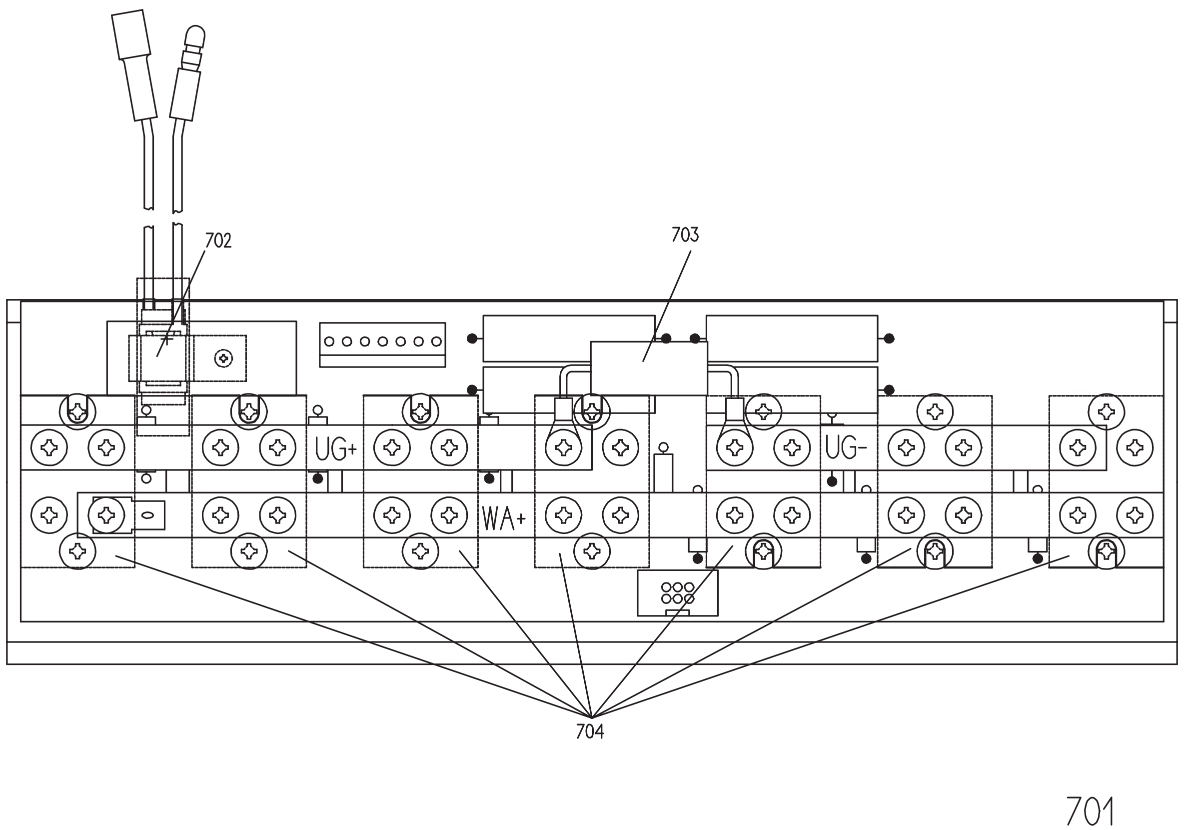
Inverter supply bus, X7 on A1, X2 on A8

Pin No.	Signal Source	Level	Description
1	A1	40 V1~	High frequency AC supply for driver stages, line 1
2	A1	40 V2~	High frequency AC supply for driver stages, line 2
3	A1	40 V1~	High frequency AC supply for driver stages, line 1
4	A1	40 V2~	High frequency AC supply for driver stages, line 2
5	A1	40 V1~	High frequency AC supply for driver stages, line 1
6	A1	40 V2~	High frequency AC supply for driver stages, line 2
7	A1	+15 V	+15 V supply for control A8
8	A1	-15 V	-15 V supply for control A8
9	A8	+15 V	Pulse-width modulation for inverter
10	GND	GND	Logic and supply ground
11	GND	GND	Not relevant for the DTG 405
12	A2	+15 V	Logic and supply ground
13	A1	+15 V	Supply error A1, low active
14	A1	+15 V	3-phase mains supply indentification, high active
15	A1	+15 V	Error: thermal overload of power stage, low active
16	A1	+15 V	Error: primary overcurrent, shut down of power stage, low active
17	A1	+15 V	Error: mains overvoltage, low active
18	A1	+15 V	Error: mains undervoltage, low active
19	A1	+15 V	I>0, low active
20	A1	+5 V	+5 V logic supply

A9, A13 COMPONENT POSITIONS

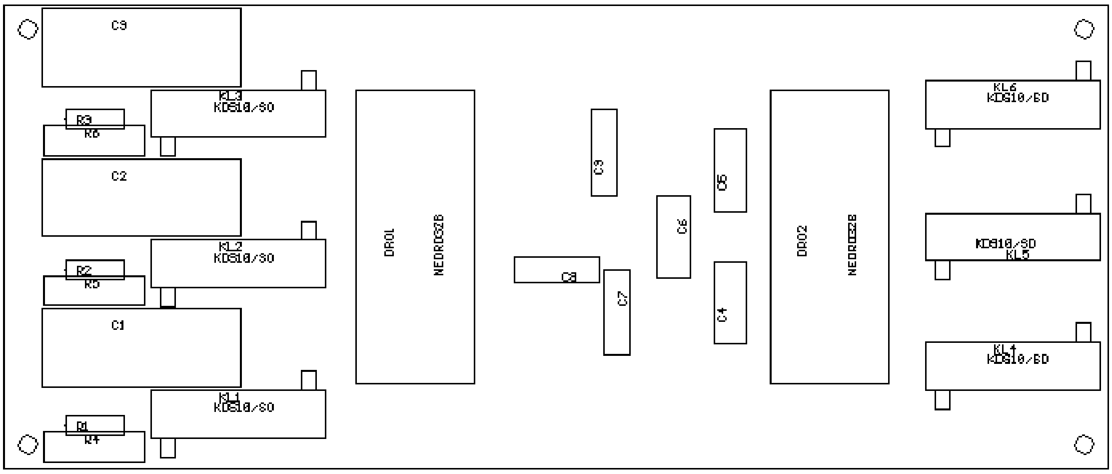


A10, A14 COMPONENT POSITIONS



A15 COMPONENT POSITIONS

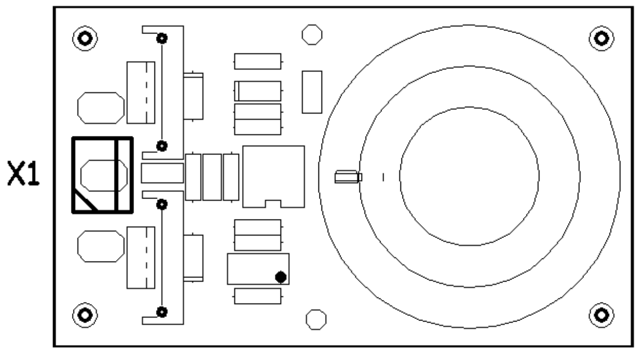
A15 works as interference suppression Filter.



nef2x32.pcx

Warning! The circuit and its parts are connected to mains voltage potential.

T2 COMPONENT POSITIONS



T2b.pcx

The trimmer on T2 defines the factory setting for the offset signal of the transformer. There is no readjustment required.

INSTRUCTIONS FOR FAULT TRACING AND REPAIR

1 SAFETY INSTRUCTIONS

Repairs may only be carried out by trained experts.

When carrying out fault tracing and repairs, remember that hazardous voltages occur in various locations on the system. Therefore, switch off the mains switch and unplug the mains plug before opening the system.

If the unit is operated in open mode, you must be that live parts are exposed.

The following modules and components are connected to the mains voltage and rectified mains voltage at particular points:

- A1, A4, A5, A6, A11, A12, A15
- C1, C2, C3, C4
- M1, M5
- K1
- Q1
- T3, T4
- X6
- For other cable conductors, see CONNECTION DIAGRAM DTG 405

NOTE! Also remember that, when the unit is open, cooling is no longer effective. For this reason, do not operate open units at high load for a long time, otherwise components may overheat.

2 PROTECTION AGAINST HAZARDOUS FAULT CURRENTS

After completing every repair, check the electrical safety of the machine. Refer to VDE 0100 and EN 60974-1 (should be kept with the machine). This manual will not deal with any extracts from these standards. The following information is not complete and no liability is assumed for the information given.

2.1 TESTING PROTECTIVE CONDUCTORS

The resistance between the terminal for the protective conductor and conductive components which may become live under fault conditions must not exceed 0.1 Ω.

Perform the measurements using 25 A AC. The protective conductor will be referred to below as PE (protective earth).

2.2 INSULATION RESISTANCE

Measure the insulation resistance using a DC voltage of 500 V.

Set up three circuits for testing:

- Input circuit: connect all the phases available in the connecting plug and, if provided, the neutral conductor.
- PE: protective conductor in the connecting plug.
- Welding circuit, control circuit: interconnect all the connectors provided (X3, X7, X2), Torch button connection (X5, all pins), and remote-regulator connector (X5, all pins).

2.3 DIELECTRIC STRENGTH

The three circuits set up for the insulation test are also needed for testing the dielectric strength.

For the dielectric strength test, the standard also specifies how "carefully cleaned, used welding power supplies shall be tested (e.g. after maintenance or repair without new windings)".

In addition, the design voltage plays a vital role. Systems operating on 400 V 3-phase AC must be tested to higher specifications than units which can only run on 230 V.

For reasons of simplification, only the higher specifications are given here.

Slowly raise the AC test voltage to full level, apply for 5 seconds, and then reduce to zero. During the test, the current must not exceed 10 mA. The suppressors may be disconnected during the test (A15, C6, C7).

AC test voltages:

Input circuit	→	PE	= 565 V
Input circuit	→	Welding circuit	= 1500 V
Welding circuit	→	PE	= 565 V

3 POWER SUPPLY DURING FAULT TRACING

An isolating transformer with voltage and current indication is an ideal power supply to the unit for fault tracing and start-up after repairs. This is especially the case whenever repairs are carried out on the primary switches A4, A5, A11, A12. Single-phase design for 0-250 V, 0-4 A is sufficient for this test.

For systems operating on 3-phase AC only, the voltage must range up to 400 V. A control transformer equipped with a 230V/400V auto-winding may be connected on the load side of the isolating transformer. A supply with the two phases L1 and L2 is adequate for start-up and testing of 3-phase AC systems at low load.

The isolating transformer offers potential isolation as well as a higher internal resistance. In the event of faults, the current is limited to levels that are much lower than mains operation. When the unit is switched on, always raise the voltage starting from 0. This avoids unnecessary follow-on defects.

Unless major faults have occurred, the unit may remain connected to the mains for fault tracing. Heed the safety instructions in this Manual.

The other voltages are still applied, i.e. the isolating transformer ranging from 0 to 230 V / 400 V, the link voltage of up to 620 V, and the derived high-frequency AC voltage. If the power supply comes from the isolating transformer, never touch any two of these points which are at different potentials.

4 LOAD APPLICATION DURING FAULT TRACING

Applying a useful load to the unit during fault tracing depends on the type of fault and the possibilities.

List of loads:

- No load
- Short circuit
- Ohmic load resistance
- Water resistor
- Welding

At no load, test whether no-load voltage is applied and whether it is approx. 90 V. However, you must select Electrode mode or start the unit by pressing the Torch button. Usually, you then 'hear' a high frequency.

When the mode is changed from DC to AC, the polarity of the no-load voltage must reverse.

If a torch and a load resistor are unavailable, you can also operate systems of this series in short-circuit mode. But remember that the inverter control board A8 has a monitoring circuit which detects short circuits and then reduces the current to be approx. 80 A. You can disable this function by connecting a jumper on the board.

If you have a suitable ammeter, you can test most unit functions when it is in the short-circuit condition:

Examples:

- Current control range and maximum currents
- Current waveform in case of AC current (slightly biased)
- Time pattern, starting current, changeover to second current (by second Torch button), remote-regulator functions, ramp setting, etc.

A ballast resistor can be used to simulate a load similar to welding for a given current. This is only practical for static loads. The dynamic response of the arc cannot be simulated by means of an ohmic resistance. Compared to welding, differences are mainly obvious in the electrode and the TIG AC current.

Select the resistance so that, for a given current, you obtain the point on the standard curve for the desired welding process.

Standard curve for electrode welding: $U = 20\ V + 0.04\ \Omega * I$; $R = U/I = 20\ V/I + 0.04\ \Omega$

Standard curve for TIG welding: $U = 10\ V + 0.04\ \Omega * I$; $R = U/I = 10\ V/I + 0.04\ \Omega$

In practice, use is commonly made of resistors ranging from 0.05 Ω to 0.2 Ω.

Water resistors permit infinitely variable adjustment of the resistor.

Fault tracing can also be conducted during welding operations as some faults only become apparent during the welding process. For measurements, however, a comparatively high interference level, e.g. resulting from HF pulses, must be taken into account. Measuring cables may be connected to induce defects on electronic control boards, since they function as aerials and feed excessively high interference currents.

5 INSTRUMENTS, MEASURING IN FLOATING MODE

Battery-operated digital multimeters are suitable for conducting measurements. They can also test diodes and transistors in many applications. Only high-quality, interference-proof instruments (e.g. Fluke 75) are suitable for measuring output voltage.

On TIG systems, do not attempt to measure on the load side of the HF reactor (X3) as the voltage of the HF pulses is so high that it could destroy the instruments. Preferably, measure at the connection for MMA (X7).

When an oscilloscope is used for measuring, it should be powered from an isolating transformer. Otherwise, connect the measuring earth to the protective conductor.

When the oscilloscope is powered via an isolating transformer and a disconnected protective conductor, the enclosure of the oscilloscope has the potential of the measuring earth selected and must not be 'touched' by a high voltage (e.g. link voltage).

When two probes are used, make sure that the earth terminals are connected to a common point.

For current measurements, current-measuring prongs are suitable for DC and AC current. An oscilloscope should be used to check the correct welding process as well as waveform in case of AC current. The current can be measured via a suitable shunt or a transformer shunt.

6 OPENING THE SYSTEM

This section describes the enclosure of the DTG405, how to open the unit and how to dismantle it to a certain degree. Depending on how the fault can be localised, not all of the steps may be necessary.

Do not start by slackening screws on the base plate since you might accidentally loosen magnetic components, power rectifier, or heat-sink mounts.

1. Pull the mains plug.
2. Unscrew the U-shaped cover.
3. Unscrew the side panel at the bottom on each side.
4. The side panels of the power block can be removed from the side without having to dismantle the entire power block.
5. Discharge the electrolytic capacitors (with resistance).
6. You can remove the connections, i.e. the busbars, between the heat sink modules by slackening the screws.
7. You can unplug or unscrew all the cables leading to the heat sink modules. Before unplugging, make sure you mark their position. This will avoid incorrect wiring later when you reassemble the module.
8. The heat sink modules are secured in their holders by screws on the sides. You can remove each heat sink module separately.

7 UNITERROR CODES

If you know what caused the unit control unit to trip, an amber LED comes on to signal a general fault and an error code is displayed on the front panel. Depending on the indication, you can probably locate the fault already.

NOTE! If the mains switch is switched off and on in quick succession, the Fault LED will come on for about 8 seconds. During this time the unit is not functional. As soon as the LED goes off, the unit becomes functional again.

GENERAL FAULT – NO ERROR CODE (BLANK)

The auxiliary contact 13-14 on mains switch Q1 is not detected as closed. Check connectors, cable connections and switches. Signal path: A1 detects contact (LED 3 on A1 comes on if contact is open) and signals the fault to A2 via A8.

ERROR CODE 1: PRIMARY OVERCURRENT

A primary trip is caused if substantially more current flows to the primary of power transformer T3 compared to maximum load. LED2 on A1 comes on as well.

Possible causes:

- Monitoring circuit on module A1 is defective.
- Inter-turn fault in power transformer T3.
- Primary switch A5, A12 or A4, A11 defective.
- Defect in secondary rectifier AP10, AP11 or its protective circuit.
- Transformer shunt T2 defective, or cable connection to inverter control board defective.
- Defect in current regulation circuit of inverter control board A8.
- Module A1 defective.
- Loose contact on T1, T5 causes high voltage arc-over which trips the primary.

ERROR CODE 2: MAINS UNDERVOLTAGE

For good welding quality, the mains voltage should be in the following range: voltage between two conductors: 400 V ± 10%.

The unit is typically switched off at about 300 V and remains off as long as the undervoltage persists.

On 3-phase AC systems, if only undervoltage is signalled in the upper power range, there may be one phase missing.

ERROR CODE 3: MAINS OVERVOLTAGE

Use a suitable instrument to check the actual value of the mains voltage while the unit displays overvoltage.

Regular or continuous operation of the unit at mains overvoltage may cause failure, first on electrolytic capacitors (C1 to C4) and on the starter (A7).

For good welding quality, the mains voltage should be in the following range: voltage between two conductors: 400 V ± 10 %.

The unit is typically tripped at about 460 V (AC) overvoltage. If the error signalling proves to be wrong, renew A1.

ERROR CODE 4: THERMAL OVERLOAD

The chain of thermal switches is interrupted. LED1 on A1 comes on. Check connectors, cable connections and thermal switches for defects. If the unit suffers an early thermal trip, check the following potential sources of error or fault:

- Fan
- MOSFETs on A9, A13, A10, A14 (parallel circuit, current conduction)
- Diodes AP10, AP11 (parallel circuit, current conduction)
- MOSFETs on A5, A12, A4, A11 (parallel circuits, current conduction)
- Temperature at which the particular thermal switch trips the unit

Signal path: A1 detects contact and signals the fault via A8 to A2.

ERROR CODE 5: COOLING WATER FAULT, GENERAL ERROR INTERRUPT, OVERVOLTAGE TRIP

Error Code 5 is signalled under certain conditions:

- Cooling water trouble, pressure switch signals a pressure drop; refer to section A6-6 and "INSTRUCTIONS FOR fault tracing AND REPAIR" - 21 Water Cooling, Adjust Pressure Contact).
- Failure of supply to A1 and A8, refer to A1-1, A1-2.
- Overvoltage trip of A1 because of excessive output voltage; refer to A1-6 and "Instructions for Fault Tracing and Repair"- 13 (unit switches off after a short delay).

8 TESTING WITH TESTER IT01

GENERAL DESCRIPTION

The tester IT01 is designed to test the interfaces between control A1, A8 and the power sections A4, A5, A9, A10, A11, A12, A13, A14 on the DTG405.

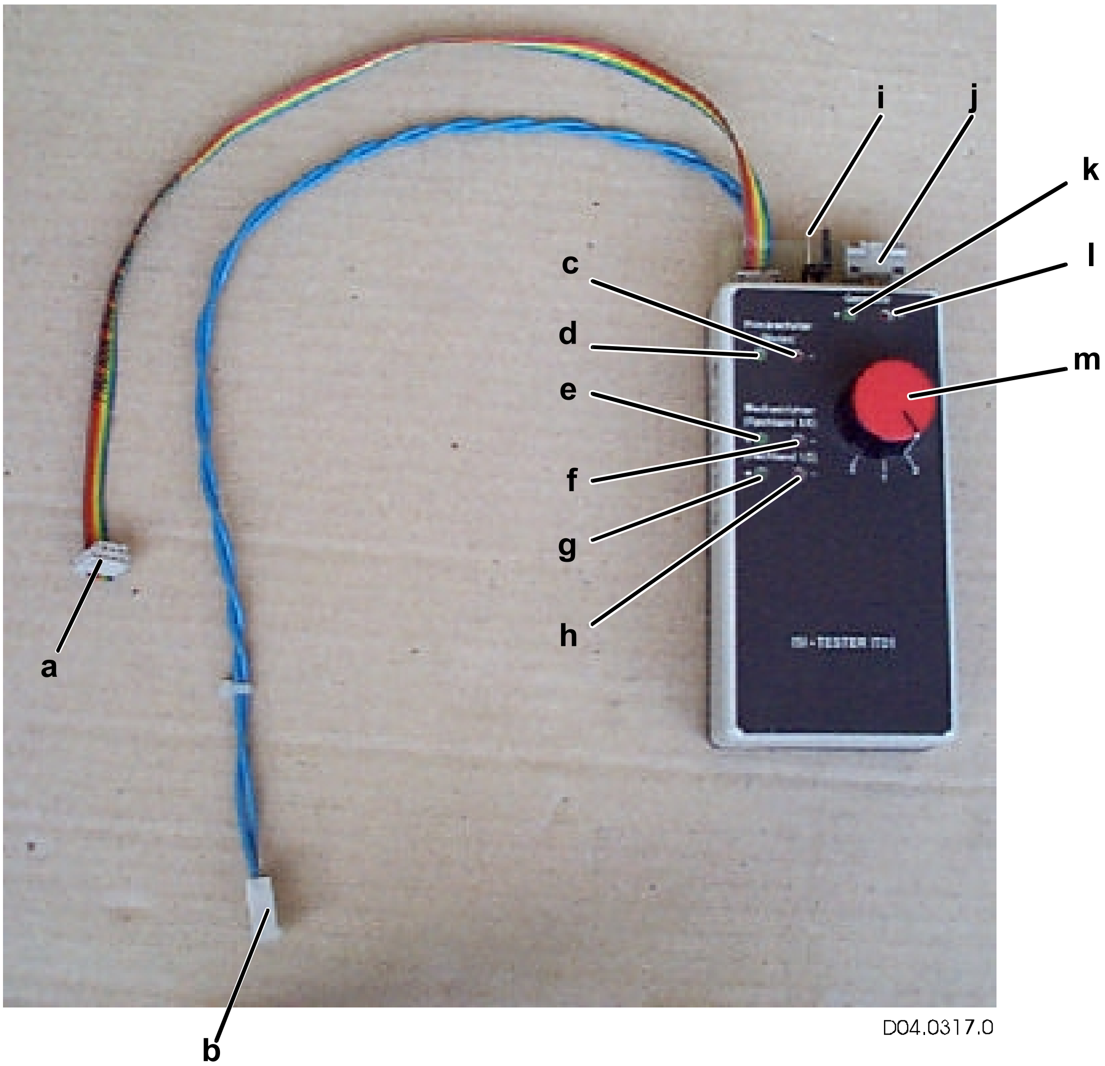
The instrument consists of a signal generator that generates +9 V (indicated by the green LED (k)) and –9 V (indicated by the red LED (l)) in an alternating sequence at a frequency of about 1 Hz.

The signal generator is capable of testing the high resistance of the MOSFET gates of all power transistors installed in the inverter power supply.

The test procedure is described so that tests are conducted without an isolating transformer and at no load.

Only the tester and mains power are required.

CAUTION! Do not connect the signal generator to the gates when the unit is on since, in this condition, mains voltage is applied to the MOSFET power transistors and the connected IT01.



In addition, IT01 comprises three identical check circuits which signal voltages greater than 6 V by a green LED (d), and voltages smaller than –6 V by a red LED (c). The check circuits check the control signals from modules A1 and A8 when the MOSFET gates are disconnected.

IT01 can only test the correct function of the drive circuits on the electronic modules A1 and A8 which may suffer damage if there are defects in the power section. The other functions of the control boards cannot be tested.

<u>Self-test of IT01:</u>

1. Connect 6-way ribbon cable (a) and 2-way Molex (b); this links the signal generator directly to the check circuits.
2. Selector switch (m).
   Switch position 1: Generator LED (k, l), Molex LED (c, d) and ribbon cable LED pins 1, 2 (e, f) blink.
3. Selector switch.
   Switch position 2: Generator LED (k, l), Molex LED (c, d) and ribbon cable LED pins 5,6 (g, h) blink.

TEST PROCEDURE WITH IT01

1. Turn off the welding system.
2. Hold the IT01 with one hand and touch the unit under test with the other hand to obtain a discharge (This is a precaution to protect the unit from electrostatic discharges).
3. Disconnect the Molex drive lead from connector X11 (i) on A1 and connect it to the tester. Switch position 1: Both generator LEDs (k, l) must blink, otherwise the upper primary switch A5, A12 is defective.
4. Disconnect the Molex drive lead from the tester and bend it aside so that no undesirable electrical connections can occur to the disconnected Molex sockets.
5. Disconnect the Molex drive lead from X12 on A1 and connect it to the tester. Switch position 1: Both generator LEDs (k, l) must blink, otherwise the upper primary switch A4, A11 is defective.
6. Disconnect the Molex drive lead from the tester and bend it aside so that no undesirable electrical connections can occur to the disconnected Molex sockets.
7. Testing the upper drive on A1:
   Connect the Molex cable (b) from the tester to X11 on A1. Set the mode selector switch on A2 to "2-Cycle Lift Arc". Turn on the welding unit: The primary switch red LED (l) must come on (no drive).
8. Set mode selector switch on A2 to "DC-Electrode": The green LED (d) and the red LED (c) must come on (drive).
9. Turn off the welding unit.
10. Testing the lower drive on A1:
    Connect the Molex cable from the tester to X12 on A1. Set the mode selector switch on A2 to "2-Cycle Lift Arc". Turn on the welding unit: The primary switch red LED (l) must come on (no drive).
11. Set mode selector switch on A2 to "DC-Electrode": The green LED (d) and the red LED (c) must come on (drive).
12. Turn off the welding unit. Disconnect the tester.
13. Disconnect inverter drive leads (ribbon cable) from connectors X6 and X7 on A8 (If possible, mark the leads before the test so they cannot be mixed up afterwards).
14. Connect the drive lead from X6 (j) to the tester.
    Switch position 1: Generator LEDs (k, l) must blink, otherwise the upper inverter switch of A9, A13 is defective.
    Switch position 2: Generator LEDs (k, l) must blink, otherwise the lower inverter switch of A9, A13 is defective.
15. Connect the drive lead from X7 to the tester.
    Switch position 1: Generator LEDs (k, l) must blink, otherwise the upper inverter switch of A10, A14 is defective.
    Switch position 1: Generator LEDs (k, l) must blink, otherwise the lower inverter switch of A10, A14 is defective.
16. Testing the AC-converter drives on module A8 X6:
    Connect the ribbon cable from IT01 to X6 on A8.
    Select the DC-Electrode mode: Two green LEDs (e, g) must come on.
    Select the AC1-Electrode mode: Two red LEDs (f, h) must come on.
17. Testing the AC-converter drives on module A8 X7:
    Connect the ribbon cable (a) from IT01 to X7 on A8.
    Select the DC-Electrode mode: Two red LEDs (f, h) must come on.
    Select the AC1-Electrode mode: Two green LEDs (e, g) must come on.
18. Turn off the welding unit. Disconnect the tester.

9 TESTING OF A4, A5, A9, A10, A11, A12, A13, A14

Using a digital multimeter, you can test the gate connections of primary switch A4, A5, A11, A12 and inverter A9, A10, A13, A14.

If there are defects in power transistors, the gate source resistors usually change from >0.001 Ω to levels of less than 100 Ω. On all power boards A4, A5, A9, A10, A11, A12, A13, A14, 1 kΩ protective resistors are installed in parallel with the control inputs.

When power modules are connected in parallel, the resistance decreases to 500 Ω.

If the resistor values are correct, the power section is in all probability OK.

For measuring, disconnect the control connecting leads to the power transistors from the power boards or from the associated control boards.

- Control board connections:
  A1: X11, X12
- A8: X6, X7

NOTES:

10 REPAIRS ON A4, A5, A9, A10, A11, A12, A13, A14

We advise you to renew the heat sink module.

If an individual repair is urgently required, take into account the information given below:

Only components of identical type may be connected in parallel on any of the switches.

Due to changes made by component manufacturers and the resulting tolerances, your unit may be equipped with power transistors (SGS-Thomson identification: ISOTOP Module) which are no longer available.

In this case, all the transistors or diodes which are connected in parallel in a switch must be renewed when a defect occurs.

The screws fitted to the electrical connecting lugs should be tightened to a torque of about 15 Nm.

The screws fitted to retain the component on the heat sink should be tightened to a torque of approx. 20 Nm.

Make sure there is a good heat transfer from the component to the heat sink; the contact area of the power conductors must be clean and smooth.

- Apply a thin film of heat-conducting paste.
- Check the gate series resistors.
- Check contacts between board and ISOTOP modules as well as the connections to the cable harness.
- Check the RC elements and the blocking capacitors.
- Check the power boards (strip conductors, etc.).

11 POTENTIOMETER ON CONTROL PANEL A2-2 DEFECTIVE

Features or functions indicating a defective potentiometer:

- Missing pins
- Allow potentiometer or switch to rotate through the full range
- No end stop
- Interruptions occur during welding (loose contact).

To check during the welding process, turn and shake the potentiometer.

When renewing, note the following instructions:

- The coding disc on switches must be properly fitted.
- Take care not to damage components when cutting pins to length. Always clamp the pins.
- Re-insert spacers correctly.
- Use only plastic potentiometers (to ensure insulation).
- Check that the potentiometer has the specified ohmage. Remember there is a difference between linear and logarithmic.
- When dismantling, match-mark ribbon cables and related components to prevent mixing them up when re-connecting. There are several 20-way ribbon cables connected.

12 UNIT HAS CRASHED

When a unit has crashed, perform the following checks:

- Check whether cable insulation is damaged.
- Check for ferrite fragments in the unit. Ferrite cores of transformer T1, reactor L1 or HF reactor L2 may be broken.
- Inspect ferrite cores of power transformer T3, reactor L1 and HF reactor L2 for visible cracks.
- Inspect metal enclosure for indents which may cause undesirable electrical connections.
- This often affects mounting locations of weld current sockets.

13 UNIT SWITCHES OFF AFTER A SHORT TIME INTERVAL

Module A1 (connector X9-1, X9-3) is always connected to the weld current sockets by two separate cables, and there is a monitor for excessive DC or AC voltages (see section A1-6).

The inverter control board A8 is always connected to the DC output voltage (connectors X3.6 and X3.8) and this voltage is regulated to approx. 90 V. As long as no current is flowing, i.e. no arc is started, no AC voltages are generated at the output.

Nevertheless, if a safety trip occurs, the inverter power supply is switched off within about 0.2 seconds after the inverter starts. Error code 5 is then shown on the display.

The inverter doesn't start until shortly after power-on, when the control unit sends a request. As a check, the control panel can be set so that the inverter is still turned off after power-on. It can then be started by selecting an electrode mode or by pressing the Torch button.

In electrode mode, the inverter is turned off as long as the current setting is zero. In TIG mode, the inverter is turned off until a start is initiated by pressing the Torch button or through the remote regulator.

Possible fault sources:

- DC output voltage (in function diagram denoted by UG+) is not connected to the inverter control board A8.
- Cable harness.
- No-load voltage regulation on inverter control board A8 is defective.
- Fault in transformer shunt T2 or in its -15 V supply; in this case the inverter control board A8 assumes that "current is flowing" and turns off the no-load voltage regulation.
- Fault in the monitoring circuit on A1-6.

14 FAULT ON MAINS POWER INPUT

As a result of defects in the main power input, the unit may not be supplied with all the phases. If L1 or L2 is missing, the control is not supplied with power and the unit fails to function. If L3 is missing, the unit will not perform as necessary in the upper range and the arc becomes unsteady. It is fairly easy to find interruptions by using the schematic diagram.

In addition, units may suffer a mains-side short which causes the mains protection to trip. In this case, do not attempt to reset the automatic circuit breakers several times to power up the unit again. In fact, mains currents of up to several 100 A flow before mains fuses trip. Currents of this size may cause damage to other components in the unit. Also, excessive fuse ratings would cause unnecessary subsequent defects. Before fault tracing in this area, make sure that the mains plug is pulled!

Possible causes:

- Short-circuit in mains cable.
- Power rectifier defective.
- Test: Disconnect the power rectifier, and measure.
- Link capacitor defective.
- Test: Disconnect the mains electrolytic capacitor. (On units capable of running on three-phase power, two electrolytic capacitors are connected in series).
- In most applications, a digital multimeter is adequate for testing. In isolated cases, an electrolytic capacitor will not cause internal arc-over until a voltage of about 100 V is applied. To ensure reliable testing, the power supply should be capable of supplying an adequately high voltage.
- Do not apply a voltage that exceeds 350 V!

CAUTION! An electrolytic capacitor charged to a high voltage carries a lot of energy. When the tested is completed, make sure you discharge the capacitor. Do not touch the connections before discharge.

15 TORCH BUTTON CONNECTION

When connecting the Torch button, make sure that part of the HF energy is coupled capacitively to the torch control leads. Therefore, the Torch button connection must be adequately insulated from the protective conductor (enclosure). Similarly, the torch control leads must be adequately insulated from other cables.

16 WEAK INSUFFICIENT HF-IGNITION

If the needle is cold and grey (oxidised), we recommend the HF ignition while putting the gas nozzle in contact with the workpiece. Additionally we advice you to dip the needle once on the workpiece to destroy the oxide on the surface of the needle before ignition.

Check that the diameter of the needle corresponds to the start-up and welding current.

If the needle is hot and the distance between needle and workpiece is not too large, there should be no HF ignition problem with a properly functioning DTG 405.

If possible, check the HF ignition conditions and compare with another machine under the same conditions (gas, gas flow, needle, torch, workpiece, etc.)

17 HF ARC-OVER ON THE SHROUDED SOCKET OUTLET

When the unit is started in DC or AC mode with HF by pressing the Torch button without holding the tungsten electrode close to a workpiece, check whether the condition of the insulation on the shrouded socket outlet and on the Torch button connection. The insulation should be undamaged.

If the insulation is damaged, you will hear high voltage arc-overs at certain points.

Possible causes:

- Mechanical damage to insulation.
- O-ring on torch defective.
- Connection of shrouded socket outlet in unit not gas-tight.

A gas leak will facilitate HF arc-overs to the enclosure.

18 NO HIGH-VOLTAGE STARTING PULSES (HF)

Possible causes:

- Poor insulation or poor gas-tightness on the shrouded socket outlet.
- Starter A7 not supplied with 42 V AC (check at 42 V AC).
- 42 V AC not applied between trigger inputs T0 and T70.
- Starter A7 defective.

When welding with AC, and if the HF is inadequately stabilised, change-over of the trigger inputs to output voltage (after starting an arc) will not function properly (see section A6-2).

Possible causes:

- Cable harness of module A6: 20-way ribbon cable connection from control unit A2 to control A6.

<u>Improvised starter test</u>

1. Disconnect starter outputs DB and D0, and insulate cable connections.
2. Connect two bare wires and bend them together to obtain about 2 mm spacing.
3. Start the unit in HF mode: HF must arc over between the wire ends.

The starter is defective if there are no HF pulses generated when supply and trigger voltage are applied.

19 NO GAS

Possible causes:

- Gas cylinder
- Pressure reducer
- Gas valve connections not supplied with 42 V AC
- Gas valve defective
- Gas connection on the torch
- Torch
- Defect on control unit A2
- Defect on control unit A6

The signal used to control the gas valve Y01 is generated on control unit A2 and goes via the supply and control bus to module A6 where it controls a relay that connects 42 V AC to the gas valve Y01.

20 CONTINUOUS GAS FLOW

Possible causes:

- Defect on control unit A2
- Defect on control unit A6
- Gas valve defective
- The inverter control A8 signals "Current flowing" to control unit A2. This may be due to a defect on control unit A8, or a defect in transformer shunt T2.
- Also, transformer shunt T2 may not be supplied with +15 V and -15 V. It only has three connections. If no current is flowing, 0 V ± 30 mV must be applied to the centre connection (output), and +15 V / -15 V to the outer connections.

21 WATER COOLING, ADJUST PRESSURE CONTACT

Integrated with the DTG405 water-cooled unit is a LOW WATER trip F11. This trip does not close until after a specific water pressure is reached (see section A6-6).

The water pressure is set at the factory and is made by means of a setscrew. See description below:

- The LOW WATER trip is open when the water pump is not running.
- The LOW WATER trip is closed when a short length of connecting hose is used to interconnect the two water connections on the unit and the water pump is running. It is assumed that, when a torch is connected, a higher pressure will build up.

If the water pressure switch fails to close, Error Code 5 ("Cooling water fault") is displayed on A2.

NOTE! When welding with an air-cooled torch and when electrode welding, the water connections should be interconnected by a short length of connecting hose, or the cooling connections of a water-cooled torch should be connected so that the pump is not overloaded.

22 RENEWAL OF CONTROL BOARDS

We advise you only to install control boards which have been factory-adjusted and pre-tested for a particular unit.

If possible, after replacing a control board, perform the commissioning procedure as described.

23 RENEWING ELECTRONIC MODULE A1

CAUTION! Before carrying out this work, make sure you disconnect the unit from the mains power supply! In the event of a fault on the unit, the electrolytic capacitors C1 to C4 may still convey hazardous voltages. Therefore, discharge the capacitors (using a resistor) before renewal!

Place the two insulating sheets supplied with the equipment under A1. The sheets must not show any signs of damage. The metal sheet contact area must not be damaged either. The contact area must be flat. Make sure that the surfaces between the sheet and the electronic module as well as between the sheet and the metal sheet are absolutely clean.

When installation is completed, conduct a high-voltage test at 1875 V (AC) between all the terminals of A1 and the housing. All A1 terminals must be interconnected conductively so that the high voltage does not damage the circuit on A1.

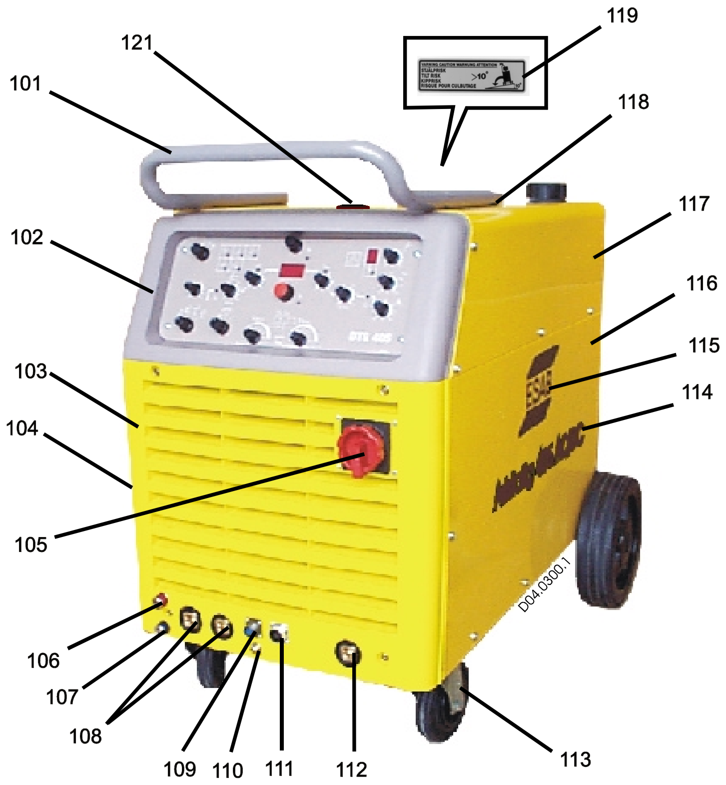
On the specified connectors, interconnect all the pins via an adapter.

Slowly raise the AC test voltage to the specified level; keep this level for 5 seconds, and then reduce to zero. During the test, the current must not exceed 10 mA. Suppression capacitors produce corrupt readings, so they may be removed for the test (A15, C6, C7).

24 EXCHANGE POWER PACKAGE DTG 405

NOTE! Refer to “Connection DIAGRAM DTG 405” on page 10.

1. Remove cover (117):
   Slacken 4 M5 screws.
2. Remove side panel (104/116):
   Slacken 3 M5 screws.
3. Remove front panel (102):
   Unplug ribbon cables from X4, X5 and X6, slacken 2 M6 screws.
4. Control ACST1 (A6):
   Unplug burner push-button cable from X4/5 and X4/6.
5. Remove front grill (103):
   Unlock switch (105) at rear and remove front grill. Slacken 2 M6 screws.
6. Current terminal 1-pole:
   Disconnect cable from +(108), -(108) and +(112).
7. HF unit (A7):
   Disconnect all cables.
8. Rectifier bridge (A3):
   Disconnect cables L1, L2 and L3.
9. Connector (X10):
   Unplug cables 0.230 and 230.
10. Connector (X9):
    Unplug from power block.
11. Control GWL (A8):
    Unplug 26-pole ribbon cable from X1.
12. Protective earth terminal on power block base:
    Slacken M5 nut and disconnect cable.
13. Cooler (209):
    Remove.
14. Power block:
    Slacken 4 M8 screws and extract power block to system front.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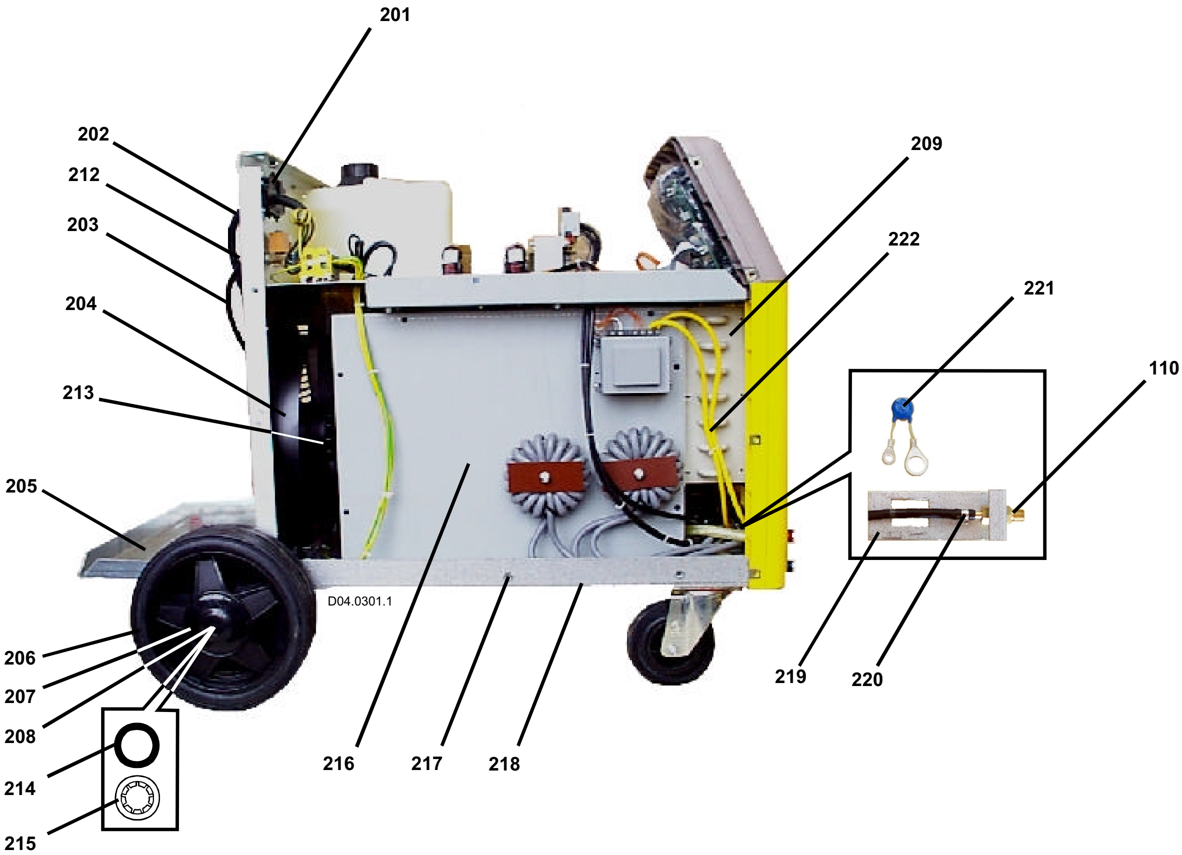
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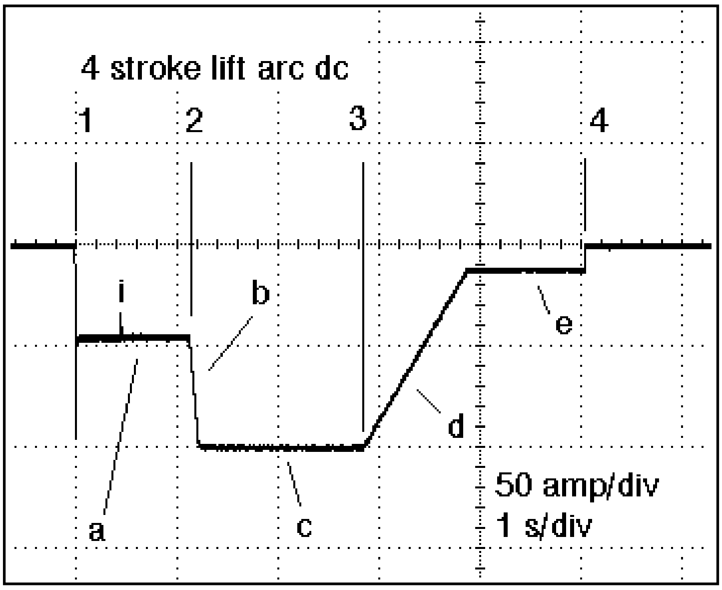
OUTPUT CURRENT IN DIFFERENT MODES

The following oscilloscope patterns show the typical output current waveforms of DTG405 units for various modes of operation. They can be used for comparison with output currents when carrying out service work.

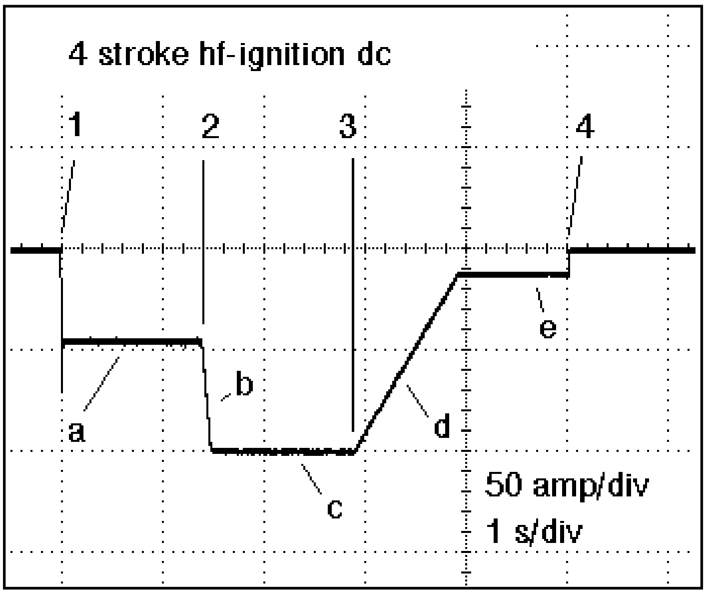
1 FOUR STROKE LIFT ARC DC



4ladc.pcx

a: I1=10 % Imax = 40 A	b: slope1=20 %
c: I2=100 A	d: slope2=50 %
e: I3=10 % I2 = 10 A	i: lift arc ignition

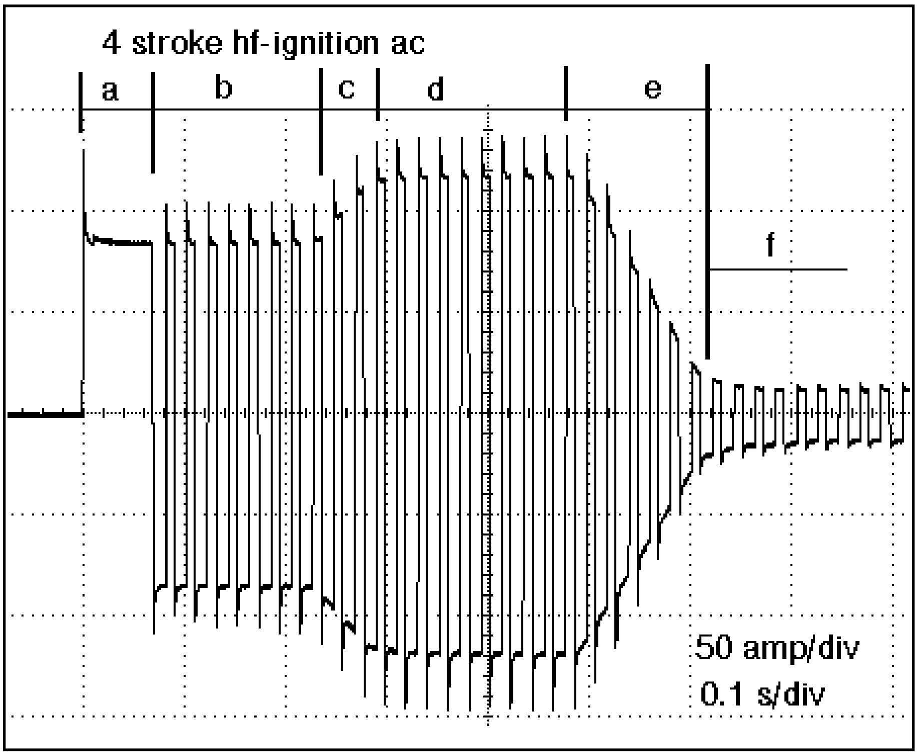
2 FOUR STROKE HF-IGNITION DC



4hfdc.pcx

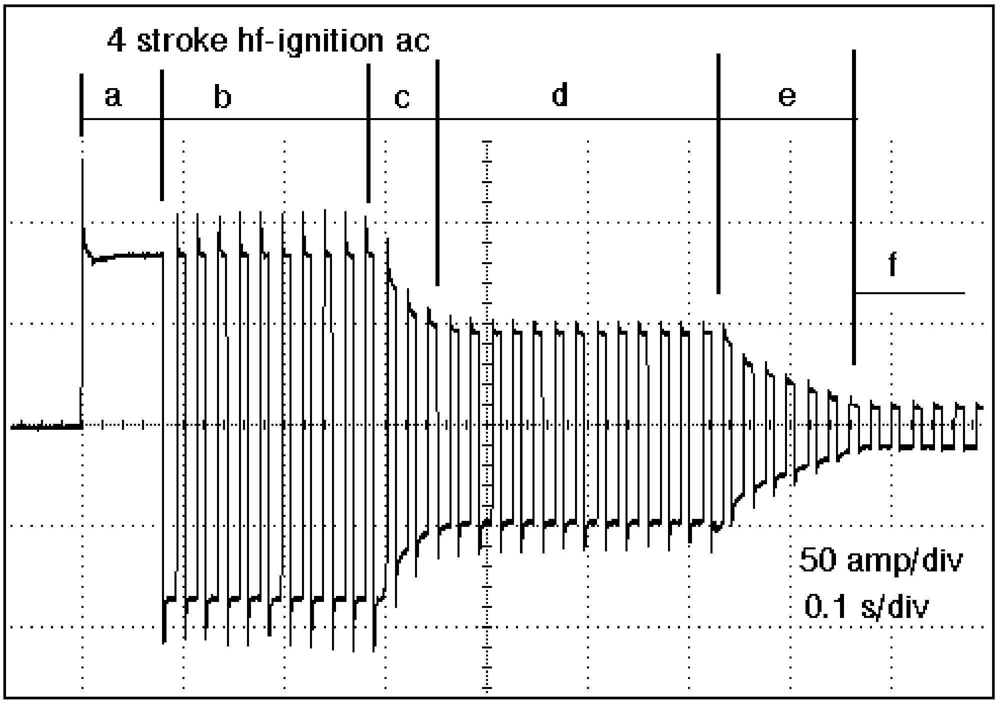
a: I1=10 % Imax = 40 A	b: slope1=20 %
c: I2=100 A	d: slope2=50 %
e: I3=10 % I2 = 10 A	

3 FOUR STROKE HF-IGNITION AC



4hfac1.pcx

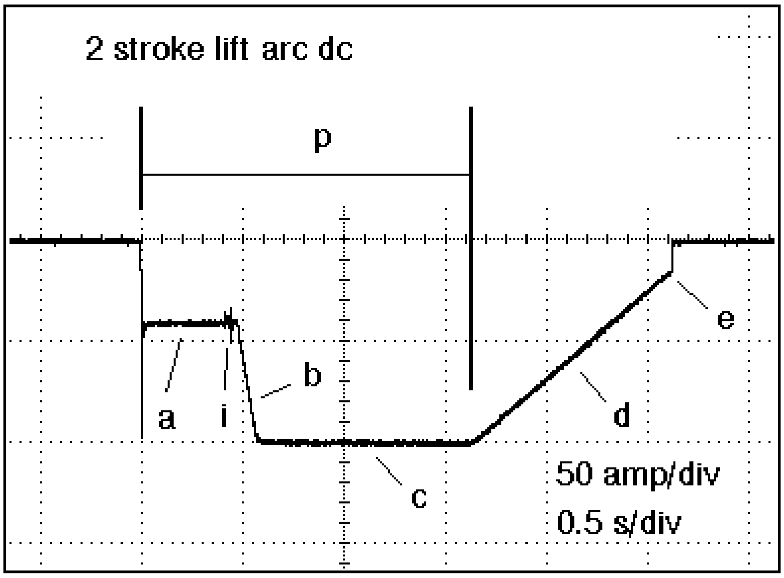
a: Positive pole time	a+b: I1=20 % Imax = 80 A	c: slope1=20 %
d: I2=120 A	e: slope2=10 %	
f: I3=10 % I2 = 12 A	50 Hz, 40 %	



4hfac2.pcx

a: Positive pole time	a+b: I1=20 % Imax = 80 A	c: slope1=20 %
d: I2=50 A	e: slope2=10 %	f: I3=10 % I2 = 5 A
50 Hz, 40 %		

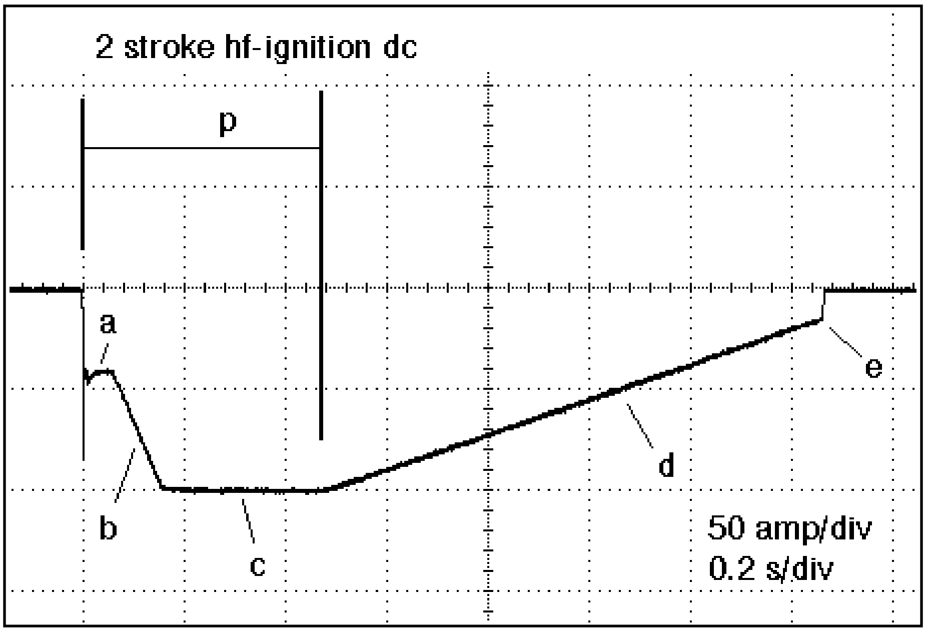
4 TWO STROKE LIFT ARC DC



2ladc.pcx

a: I1=10 % Imax=40 A	b: slope1=20 %	c: I2=100 A
d: slope2=50 %	e: I3=10 % I2=10 A	i: lift arc ignition
p: pressing torch button		

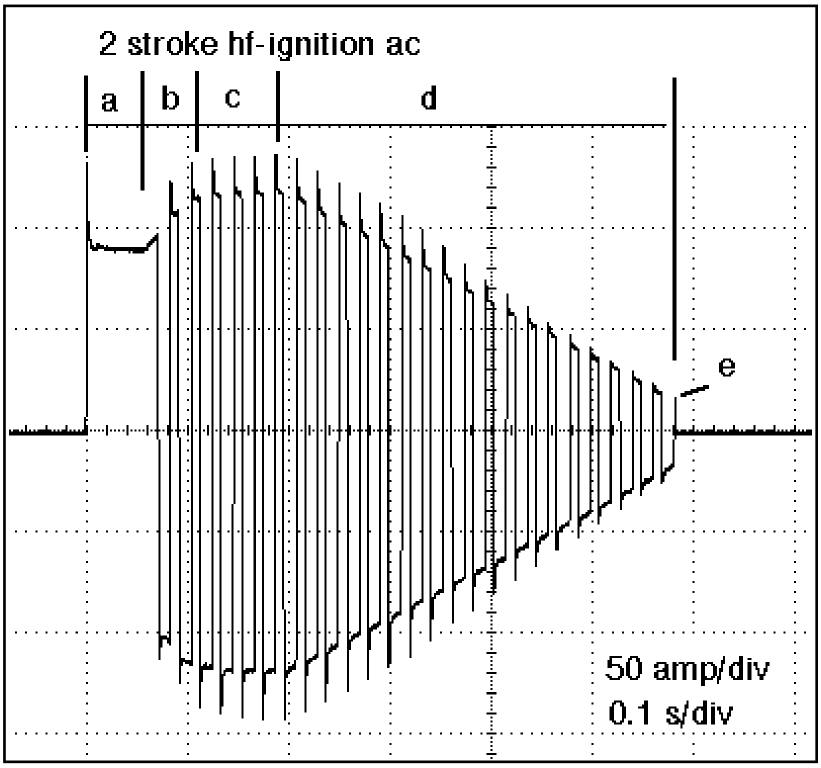
5 TWO STROKE HF-IGNITION DC



2hfdc.pcx

a: I1=10 % Imax=40 A	b: slope1=20 %	c: I2=100 A
d: slope2=50 %	e: I3=10 % I2=1 0A	p: pressing torch button

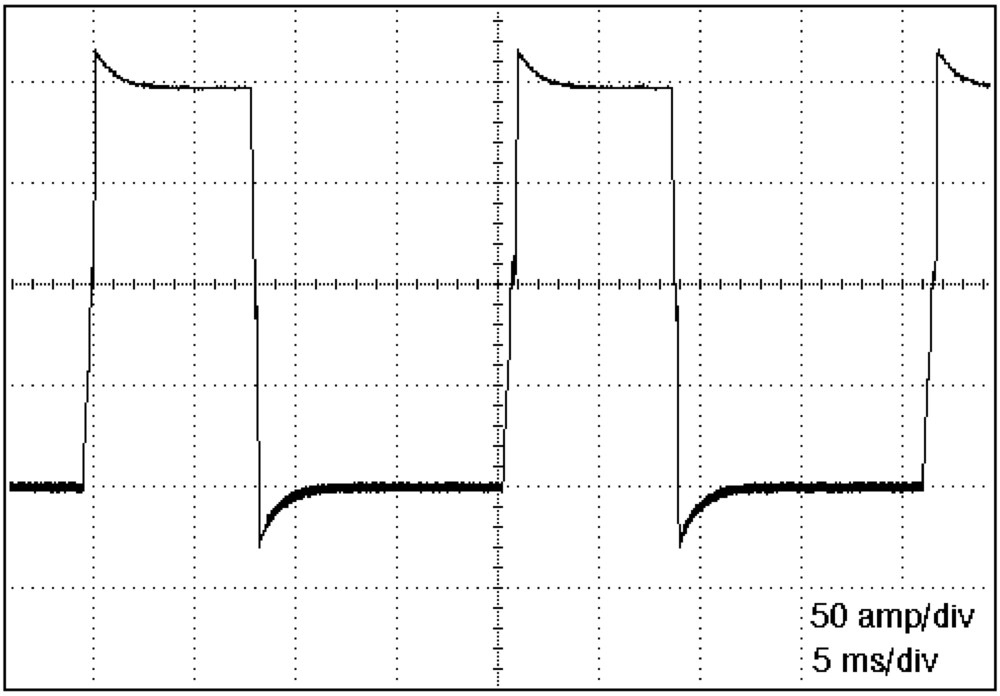
6 TWO STROKE HF-IGNITION AC



2hfac.pcx

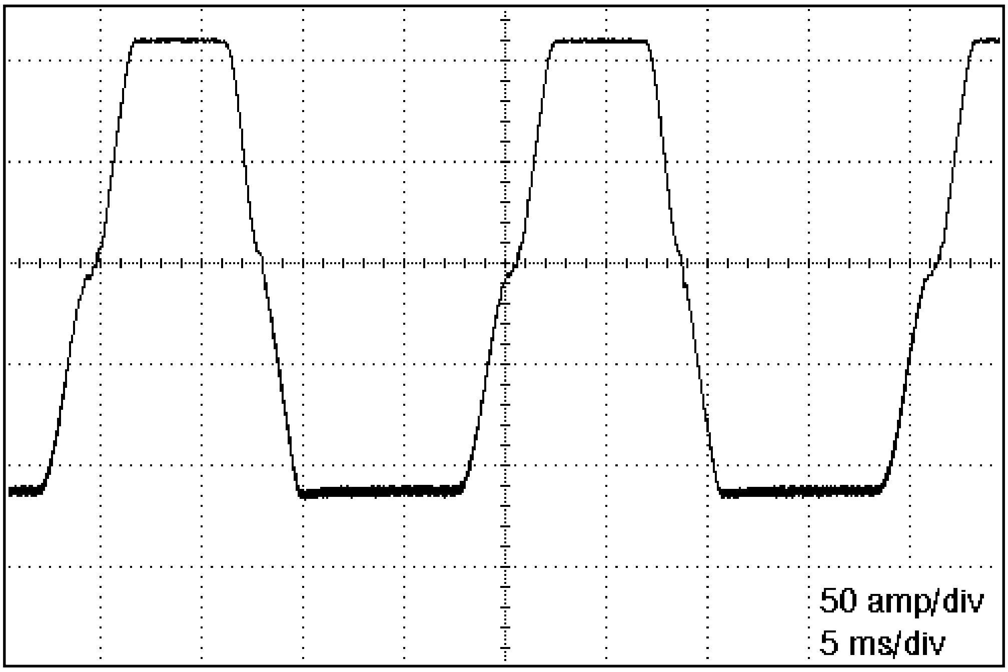
a: I1=20 % Imax=80 A	b: slope1=20 %	c: I2=120 A
d: slope2=10 %	e: I3=10 % I2=10 A	

7 WAVEFORM AC1 (SQUARE WAVE)



ac1.pcx

8 WAVEFORM AC2 (SMOOTH WAVE)



ac2.pcx

STARTING UP

1 GENERAL INFORMATION

The commissioning procedures described are very similar to those conducted during factory repairs if the fault in the unit is unknown. Depending on the type of fault and the test facilities available, it may be useful to conduct only part of the test procedure.

The test procedure selected can pre-test several functions on the isolating transformer before connecting the unit to the mains.

Only carry out adjusting operations if the trimmers on control boards A8 and A2 have not been tuned to the particular unit.

As a rule, new boards or replacement boards have already been adjusted, so the procedure described here is not necessary but may be useful for checking.

The shut-off described for the air duct, or disconnecting fans is only required if the unit is subjected to a thermal test.

The thermal test should be conducted in the following cases:

- Thermal switch T4 (through TC10) was renewed.
- Defective thermal switch(es) is/are suspected.
- After renewing power electronics components such as A3, A4, A5, A9, A10, A11, A12, A13, A14, power transformer T3, reactor L1, etc.

2 COMMISSIONING OF DTG405 POWER SECTION

1. Test for electrical safety.
2. Disconnect water pump. Jumper the water pressure switch input (X9-1 to X9-2). Disconnect the fan.
3. Measure the resistances of the primary switch drive leads for A4, A5, A11, A12 and for the current transformer T1, T5. To do this, disconnect connectors X10, X11, X12 on A1. Lay down disconnected cables so that no accidental electrical connections can occur; these cables are connected to the link voltage.

- Connector X11-1 to X11-2: 500 Ω
- Connector X12-1 to X12-2: 500 Ω
- Connector X10-1 to X10-2: < 5 Ω
- Connector X10-3 to X10-4: < 5 Ω

4. Do not re-connect the drive leads for primary switch A4, A5, A11, A12, and connect the oscilloscope to A1: X11, X12.
5. Turn on the unit. Connect the 230 V / 400 V transformer to the 0-230 V isolating transformer and to the unit. Turn the isolating transformer to zero. Apply voltage to L1, L2 via adapter.
6. Connect negative cable to unit negative socket with HF reactor.

   Connect positive cable to unit positive socket.
7. Load resistor: No load.
8. Settings on control panel of A2:

   Set all to MIN. Set balance to 50%.

   Position of mode selector switch: Electrode; DC with HF; no pulsing.
9. Increase voltage on isolating transformer, starting at zero. Driving will work from 150 V (the conductor voltage is 1.41 times higher).

10. Test the drive signals for the primary switch (X11.1-X11.2, X12.1-X12.2):

    Voltages: +12 V / -12 V; duty cycle: 45% to 48%; frequency 66 kHz

    Cf. "TESTING OF MODULES A4, A5, A11, A12" (Checking gate pulses)

11. Increase voltage on isolating transformer up to 253 V max. (conductor voltage not to exceed 440 V). Driving must remain unchanged in range from 150 V to 253 V.

12. Reduce voltage on isolating transformer and wait until A1 is OFF. Disconnect the oscilloscope.

13. Connect drive leads (A1: X10, X11, X12) again; then increase voltage on isolating transformer again.

    From 150 V on the isolating transformer, the no-load voltage (86 V to 92 V) will be applied and will be constant up to 253 V.

14. Set mode to "4-Cycle DC-TIG with HF".

    Set load resistor to "Short-Circuit". Set isolating transformer to 230 V. Start the unit by pressing the Torch button.

    Increase the current starting at MIN, and check the following:

    Maximum short-circuit current without short-circuit jumper: 70 A

    Short-circuit current when 3 A are drawn from the isolating transformer (with short-circuit jumper): 110 A

    The short-circuit jumper disables the current-lowering function when short-circuit is detected. This function is located on module A8 (J1). It detects short-circuit when current flows for about 2 seconds while the output voltage is less than approx. 8 V.

    Do not forget: After starting the hot test, remove the short-circuit jumper from J1.

15. Set the load resistance to 0.2 Ω. Increase the current to isolating transformer current of 3 A; then the load current must be about 40 A.

    The previous two test steps enable faults to be detected on the isolating transformer since, if faults have occurred, the figures given in table are not normally reached.

16. Disconnect the isolating transformer. Connect the unit to mains voltage.

    Increase the current until it becomes 'wavy'; do not exceed 250 A:

17. Load resistance: 0.05 Ω

18. Check maximum display: 400.

    When in the "4-Cycle DC" mode with HF, do not start the unit; only check the display range by turning the current potentiometer.

19. Check the maximum currents and adjust by means of TR4 on module A8 as necessary:

    When making adjustments, make sure you do not exceed the maximum permitted current of the unit. To achieve this, you should have some means of measuring the current accurately and interference-free.

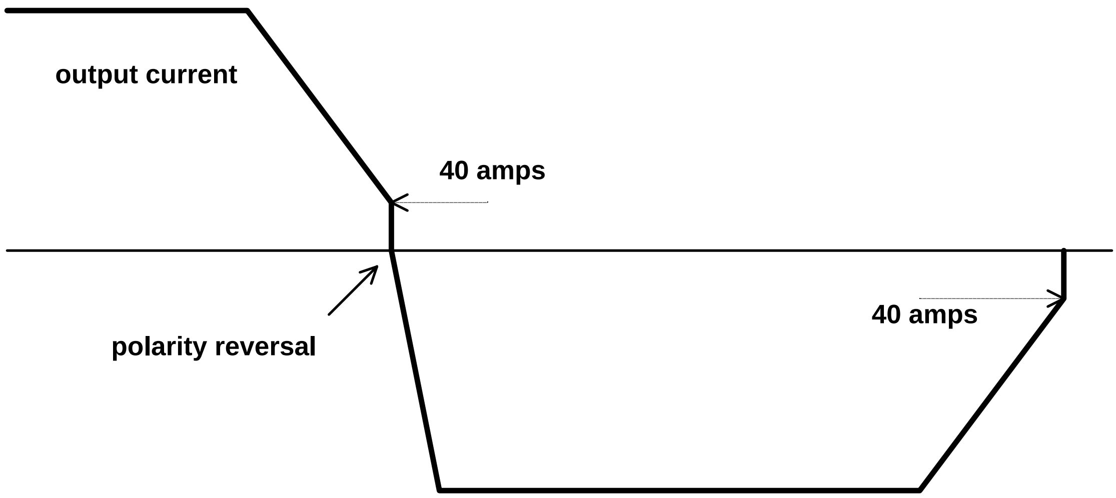
20. "4-Cycle DC" mode with HF: Trim MIN DC by means of TR3 on module A8:

21. "4-Cycle AC1" mode; Test: MIN AC: 10 A.

    If necessary, adjust by means of TR6 on module A8.

22. Test: Change-over current 40 A, Frequency regulation, Balance control.

    A transformer shunt or current-measuring prongs and an oscilloscope are required for this test step.



Cf. Current waveform AC1 in Section "OUTPUT CURRENT IN DIFFERENT MODES".

23. Increase AC1 current to MAX.
24. Check current waveform for AC2 mode. Cf. Current waveform AC2 in Section "OUTPUT CURRENT IN DIFFERENT MODES".
25. Connect the remote regulator to socket X5 and test.
26. Thermal trip at 0.05 Ω load resistance and maximum current.

    Mode: 4-Cycle AC1-TIG with HF; frequency 50 Hz, balance 40%.

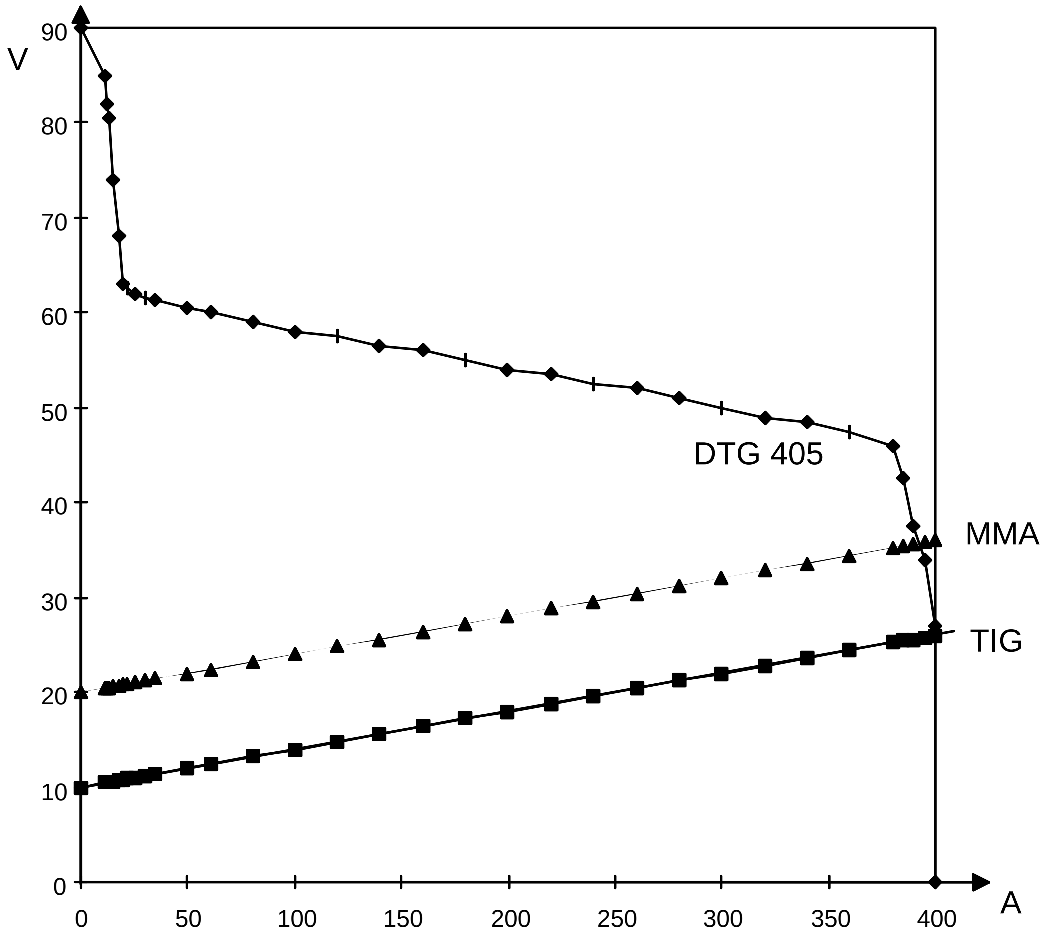
    Remove the short-circuit jumper once the test has started.
27. When thermal trip has occurred, re-connect fan and water pump.
28. Connect pressure gauge. Check cooling water pressure. Adjust LOW WATER trip if necessary.
29. Weld.

3 COMMISSIONING A2

1. Turn on the unit; switch position 400 V; turn current potentiometer I2 fully anticlockwise. Set mode selector switch to "2-Cycle DC". Adjust trimmer 2 (refer to component mounting diagram of A2-2) until the display shows 003.
2. Turn the potentiometer I2 fully clockwise. Set mode selector switch to "2-Cycle DC". Adjust trimmer 6 (refer to component mounting diagram of A2-2) until the display shows 401.
3. Turn the potentiometer I2 fully clockwise. Set mode selector switch to "2-Cycle AC2". Adjust trimmer 4 (refer to component mounting diagram of A2-2) until the display shows 371.
4. The positive time can be adjusted by means of trimmer 2 (refer to component mounting diagram of A2-1).
5. The gas lead time can be adjusted by means of trimmer 3 (refer to component mounting diagram of A2-1). The gas lead time is factory-set to 200 ms.
6. The starter turn-off lag can be altered by means of trimmer 4 (refer to component mounting diagram of A2-1).
7. The UP slope time can be increased or reduced by means of trimmer 6 (refer to component mounting diagram of A2-1). When the time is altered, the UP slope potentiometer must be turned fully clockwise. Make sure that the voltage on IC2 Pin 14 (refer to component mounting diagram of A2-1) does not exceed 7.45 V.
8. The DOWN slope time can be increased or reduced by means of trimmer 5 (refer to component mounting diagram of A2-1). When the time is altered, the DOWN slope potentiometer must be turned fully clockwise. Make sure that the voltage on IC2 Pin 8 (refer to component mounting diagram of A2-1) does not drop below 7.55 V.

NOTES:

LOAD CHARACTERISTICS



NOTES:

OPERATION

1 GENERALLY

Generaly safety instructions for the operation of the welding device are found on page 6. Read the instructions before using the welding device.

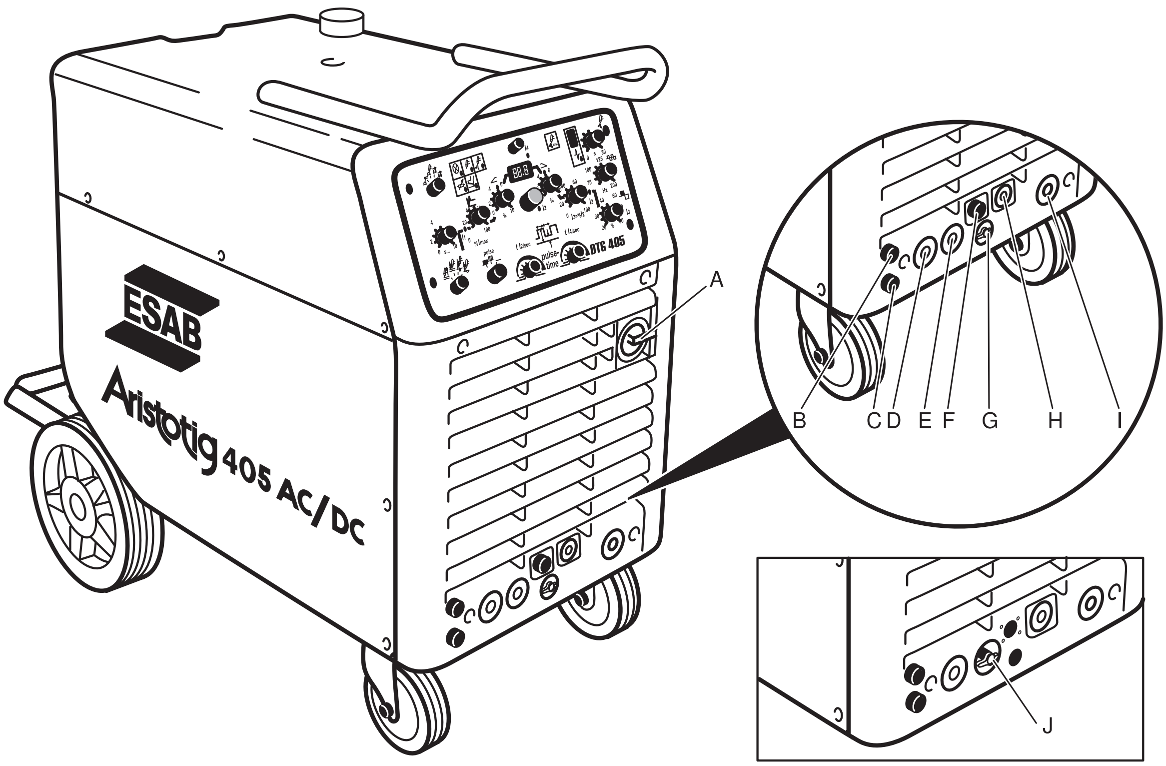
2 CONTROL INSTALLATIONS AND CONNECTIONS

CAUTION! The Positions F and G are omitted in versions with a central connection.

3 REMOTE CONTROL

The welding current during the TIG- and electrode welding can be adjusted using the remote regulator.

With the remote regulator, any current between 3 A and the preset welding current I2 of the unit can be selected.



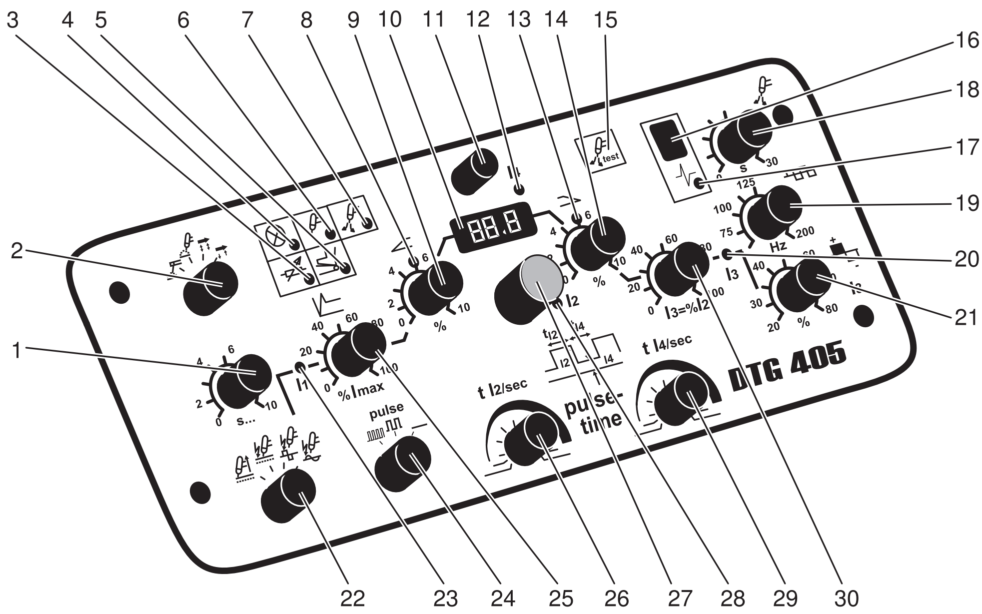
A	Mains switch	**F**	TIG torch control cable connection
B	Cooling water-return (red)	**G**	Gas connection for TIG torch
C	Cooling water-outlet (blue)	**H**	Remote control input
D	Bayonet-connection of the TIG torch	**I**	Welding current socket positive terminal
E	Welding current socket negative terminal	**J**	TIG torch central connection

4 OVERHEATING PROTECTION

- An integrated thermal cut-out in the welding device protects the equipment from overheating.
- The welding process is interrupted and the fault display (16) indicates error "4" .
- The equipment must be left in that condition to cool with the main switch left in the on position and the cooling fans running.

CAUTION! When the error indicator "4" disappears, the position "Electrode" has to be set to the open circuit voltage on the electrode; on position "TIG" the welding device can now be started with the torch button. After cooling, the device is reconnected automatically.
Care must be taken to ensure that the electrode does not touch the welding table, the workpiece or any other electrical conducting object during the cooling phase of the power source in order to prevent unintentional arc ignition when switching it on again.
An unintentionally ignited arc may damage the electrode holder, the workpiece or the equipment.

5 CONTROL PANEL



1	**Potentiometer, spot time**	This potentiometer allows the duration of the spot time to be set to values in the range from 0.1 to 10 s.
2	**Operation mode selector**	• Electrode welding with rod electrodes. • TIG spot welding • TIG four-step welding • TIG two-step welding
3	**LED, external current selection**	LED illuminates, when the foot operated or hand operated remote controls are connected and are controlling the welding current.
4	**LED, mains**	The green LED illuminates when the device is connected to the mains and the mains switch is activated.
5	**LED, foot operated remote control**	LED illuminates, when a foot operated remote control is connected, i.e. that the set point is fixed externally and the arc can be started using the torch button as well as via the pedal.

6	**LED, welding**	LED illuminates when voltage is applied to the welding current socket. In the TIG operation mode, after activating the torch button whereas in the electrode operation mode, this occurs after selecting electrode welding.
7	**LED, protective gas on**	LED illuminates when the solenoid valve is open and the protective gas can flow. After switching the device on, the hose bundle is automatically purged with protective gas.
8	**LED, ramp up**	LED lights in the ramp up phase (Up-Slope).
9	**Potentiometer, ramp up**	Sets the rate at which the current ramps up from the ignition current I1 to the welding current I2. Turning direction anticlockwise decreases the ramp rate.
10	**Welding current 7 segment display**	Displays the value of the welding current of the current function.
11	**Potentiometer, I4**	Sets the current I4 during pulsed operation.
12	**LED, I4 active**	I4 active. During pulsed operation: Toggles between the two displays I4 and I2 with fixed pulse frequency.
13	**LED, ramp down**	Displays the ramp down phase (Down-Slope).
14	**Potentiometer, ramp down**	Sets the rate at which the welding current I2 ramps down to the drop-off current I3 at the end of throat. The ramp down prevents cratering.
15	**Button, gas test**	In order to manually purge the hose bundle with protective gas. Pressing this button opens the gas valve without applying a welding voltage to the electrode. During pulsed operation: When activating the button gas test, the display (10) switches to the I4 value.
16	**Display, error code**	Display of possible error messages.
17	**LED, fault**	LED flashes if a fault condition occurs in the device. The error message appears in the error display.
18	**Potentiometer, gas post-flow time**	Sets the gas post-flow time after finishing welding to protect the weldpool. The time can be set from approximately 0.2 to 30s.
19	**Potentiometer, AC frequency**	Continuous setting of the AC frequency from 50 Hz up to 200 Hz.
20	**LED, final current I3**	LED illuminates when the final current I3 is active.
21	**Potentiometer, AC balance**	If the potentiometer is set to the middle position, the positive and the negative half cycles are equal for AC welding. This potentiometer is deactivated, when welding using DC current (DC operation).
22	**Welding current selector**	• DC with lift arc ignition • DC with HF ignition • Square AC with HF ignition • Sinusoidal AC with HF ignition
23	**LED, I1**	LED illuminates, when the ignition current I1 is active.
24	**Switch, pulse welding/ normal welding**	• Fast pulse Pulse frequency in the range of 250 Hz to 5 Hz. • Normal pulse Pulse frequency in the range of 25 Hz to 0.5 Hz. • Normal welding Normal TIG welding without pulsation.
25	**Potentiometer, ignition current I1 Soft-Hot-Start**	Potentiometer I1 determines the ignition behaviour for electrode and TIG welding. It can be set as a percentage of the possible welding current of the power supply.
26	**Potentiometer, pulse time I2**	Sets the current I2 pulse time.

27	**Potentiometer, welding current I2**	Sets the welding current. The welding current can be set during no-load operation and is shown in the 7 segment display.
28	**LED, welding current I2**	LED illuminates, when the welding current I2 is active. During pulsed operation: Toggles between the displays I2 and I4 with fixed pulse frequency.
29	**Potentiometer, pulse time I4**	Sets the pulse time of the current I4.
30	**Potentiometer, final current I3**	Sets the final current I3. Select a value so that no craters are caused.

5.1 ERROR CODES

	Error	**Possible cause**	**Action**
1	**Primary overcurrent**	Fault in power supply	Call service
2	**Primary undervoltage**	Faulty power supply Faulty fuses	Check power supply
		Generator is underdimensioned	Use generator with sufficient power
3	**Primary overvoltage**	The voltage used does not comply with the rated voltage	Check power supply
4	**Overtemperature in-let/ outlet vents blocked**	Exceeded allowed duty cycle	Let device cool while running Check air supply
		Ambient temperature too high	Let device cool while running
5	**Cooling water distur-bance**	No water in cooling device	Refill (Remember antifreeze!)
		Defective or calcified switch	Install a new switch
		Water pump defective	Install a new pump

NOTES:

5.2 INSTRUCTION TYPES SELECTION (2)

Electrode welding (MMA)

Welding with coated electrode.

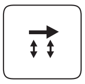
HF unit and Lift arc function are switched off, Soft-Hot-Start function is activated.

Spot welding TIG (Up-Slope and Down-Slope active)

Welding with defined period (from 0,1 to 10 s adjustable).

By pressing the torch button:

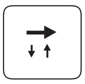
- Arc is ignited.
- Current increases to the preset welding current rate.
- Spot time begins to count down.
- Welding current rate drops to the preset drop-off current .
- Arc extinguishes and preset gas post-flow runs off.
- Pressing of the torch key again allows the welding process to be repeated.



Four-stroke-mode

Continuous welding

- The ignition current 1 (Soft-Hot-Start) starts to flow when pressing the torch button.
- The main current I2 is activated (Up-Slope active) by releasing the torch button.
- The down ramp is started by pressing and maintaining the torch.
- The welding is finished by releasing the torch button.



Two-stroke-mode

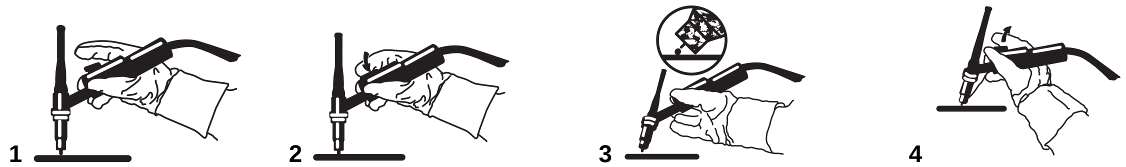
Short tack weldings

- By pressing the torch button, the arc is ignited (Up-Slope active).
- By releasing the torch button the down ramp is activated, after reaching the final current I3 the welding is finished.

5.3 WELDING CURRENT SELECTION SWITCH (22)

Direct current (DC) with lift arc ignition

- Place the electrode on the workpiece at the position where the start of the weld is desired.
- Press the torch button.
- Lift up the torch to ignite the arc.
- Welding current rises at the preset rate.
  To finish the weld, release the torch button.
  Weld current drops to the preset final current.



1 Locate torch.

2 Press the torch button.

3 Lean torc
Arc ignites by lifting.

4 To finish the welding,
release the torch button.

Direct current (DC) with HF-ignition

(contactless ignition)

- Locate torch with electrode over the place where the start of the weld is desired.
- Press the torch button.
- Arc is ignited.
- Welding current rises to the preset rate.
  To finish the weld, release the torch button.
  Welding current drops to the preset drop-off current.

Square AC with HF ignition

- Highest effectiveness, through stable arc.
- For light metals such as aluminium.

Sinusoidal AC with HF ignition

- High effectiveness.
- Lower noise than square AC.

5.4 REMOTE CONTROL

LED foot operated remote control

This LED indicates, that a foot operated remote control is connected to control the set value of the welding current.

The device changes automatically to two-stroke-mode and disconnects the slope functions.

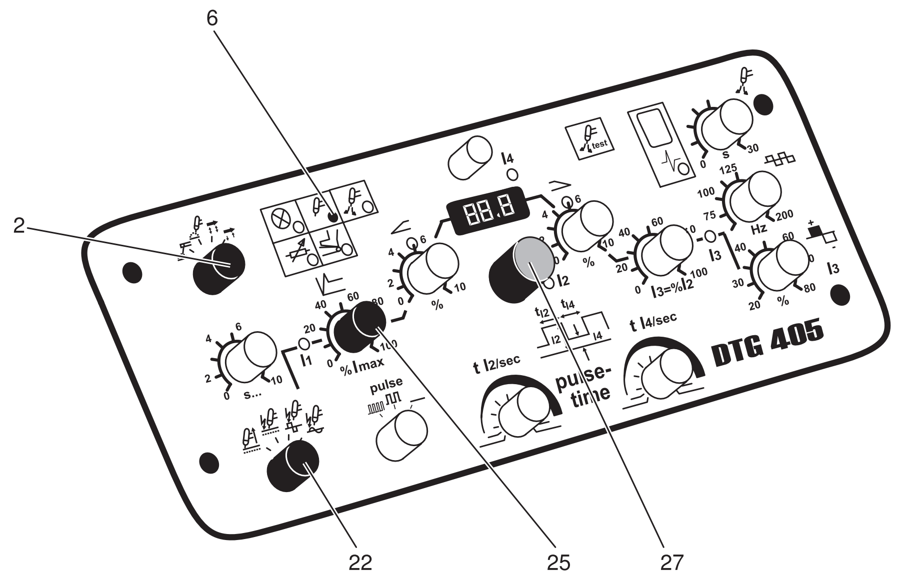
Using the foot operated remote control, the maximum available welding current is set using the potentiometer I2 (27).

LED hand operated remote control (current selection external)

This LED (3) illuminates, if an external device (foot or hand operated remote control) is connected and the welding current is determined by that control.

The maximum available welding current is set using the potentiometer I2 (27).
The Up-Slope (9) and Down-Slope (14) have to be set by connection of a hand operated remote control.

6 ELECTRODE WELDING (MMA)

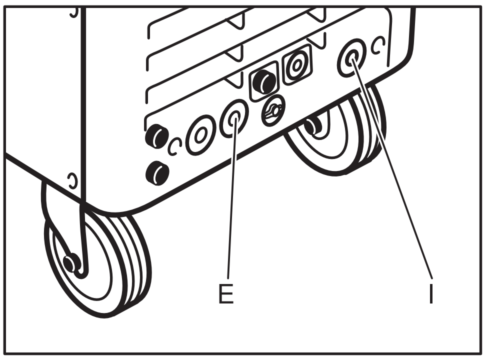


6.1 SETTINGS ON THE CONTROL PANEL WHEN ELECTRODE WELDING

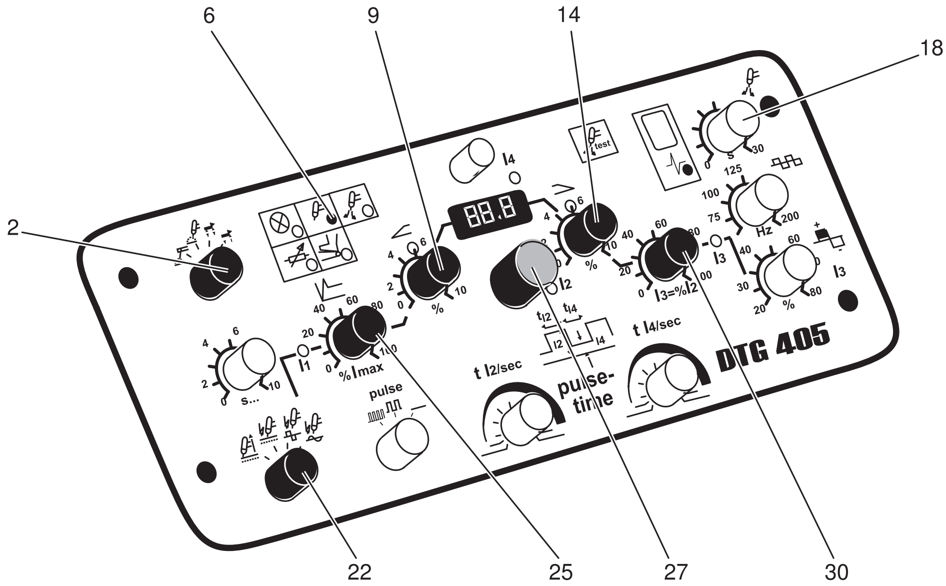
The polarity of the electrode depends on the type of electrode and the welding process. Pay attention to the producer's instructions on the electrode package.

Application of pulsed welding current is possible.

1. Connect the welding current cable to the welding current socket (E) and (I) with reference to the polarity.
2. Set mode selection switch (2) to electrode welding.
   Light emitting diode (6) indicates that voltage is applied to the welding current sockets (E) and (I).
3. Set the desired welding current type with welding current selection switch (22).
4. Set Soft-Hot-Start function (ignition current) using the potentiometer I1 (25).
   The ignition current is a percentage of the power sources maximum output of 400 A (ie. a setting of 25% will give an ignition current of approximately 100A)
   Set this control to a level that provides easy ARC.
5. Set welding current value I2 using the potentiometer (27).
   The welding current can be also controlled by a hand or foot operated remote control.



7 TIG WELDING

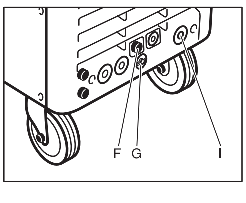


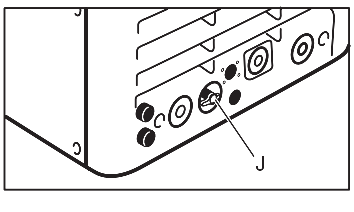
For TIG welding, the operating type selector has three positions:

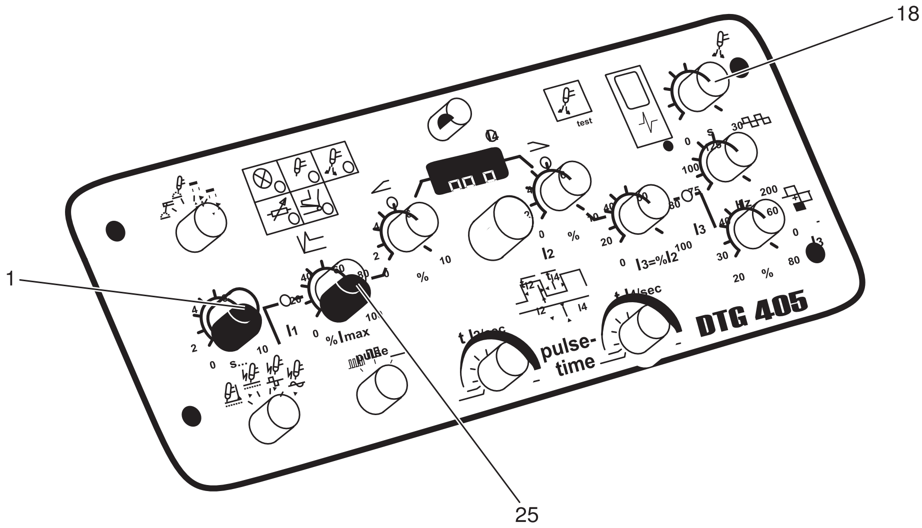
- Spot welding
- TIG four-step welding
- TIG two-step welding

7.1 SETTINGS ON THE CONTROL PANEL WHEN TIG WELDING

1. Connect the TIG-torch to the control cable connection (F) and gas connection (G).
   Connect the return cable to the positive side of the welding current socket (I) .
   Connect the TIG torch to (J) when using central connection.
2. Gas pre-flow time has an internal default value.
3. Set operation mode selector (2) to the desired position.
   (Explanation of the particular operation types, see page 84.)
   LED (6) indicates the voltage on the welding current socket after manipulation of the torch button.
4. Set the desired welding current type and ignition method using the welding current selection switch (22).
5. Set Soft-Hot-Start function (ignition current) using the potentiometer I1 (25).
   The ignition current is a percentage of the power sources maximum output of 400 A (ie. a setting of 25% will give an ignition current of approximately 100A).
   Set this control to a level that provides easy ARC.
6. Set welding current value I2 using the potentiometer (27).
   The welding current can be controlled by a hand or foot operated remote control.
7. Set the ramp up rate using the potentiometer Up-Slope (9).
8. Set the ramp down rate using the potentiometer Down-Slope (14).
9. Set desired final current using the potentiometer I3 (30).
10. Set gas post-flow time using the potentiometer (18).







7.1.1 SPOT WELDING

1. Set the spot time using the potentiometer (1) between 0.1 and 10 s.
2. Set the gas post-flow time using the potentiometer (18).
3. Touch the torch key to interrupt welding process after preselected time.

Pressing the button again causes the process to be repeated.

7.1.2 TIG FOUR-STROKE WELDING

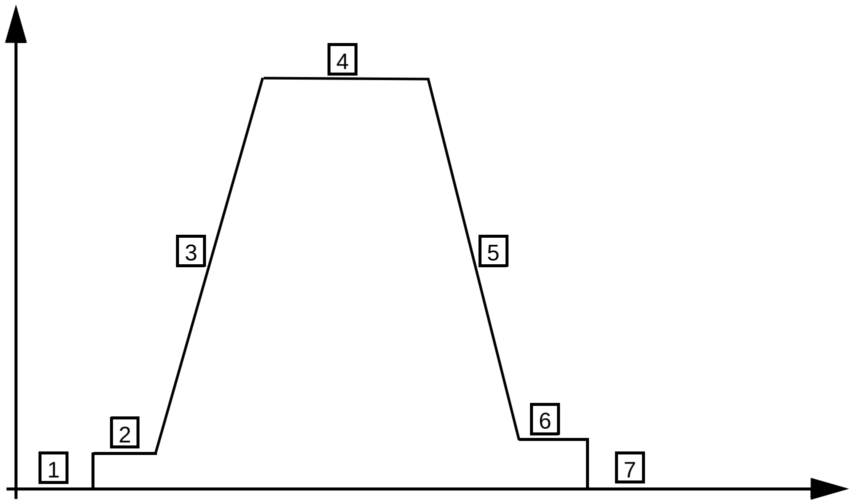
Step 1: By pressing the torch switch the ARC is ignited.
(After the pre-flow time has expired) at a current level determinated by the soft-hot-start (ignition current) control.

Step 2: Releasing the torch button causes the current to increase to the welding current value I2 using the potentiometer Up-Slope set time.

Step 3: Pressing the torch button again and holding causes the Down-Slope to start.
The current slopes down to the set final current I3 after the time set using the potentiometer Down-Slope.

Step 4: By releasing the torch button, the arc extinguishes and the gas flows for the time set on the gas post flow control (18).

TIG four-stroke welding process



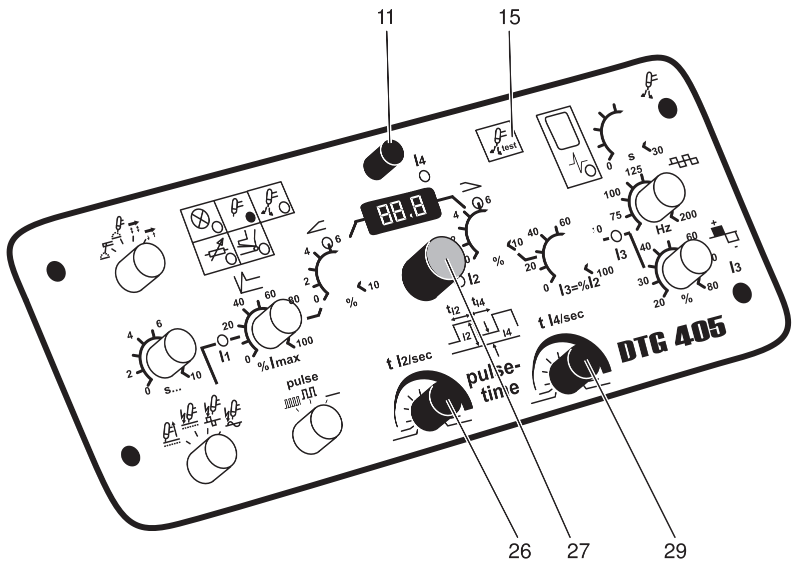
1. The gas pre-flow time has an internal fixed default value.
2. Set ignition current I1 using the potentiometer (25).
3. Set Up-Slope using the potentiometer (9), at maximum (I2=400A) a ramp time of 10s is obtained. The ramp time is dependant on the set welding current I2.
4. Set welding current I2 using the potentiometer (27).
5. Set Down-Slope using the potentiometer (14), at maximum (I2=400A) a ramp time of 10s is obtained. The ramp time is dependant on the set welding current I2.
6. Set final current I3 using the potentiometer (30)
7. Set gas post-flow time using the potentiometer (18) 0.2–30 s.

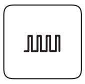
7.1.3 TIG TWO-STROKE WELDING

Step 1: By pressing the torch switch the gas flows for the preset time and the ARC ignites at a current level set by potentiometer I1 (25).
After a fixed time the current rises at a rate set by the up-slope control (9) to the welding current value set by the potentiometer I2 (27).

Step 2: By releasing the torch button, the current slopes down to the set final current in the time set using the potentiometer Down-Slope. Afterwards, the arc extinguishes and the gas post-flow time runs off.

7.1.4 SWITCH PULSE WELDING/NORMAL WELDING (24)



 **Fast pulse**

The arc pulses between the two current values set using the potentiometer I2 (upper value) (27) and the potentiometer I4 (lower value) (11).

The time for I2 can be set using the potentiometer pulse time I2 (26), the time for I4 is set using the potentiometer pulse time (29).

Without activating the gas test button (15), the welding current I4 cannot be set.

The range of times which can be set using this switch, is from 0.002 to 0.1s, corresponding to a frequency range of 250 to 5 Hz.

 **Normal pulse**

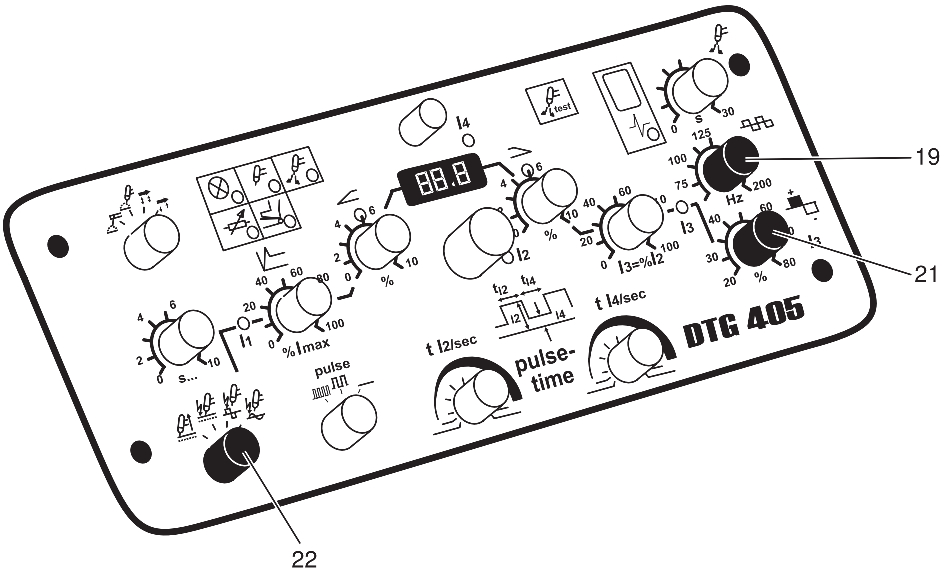
The arc pulses between the two current values set by the potentiometer I2 (upper value) (27) and the potentiometer I4 (lower value) (11).

The time for I2 can be set using the potentiometer pulse time I2 (26), the time for I4 is set using the potentiometer pulse time (29).

Without activating the gas test button (15), the welding current I4 cannot be set.

The range of times which can be set using this switch is from 0.02 to 0.1s, corresponding to a frequency range of 25 to 5 Hz.

7.2 SETTING, DC AND AC



Setting of the desired welding current type using the welding current selection switch (22).

7.2.1 DIRECT CURRENT

When DC welding, the electrode (TIG- and electrode welding) is connected to the negative pole and the return cable to the positive pole.

7.2.2 ALTERNATING CURRENT

Connect as for DC configuration. Two different AC types can be selected using the welding current selector (22).

- A square alternating current is distinguished by a stable arc, although, it causes a higher working noise.
- The sinusoidal type provides the user with an alternating current curve with less noise.

Using the potentiometer AC frequency (19), the frequency is progressively adjustable from 50 up to 200 Hz. A higher AC frequency results in a more concentrated and a more stable arc.
It is suitable for lower currents and for welding thin plates.
Using the potentiometer AC balance (21), the balance can be varied between positive and negative half cycles.
A balance shift in the positive direction causes a higher cleaning effect. A shift in the negative direction causes a higher penetration.

8 FORCED INTERRUPTION

When the torch button or the foot operated remote control is activated, but no arc is generated, the open-circuit voltage is turned off automatically after 2 seconds. It will also turn off, when the arc is lost.
The arc can be started again by releasing the torch button and activating it again.

This function prevents:

- Uncontrolled arc ignition
- Material damage
- Protective gas leakage
- Accidents

MAINTENANCE

The unit is maintenance-free. The following points should be checked regularly:

- Mains plug and cable as well as the welding torch and earth connection from time to time for damage.
- After every package of electrodes or after 30-40 hours of TIG welding operation, blow out the unit with dry compressed air at low pressure. For this purpose, switch off the unit and pull the mains plug. Blow the compressed air from the front through the ventilating grill to the rear. Leave the housing closed. Never blow the compressed air through the grill on the rear of the unit. A ventilating fan is located there that would be brought to such a high rotating speed by the compressed air that the bearing could be damaged.

ACCESSORIES

Remote control unit:

The hand remote regulator PHA1 (Order-No. 0367 657-881) and the foot pedal remote regulator FS003 (Order-No. 0700 155 880) can be connected.

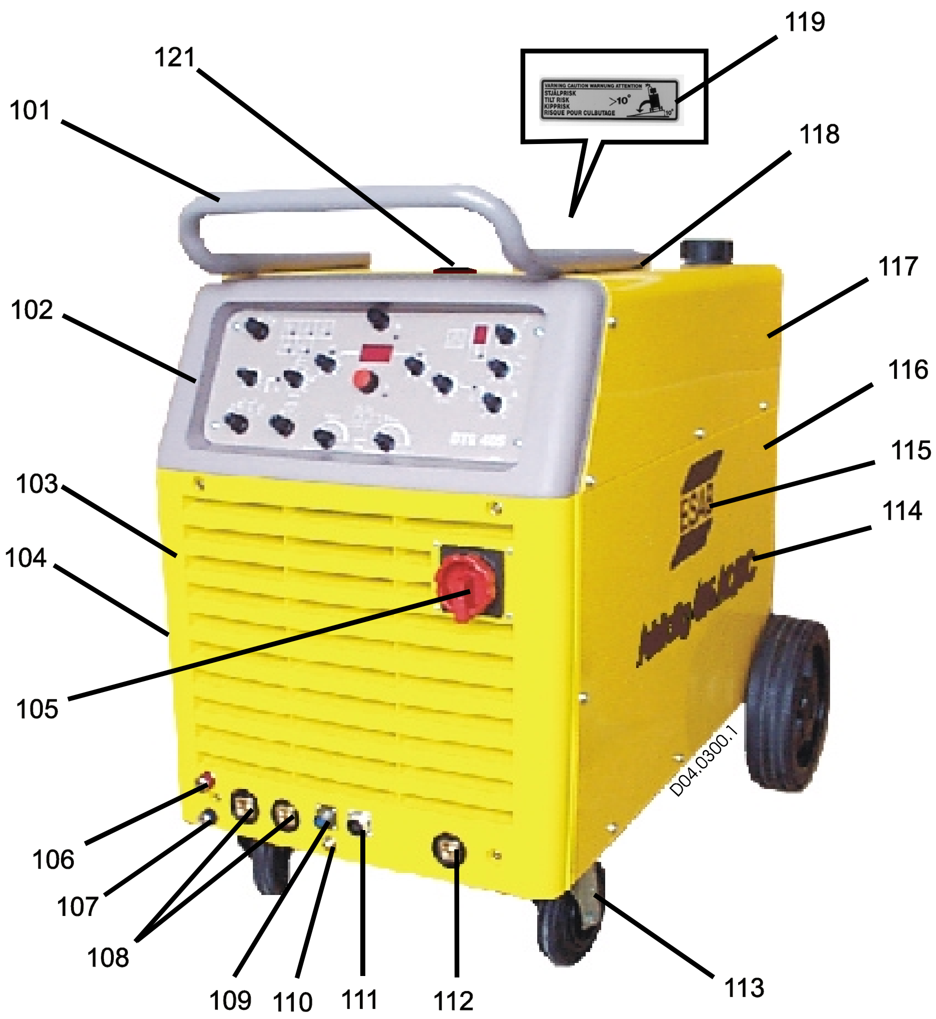
TIG torch and electrode holder:

Information concerning other TIG torches, electrode holder and remote control units as well as additional accessories are contained in separate brochures.

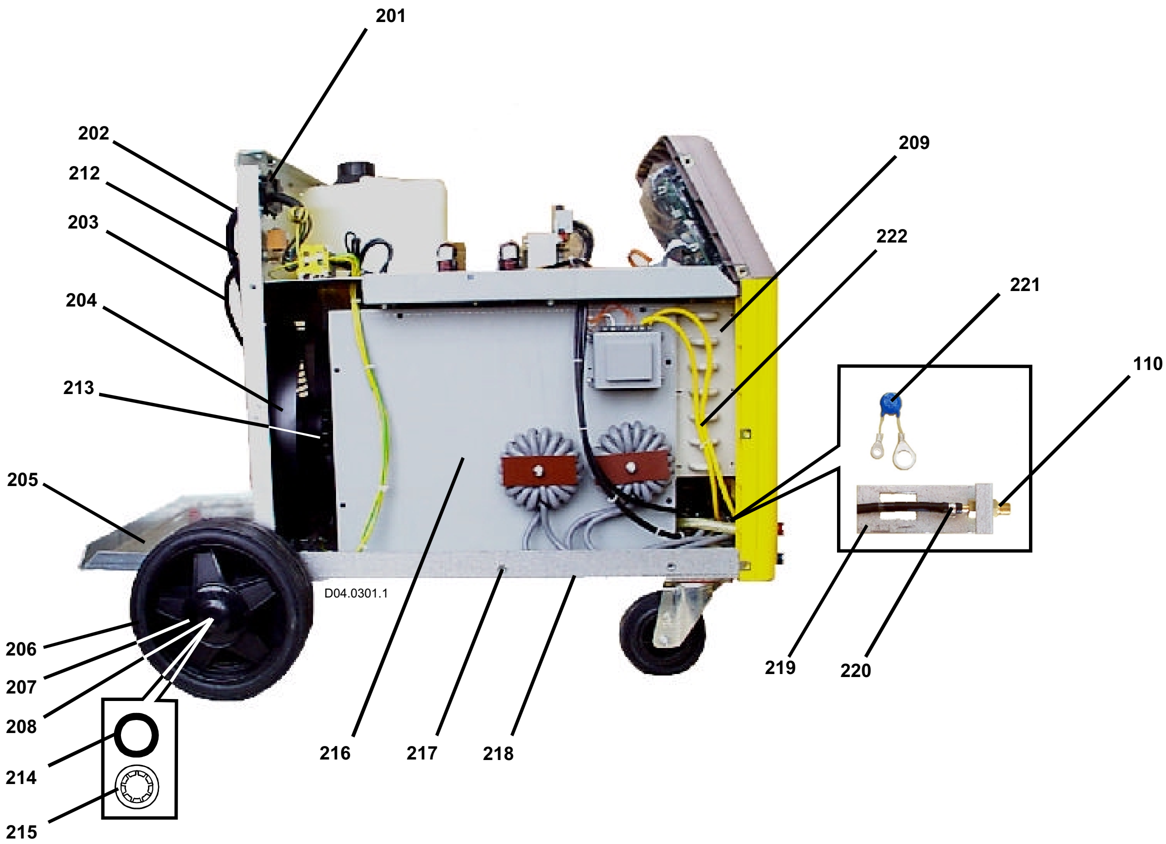
NOTES:

NOTES:

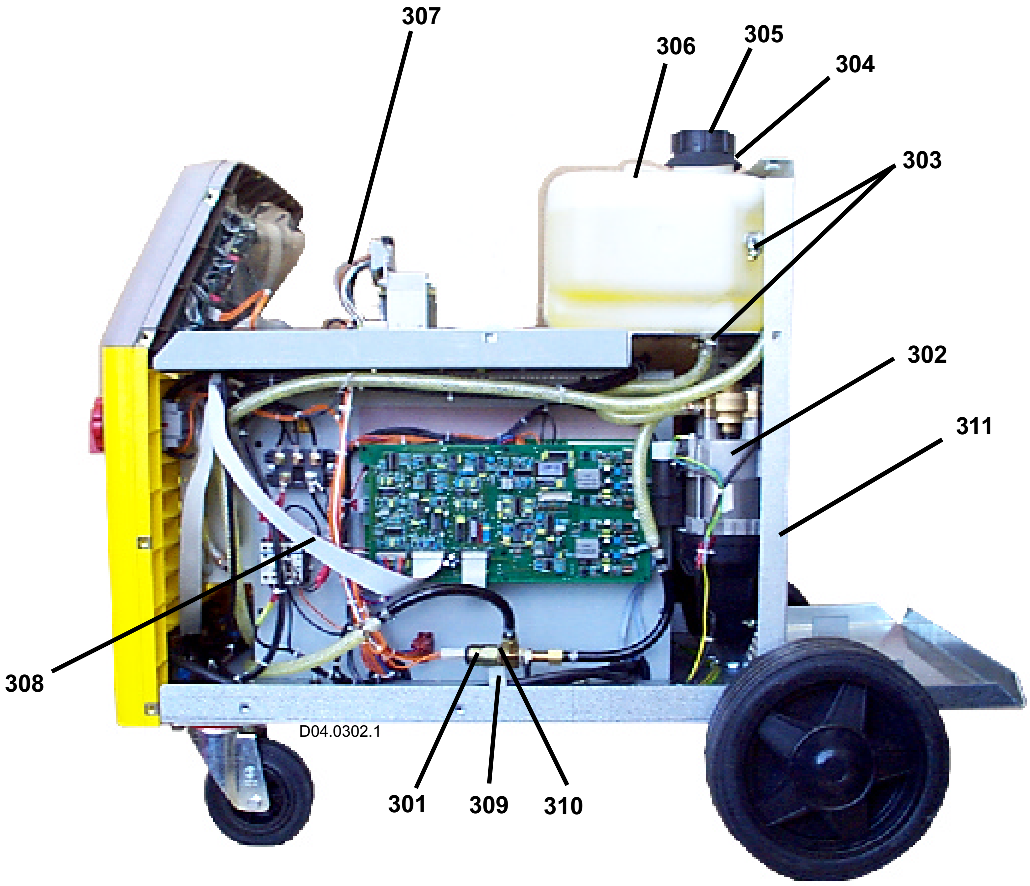
SPARE PARTS LIST



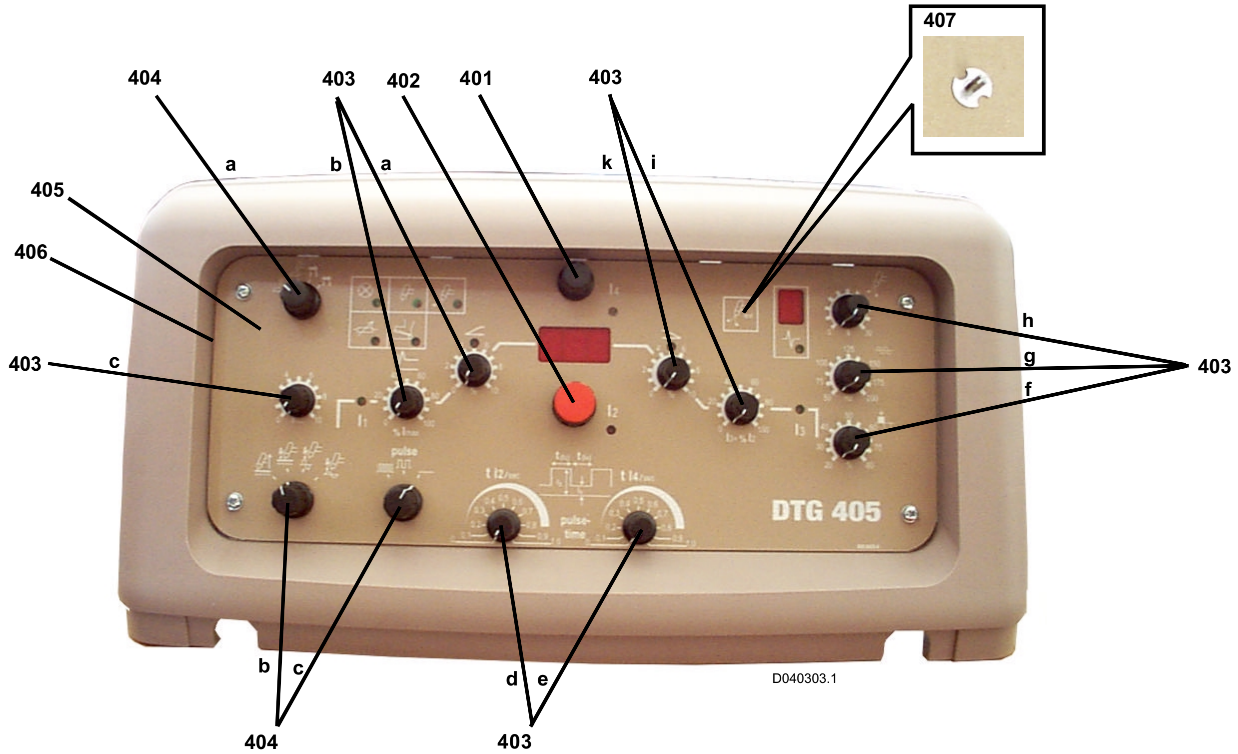
Item	Qty	Order-Nr.	Denomination	C
101	1	0469 868 001	Handle	
102	1	0469 704 001	Front panel (Top)	
103	1	0469 703 003	Front grill	
104	1	0457 150 001	Side panel (left)	
105	1	0458 165 052	Switch 0/1 32A	Q1
106	1	0365 803 008	Quick connector red	
107	1	0365 803 009	Quick connector blue	
108	2	0458 165 065	Current terminal 1-pole	X3, X7
109	1	0538 500 902	2 pole panel socket	X5
110	1	0457 377 039	Gas connection nipple	
111	1	0458 165 055	Remote regulator socket, Burndy, complete	X4
112	1	0458 165 065	Current terminal 1-pole	X2
113	2	0458 165 008	Castor wheel	
114	2	0458 165 009	Sticker "Aristotig 405 AC/DC"	
115	2	0457 377 022	Sticker "ESAB"	
116	1	0457 149 001	Side panel (right)	
117	1	0458 165 101	Cover	
118	4	0455 174 002	Seal 20/5	
119	1	0468 401 001	Sticker "10°"	
121	1	0456 167 002	cover 39/31	

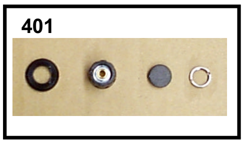


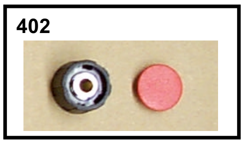
Item	Qty	Order-Nr.	Denomination	C
201	1	0469 950 880	Cable inlet	
202	1	0458 165 058	Main cable 4x4 / CEE32	X1
203	1	0458 165 013	Gas hose, 1.8m R1/8	
204	1	0458 165 006	Wall ring 300 / 58	
205	1	0456 683 001	Shelf	
206	2	0469 872 001	Wheel with looking cap	
208	1	0469 519 005	Shaft 20mm	
209	1	0458 165 028	Cooler	
212	1	0458 165 024	Hose clip 9,8 - 12,3	
213	1	0458 165 064	Fan 300mm	M1
214	2	0458 165 005	Spacer M20	
215	2	0192 859 026	washer 36/21x3	
216	1	0458 165 066	power unit	
217	19	0458 165 004	Nut M6 spezial	
218	1	0458 246 001	Bottom sheet metal	
219	1	0456 273 001	Holding plate solenoid valve	
220	1	0458 165 022	Hose clip 6,8 - 8	
221	2	0458 165 071	capacitor 4700pF 400VAC	C6/C7
222	2	0458 165 057	HF cable 450mm	

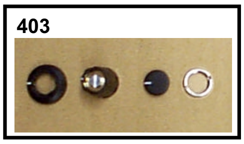


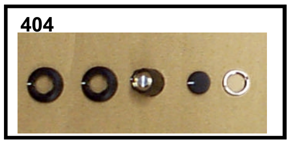
Item	Qty	Order-Nr.	Denomination	C
301	1	0458 165 062	Water-pressure-switch 0,1-1 bar	F11
302	1	0458 165 094	Water pump	M5
303	2	0458 165 027	Hose clip 15,6 - 17,8	
304	1	0366 481 004	Seal 82/46	
305	1	0469 689 002	Cover watertank	
306	1	0469 689 001	Water tank	
307	1	0458 165 059	Cable set DTG 405	
308	1	0458 165 056	Flat cable, 26 conductor, 800mm	
309	1	0457 377 071	Interference suppression choke with prot. conduktor	
310	2	0458 165 030	sealing ring	
311	1	0458 245 001	Rear panel	



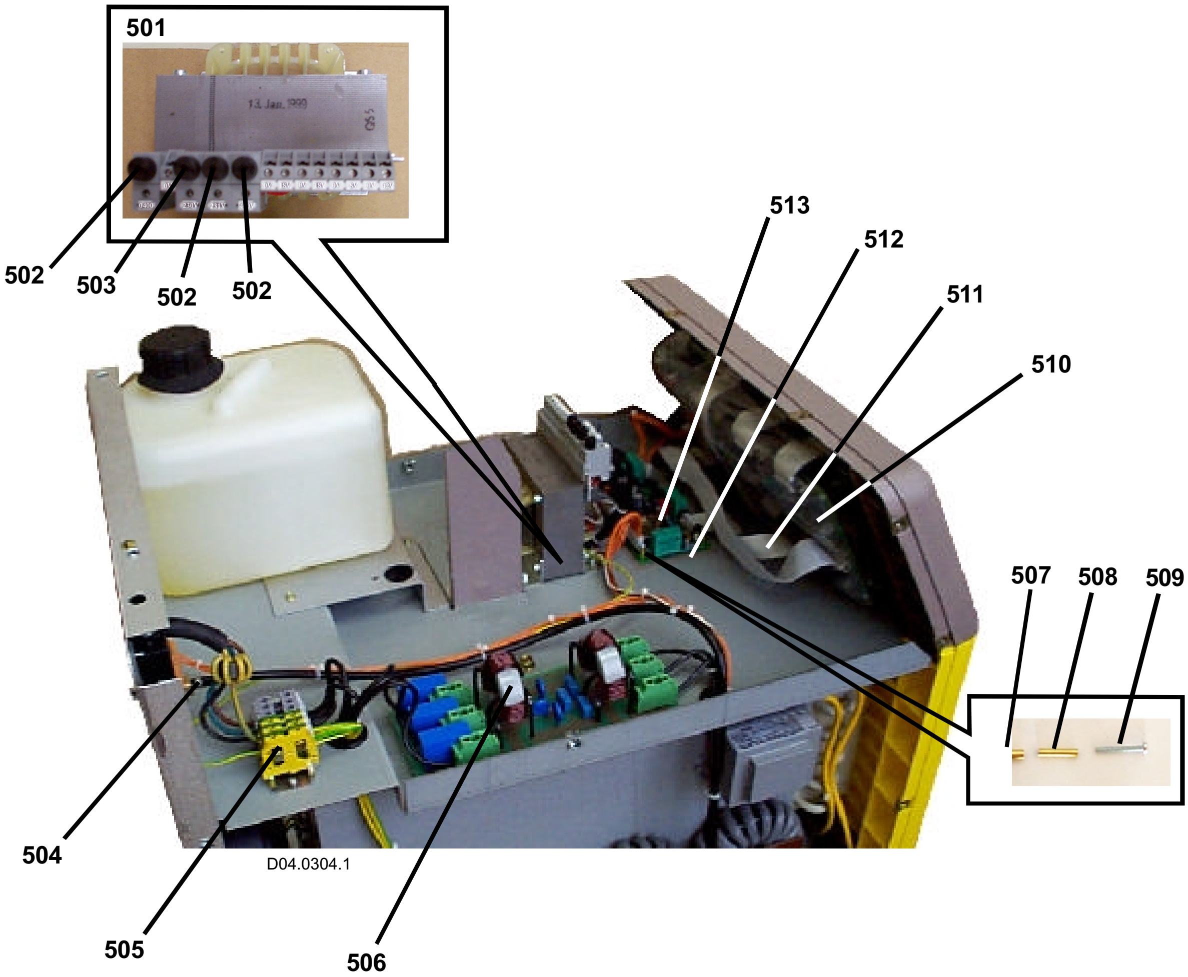








Item	Qty	Order-Nr.	Denomination	C
401	1	0458 165 072	Knob 16mm, 6.35 complete set	
401	1	0458 165 076	Potentiometer 10 turns 10k	
402	1	0458 165 073	Knob 23mm, 6.00 complete set	
402	1	0458 165 076	Potentiometer 10 turns 10k	
403	10	0458 165 074	Knob 13mm, 6.00 complete set	
403	1	0458 165 077	Potentiometer 10k 300°	
403	1	0458 165 078	Potentiometer 100k 300°	
403	1	0458 165 077	Potentiometer 10k 300°	
403	1	0458 165 077	Potentiometer 10k 300°	
403	1	0458 165 077	Potentiometer 10k 300°	
403	1	0458 165 077	Potentiometer 10k 300°	
403	1	0458 165 077	Potentiometer 10k 300°	
403	1	0458 165 077	Potentiometer 10k 300°	
403	1	0458 165 077	Potentiometer 10k 300°	
403	1	0458 165 078	Potentiometer 100k 300°	
404	3	0458 165 075	Knob 16mm, 6.00 complete set	
404	1	0458 165 079	Switch 2x6	
404	1	0458 165 079	Switch 2x6	
404	1	0458 165 079	Switch 2x6	
405	1	0458 165 010	Front upper foil DTG 405	
406	1	0458 165 007	Front sheet metall (Controll)	
407	1	0458 165 069	Spacer pin for push button	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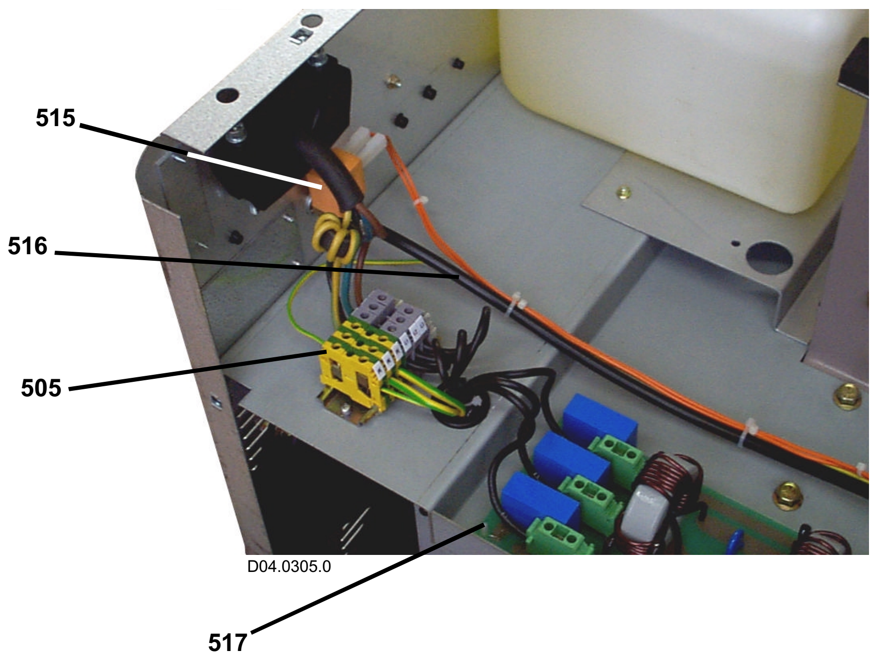
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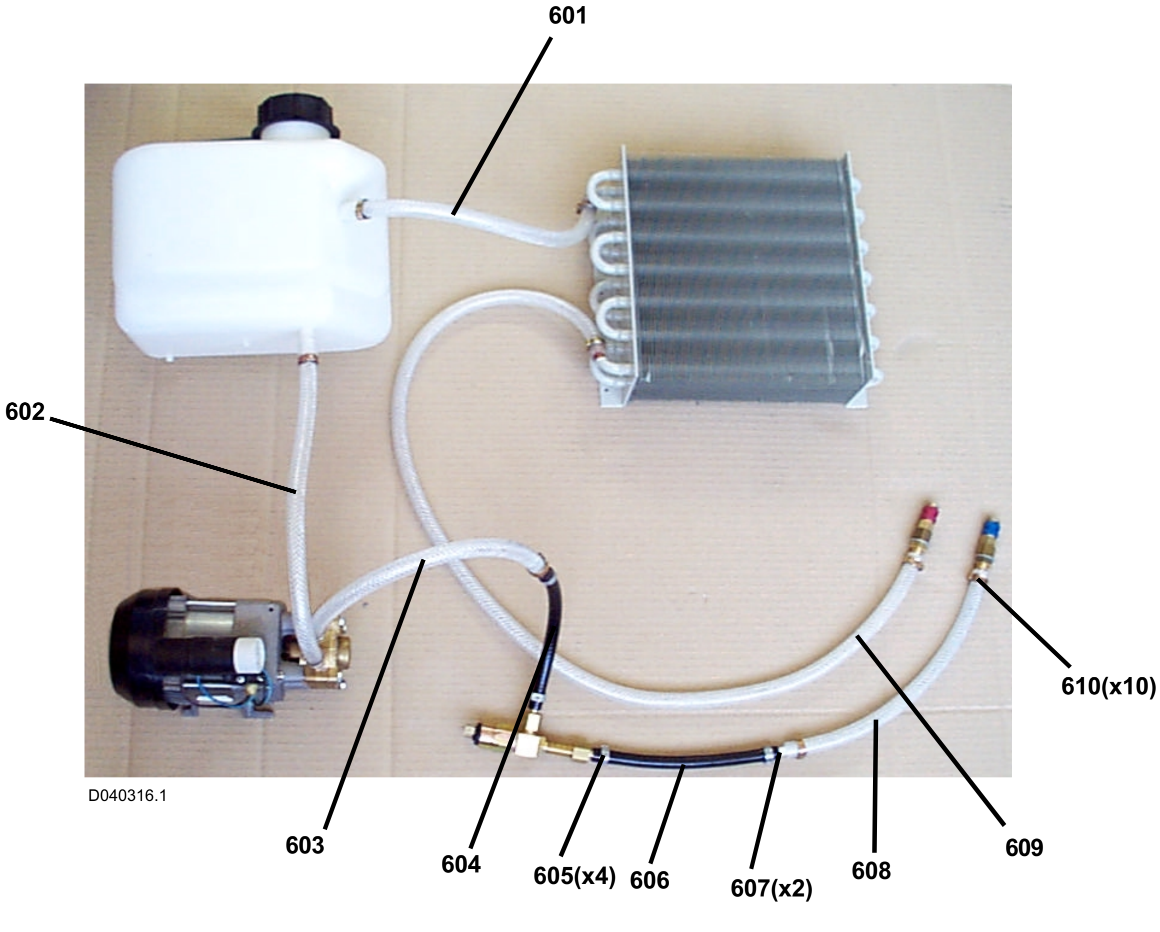
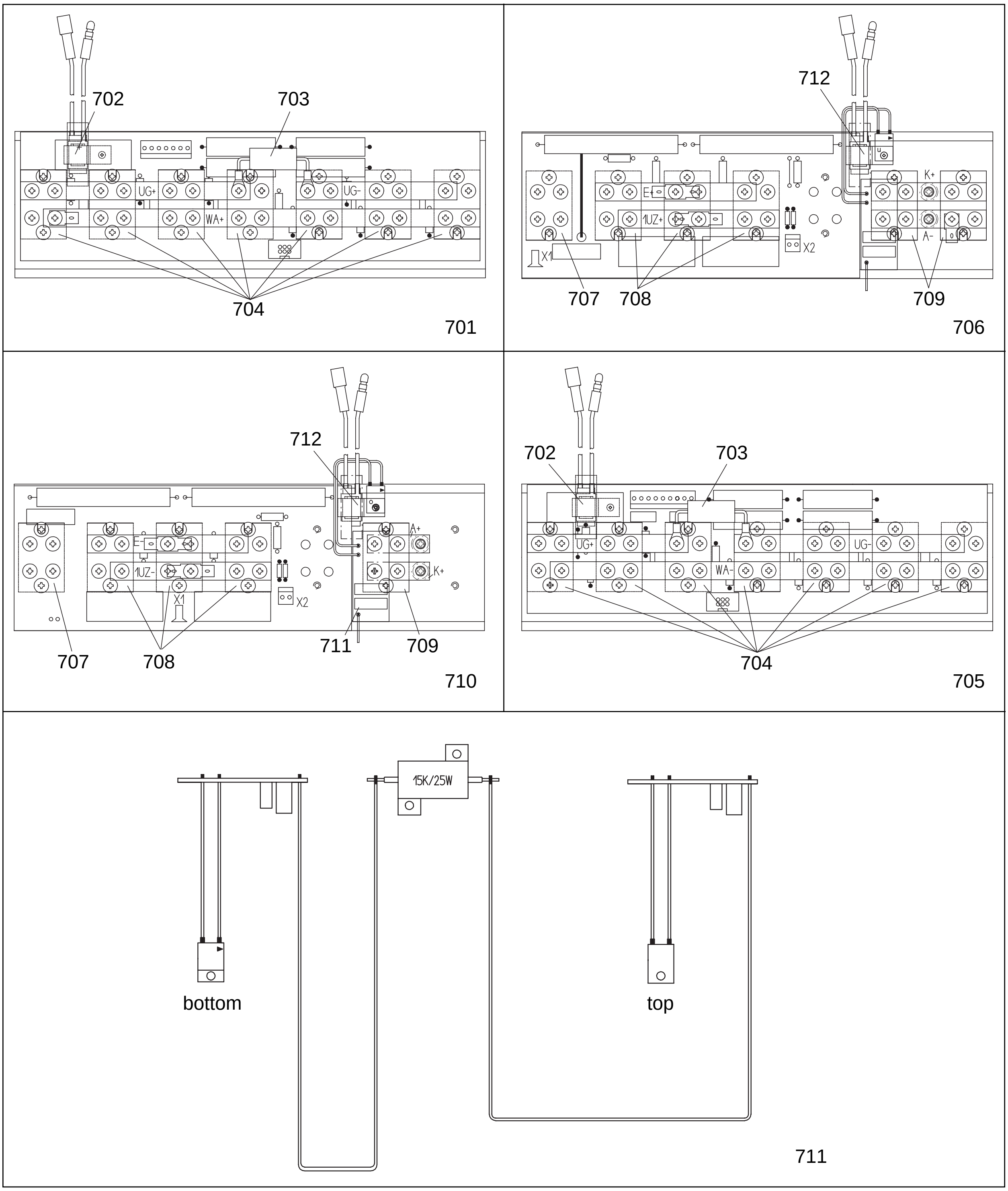
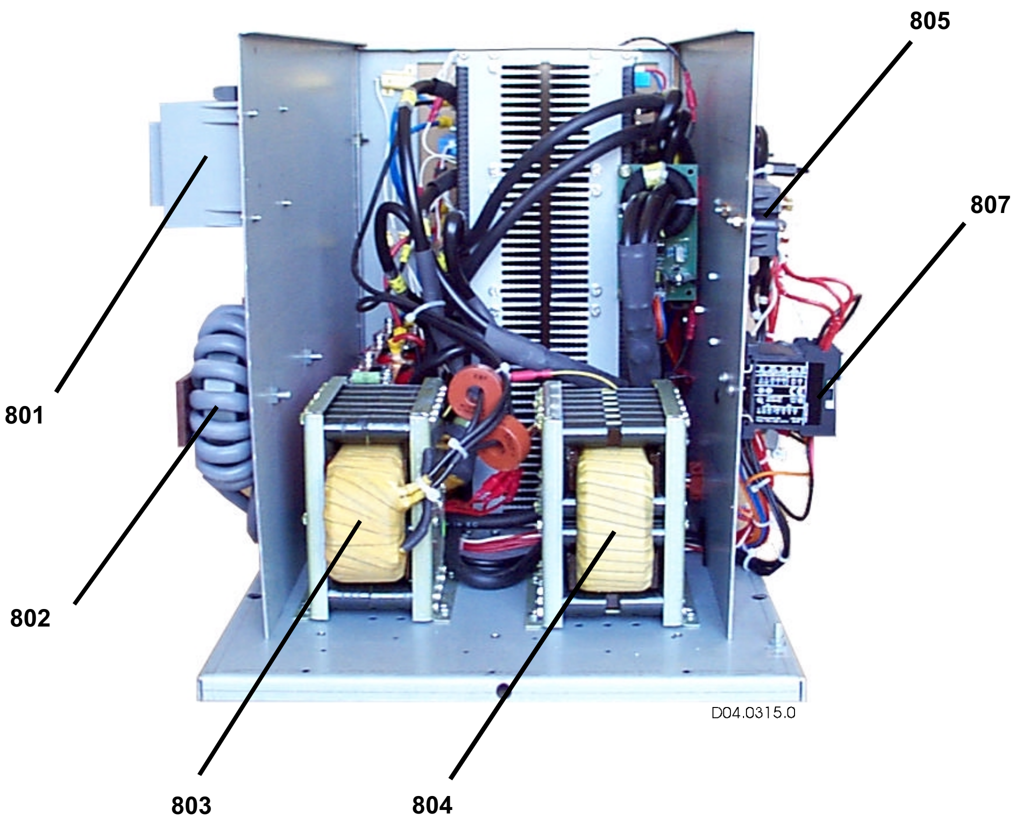
Item	Qty	Order-Nr.	Denomination	C
501	1	0458 165 051	Control transformer	T4
502	1	0458 165 068	Fuse 2,5A	F12,F14,15
503	1	0458 165 067	Fuse 1A	F13
504	1	0458 165 023	Hose clip 7,8 - 9,5	
505	1	0458 165 063	Connection block main voltage	X6
506	1	0458 165 031	E-Assembly, Power filter	A15
507	10	0458 165 011	Spacer sleeve 4,2x5x12	
508	10	0458 165 012	Spacer sleeve 3,2x4x18	
509	10	0458 165 003	Screw M3x22	
510	1	0458 165 033	Control, ACI 30 ESD	A2
511	1	0458 165 054	Flat cable, 20 conductor, 500mm	
512	1	0458 165 060	Insulating foil	
513	1	0458 165 032	Control, ACST1 ESD	A6
515	1	0458 165 061	Solenoid valve, 42V	Y1
516	1150mm	0458 165 021	Gas hose black 5x1,5	
517	4	0458 165 070	Spacer screw	

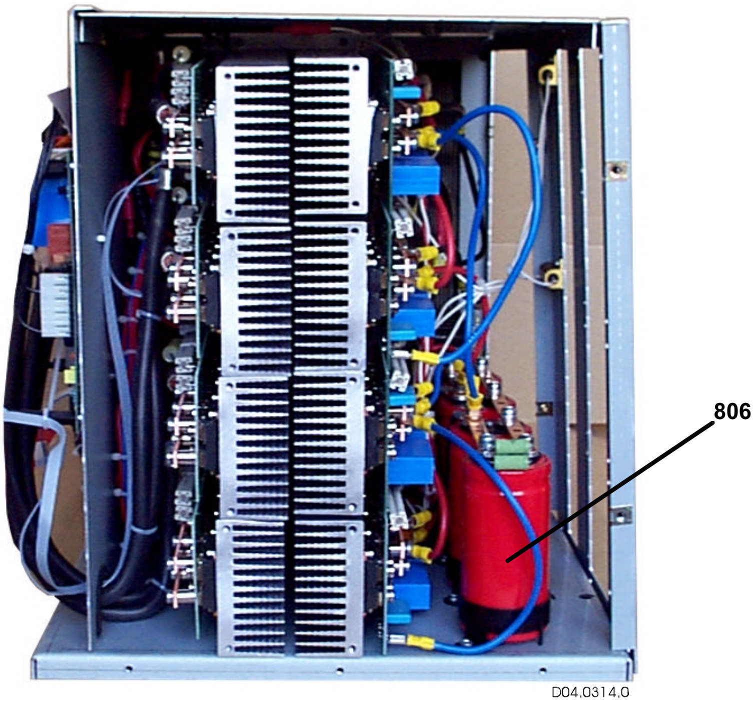


Item	Qty	Order-Nr.	Denomination	C
601	950mm	0458 165 016	Gas hose clear 9x3	
602	300mm	0458 165 017	Gas hose clear 9x3	
603	200mm	0458 165 018	Gas hose clear 9x3	
604	200mm	0458 165 014	Gas hose black 6x3	
605	4	0458 165 025	Hose clip 10,8 - 13,3	
606	200mm	0458 165 015	Gas hose black 6x3	
607	2	0458 165 029	reduction 8/6	
608	700mm	0458 165 019	Gas hose clear 9x3	
609	600mm	0458 165 020	Gas hose clear 9x3	
610	6	0458 165 026	Hose clip 14,6 - 16,8	

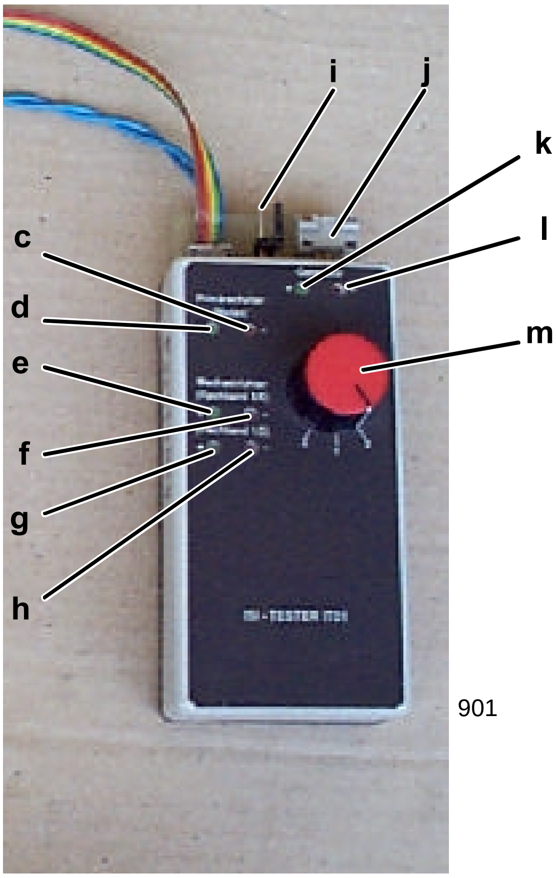


Item	Qty	Order-Nr.	Denomination	C
701	2	0458 165 039	Modul, WPH-PL ESD	A10/A14
702	2	0458 165 087	E-Assembly, thermal switch opening 80°	F1/F2/F3/F4/F5/F6/F7/ F8
703	2	0458 165 041	E-Assembly, capacitor	
704	14	0458 165 081	Mosfetmodul N-200V 100A	
705	2	0458 165 040	Modul, WPH-MI ESD	A9/A13
706	2	0458 165 037	Modul, GPD-PL ESD	A5/A12
707	4	0458 165 082	Rectifiermodul B23 P10	
708	6	0458 165 080	Mosfetmodul N-900V 26A	
709	6	0458 165 083	Rectifiermodul B200 P400	
710	2	0458 165 038	Modul, GPD-MI ESD	A4/A11
711	2	0458 165 086	E-Assembly, suppressor top / bottom 15k	A4/A5/A11/A12
712	4	0458 165 088	Thermal switch opening 90°	





Item	Qty	Order-Nr.	Denomination	C
801	1	0458 165 090	HF unit	A7
802	2	0458 165 091	HF choke	L2
803	1	0458 165 097	Main transformer	T3
804	1	0458 165 098	Main choke	L1
805	1	0458 165 089	Rectifier bridge	A3
806	1	0458 165 100	E-Assembly, 4x 1500yF 385V kpl. set	C1/C2/C3/C4/R1/R2/ R3/R4
807	1	0458 165 095	Contactor	K1



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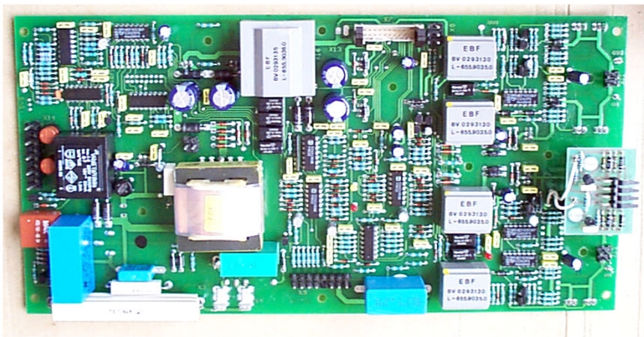

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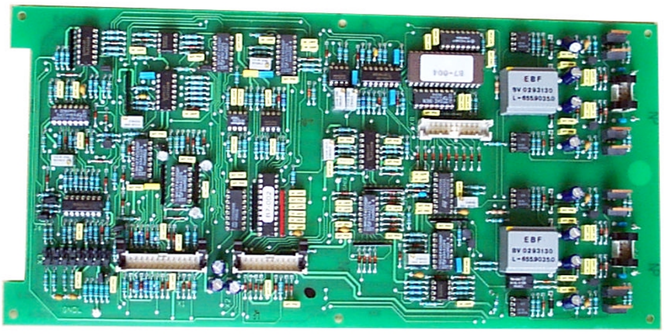

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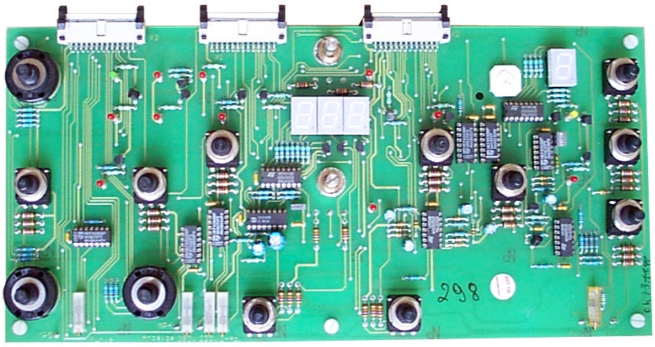

904

Item	Qty	Order-Nr.	Denomination	C
	1	0458 165 001	Instruction manual DTG 405	
	1	0458 165 002	Service manual DTG 405	
903	1	0458 165 034	Control, GWL DTG 405 ESD	A8
	1	0458 165 035	Control, LSW ESD	T2
	1	0458 165 036	Control, SNT / DSW2B ESD	A1
	1	0458 165 092	Minifuse 315mA	
	1	0458 165 093	Minifuse 500mA	
901	1	0458 165 095	ISI-Tester IT01	
	1	0458 165 099	Central connection with cable set	
	1	E458 165 042	Control, ACST1 "for exchange" ESD	
904	1	E458 165 043	Control, ACI 30 "for exchange" ESD	
	1	E458 165 044	Control, GWL DTG 405 "for exchange" ESD	
902	1	E458 165 045	Control, SNT / DSW2B "for exchange" ESD	
	2	E458 165 046	Modul, GPD-PL "for exchange" ESD	
	2	E458 165 047	Modul, GPD-MI "for exchange" ESD	
	2	E458 165 048	Modul, WPH-PL "for exchange" ESD	
	2	E458 165 049	Modul, WPH-MI "for exchange" ESD	
	1	E458 165 050	Control, LSW "for exchange" ESD	

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