

BALDOR[®]
MOTORS AND DRIVES

**BTS 10 R/RL SERIES
SERVO CONTROL
FOR BRUSHLESS AC MOTORS**

INSTALLATION & INSTRUCTION MANUAL

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Warning!

These instructions are for use by qualified personnel only.

In order to avoid electrical shock, do not perform any servicing other than that contained in the Operating and Service Manual unless you are qualified to do so.

Dangerous voltage exists on the screw terminals of power inlet and outlet when energized. Exercise extreme care when working on an energized circuit.

When a unit needs to be replaced, wait at least 2 minutes to allow a discharge of the power-capacitors and touch only the handle on the front-side. Use isolated tools for removal of connecting wires and avoid to touch the contacts.

CHANGE NOTICE

On reprint of this manual the following changes are included:

1. Instructions and information for BTS 10 RL (Low Power) added.
2. Page 1: Cont. Output Power corrected

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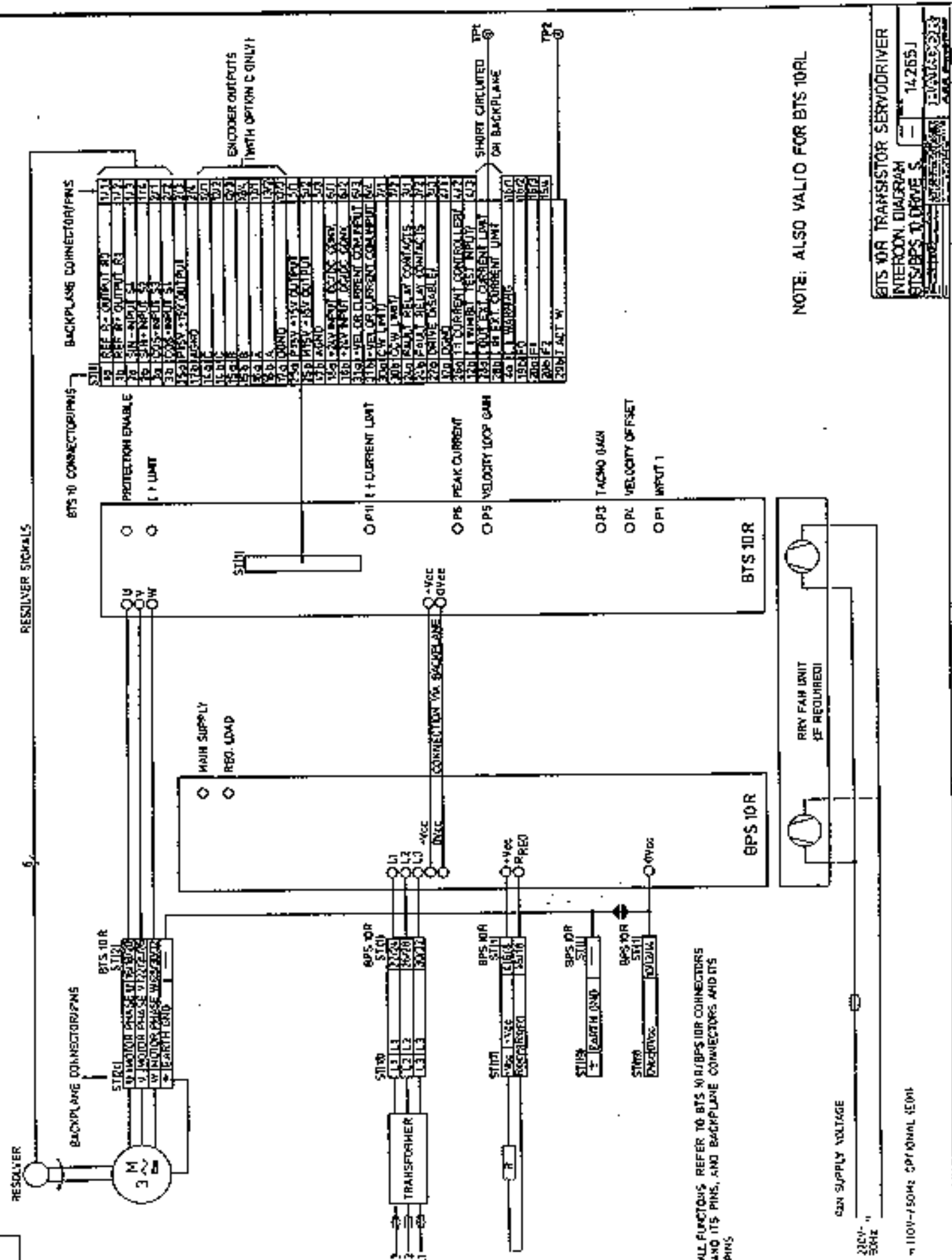
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BTS 10 R/RL - DRIVE SPECIFICATION SHEET

PARAMETER	Units						
	200-1 RL	200-2.5 R/RL	200-5 R/RL	200-10 R	200-15 R	200-22.5 R	200-22.5 R
GENERAL							
Nom. DC Bus Voltage ¹	V DC	200.0					
Voltage Range	V DC	160 - 240					
Max. Output Voltage at nominal Bus (U _{LL})	V AC	153.0					
Cont. Phase Current	A(rms)	1.0	2.5	5.0	10.0	15.0	22.5
Max. Peak Current 2.5 s	A(rms)	2.0	5.0	10.0	20.0	30.0	45.0
Cont. Output Power	kVA	0.3	0.7	1.3	2.7	4.0	6.0
Switching Frequency	kHz	10.5	10.5	10.5	10.5	10.5	10.5
PREAMPLIFIER							
Input Impedance	kOhm	22					
Velocity/Current Command	V	0 to +/- 10					
Gain Stability	%	+/- 1					
Gain Linearity	%	+/- 2					
Drift (referred to input)	μV/°C	+/- 10 max.					
Offset		adjustable to zero					
FEEDBACK CIRCUIT (Resolver)							
Resolution		12 Bit					
Encoder Simulation Option "C"	ppr	100 / 200 / 500 / 1000					
Signal Reference Pulse		5 V TTL A, \bar{A} B, \bar{B} C, \bar{C} non-adjustable					
MECHANICAL							
Mounting Dimensions	6 HE mm	Rack 220x60				Rack 220x120	
Weight	kg	RL: 0.9 R: 1.4				3.6	
POWER SUPPLY BPS 10 R							
Input Voltage 3-phase		V AC	140.0 ± 20 %				
Output Voltage		V DC	200.0 ± 20 %				
Cont. Output Current		A	20.0	40.0	60.0		
Max. Output Current 2.5 s		A	40.0	80.0	120.0		
Nominal Power		kW	4.0	8.0	12.0		
Regeneration Switching Current		A	20.0	20.0	20.0		
Regeneration Resistor (internal) ²		W	80.0	80.0	80.0		
MECHANICAL							
Mounting Dimensions		mm	Rack 6 HE 220 x 60				
Weight		kg	1.0				
TEMPERATURE BTS/BPS 10 R							
Ambient for Nominal Ratings		deg.C	25				
Operating Range		deg.C	0 to +45				
Storage		deg.C	-20 to +70				

¹ 24/48 V also available

² or 320 W external on order



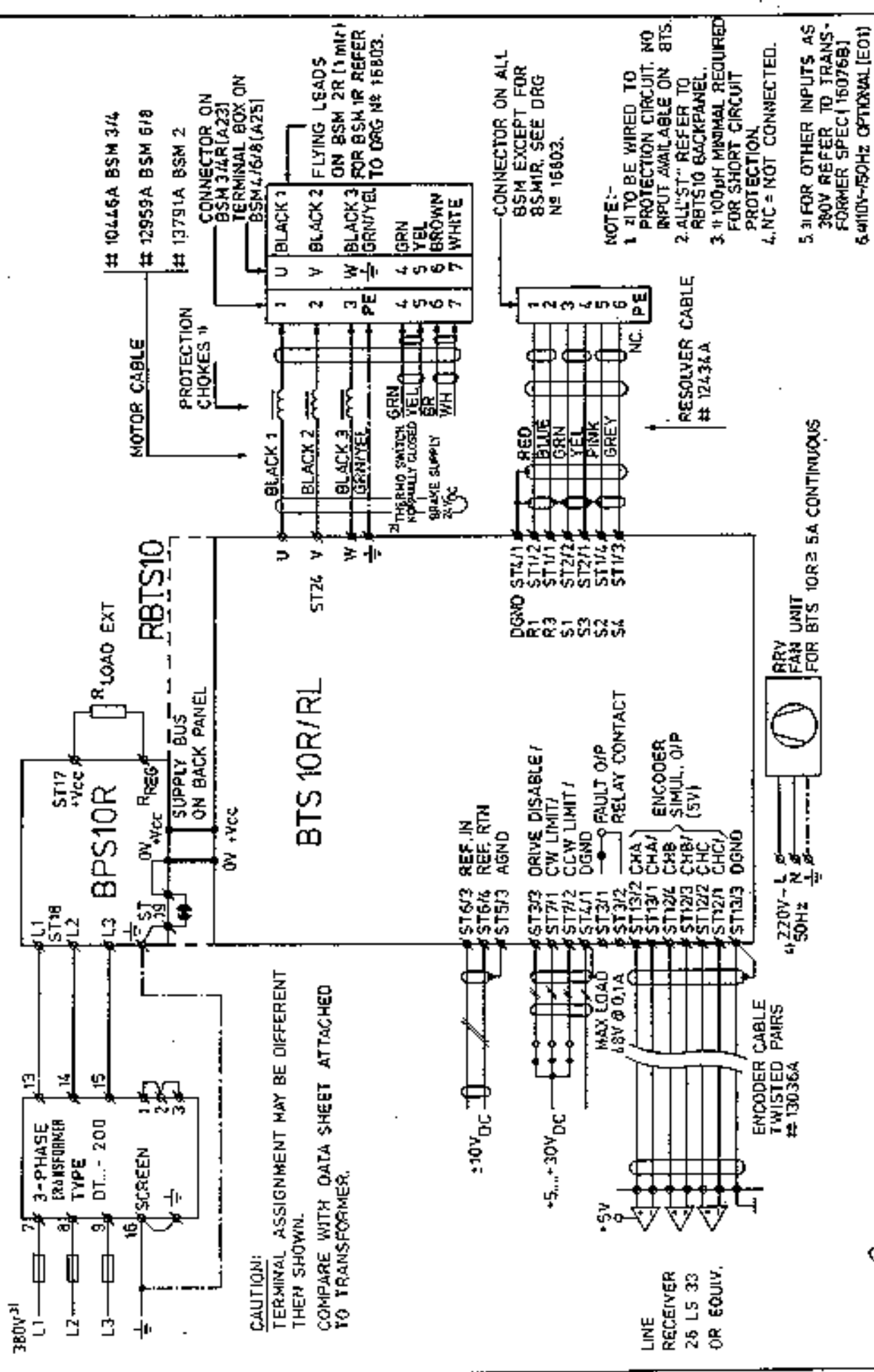
NOTE: ALSO VALID FOR BTS 10RL

BITS 10R TRANSISTOR SERVO DRIVER
 INTERCONNECTION DIAGRAM
 SITS/BPS TO DRIVE S

ALL FUNCTIONS REFER TO BTS 10R/BPS 10R CONNECTORS AND ITS PINS, AND BACKPLANE CONNECTORS AND ITS PINS

220V-50Hz
 CAN SUPPLY VOLTAGE

110V-150Hz OPTIONAL (EOM)



CAUTION:
 TERMINAL ASSIGNMENT MAY BE DIFFERENT THEN SHOWN.
 COMPARE WITH DATA SHEET ATTACHED TO TRANSFORMER.

REV	DATE	BY	CHKD	DESCRIPTION
01	10/10/85	...	...	...
02	...	...	...	...
03	...	...	...	...

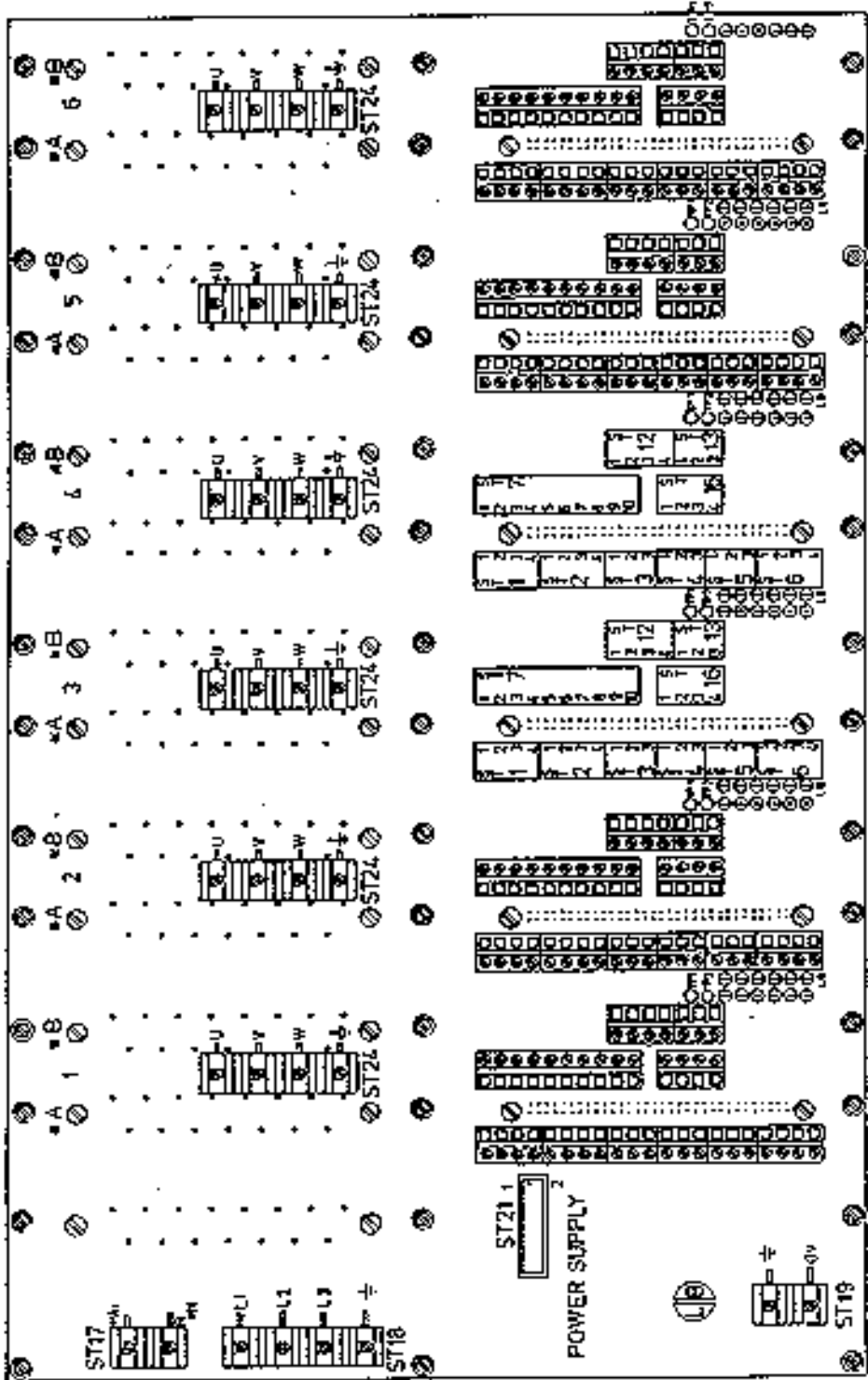
PROVISIONAL WIRING DIAGRAM
 THIS DIAGRAM IS SUBJECT TO CHANGE WITHOUT NOTICE.
 IT IS THE USER'S RESPONSIBILITY TO VERIFY THE CORRECTNESS OF THE WIRING DIAGRAM BEFORE USING IT.
 DATE: 10/10/85

FILE: RBTS 10R/RL CONNECTION DIAGRAM FOR RESOLVER BASED SYSTEM

SKJ 15240E

BRADBORNSR

COMPONENT SIDE VIEW



NOTE:-

- A- POWER CONNECTOR FOR BITS 10RL VERSION
- B- POWER CONNECTOR FOR BITS 10R VERSION
- 1. HOLES MARKED THUS: -⊙ ARE SOLDER STUDS.
- 2. BOTH X SECTIONS ARE ASSEMBLED AS PER Y SECTION.

BIT 5 10R/7L RACK BACK PLANE (COMPLETE) ASSEMBLY DRAWING (COMP. SIDE)		1:1	
15206C		15206C	
TRIMBOR		A.S.A. CORPORATION	

BTS 10 R/RL - SET-UP PROCEDURE

Encoder Output/Pole Pair Select

By means of a 5-way Dip switch it is possible to select the encoder resolution and the number of poles of the connected brushless motor.

The switch is located on the top card or resolvercard (see page 10).

1. Pole Pair Select

Number of pole pairs	S1/1	S1/2	S1/3	Motortype	Option
1	OFF	OFF	OFF	BSM 2 R	B01
2*	ON	OFF	OFF	BSM 1/3/4 R	B02
3	OFF	ON	OFF	BSM 6 R	B03
4	ON	ON	OFF	BSM 4/6/8 F	B04
5	OFF	OFF	ON		
6	ON	OFF	ON	* set ex	*
7	OFF	ON	ON	works	
8	ON	ON	ON		

2. Max. Speed Setting

R 38 = 422 k Ω , 1 $\frac{1}{2}$, 0,5 W standard for 2000 rpm motors

R 38 = 221 k Ω , 1 $\frac{1}{2}$, 0,5 W standard for 4000 rpm motors *

R 38 = 150 k Ω , 1 $\frac{1}{2}$, 0,5 W standard for 6000 rpm motors

For location of R 38 see page 10. * fitted ex works

3. Encoder Simulation*² (Option C)

Pulses/Rev.	S1/4	S1/5	Option	
1000*	OFF	OFF	C08	* set ex works
500	ON	OFF	C07	
250	OFF	ON	C06	
100	ON	ON	C05	

Note: Other resolutions available on request

*² EPROM IC 13 # 15996

4. Velocity or Current Mode

With control input "1:1" on ST 4/2 it is possible to use the amplifier as velocity controller or current controller.

When taken "low", the velocity feedback is switched out and the input gain is set to unity. With P1 and P6 set fully CW the overall gain is: $G = \frac{I_{pk}}{9,65} (A/V)$.

LB 101 has to be open.

5. Phase Advance

The generated current in each winding lags the current command as a function of shaft velocity. This is due to the current loop bandwidth, limited by the fixed intermediate bus voltage.

BTS 10 R/RL - SET-UP PROCEDURE (CONTINUATION)

To produce max. torque per ampere the real current vector (or torque producing) must be in phase with the EMF of the motor. Advancing the phase angle must be performed as a function of motor speed and electrical time constant. R65 located on the resolvercard (see page 10) determines the amount of phase advance. With the standard value ($R65 = 26,7 \text{ k}\Omega$) the current efficiency is approx. 90 ... 95 %.

For all BSM R/F motors the optimum resistor value is available on request.

Note: Wrong resistor values may lead to speed limiting.

6. Voltage check

The BTS 10 R/RL work on 200 V DC nominal with a maximum working voltage of 240 V DC. The 3-phase transformer should have an AC-output of 140 V nominal or 169 V max. @ no load (starconfiguration line to line voltage).

Note: The voltage check should be made with all amplifiers removed. The AC-supply should be measured without BPS 10 R, the DC-supply with BPS 10 R.

7. Potentiometer Preset

Equip chassis with BTS 10 R/RL amplifiers and BPS 10 R power supply and set the potentiometers as follows:

- a) RP 1 (command input) clockwise for max. input gain
- b) RP 3 (velocity feedback gain) clockwise for max. gain
- c) RP 5 (velocity loop gain) anti-clockwise for min. gain
- d) RP 6 (peak current) anti-clockwise for reduced current

8. Speed Adjust

- a) Remove command signal lines and short circuit input (ST 6/3 and ST 6/4)
- b) Power on. Turn RP6 slowly clockwise until motor develops torque. If no torque - check CW/CCW limit and total disable inputs. If motor shaft accelerates - check resolver wiring.
- c) Adjust RP4 (velocity offset) until motor comes to a complete rest.
- d) Connect command signal and adjust speed with RP 1 and RP3 as necessary in your application.
- e) Check offset again.

9. Response Optimization

The step response can be optimized with the velocity loop gain potentiometer RP5.

In order to achieve proper adjustment it is necessary to observe the current waveform on TP5 with an oscilloscope. RP5 is adjusted properly when the current waveform shows a single overshoot on applying a step command. At constant velocity the AC-component on TP5 should be kept as low as possible but should not exceed 2 Vpp in order to avoid excessive motorheating.

POTENTIOMETERS ON BTS 10 R/RL

For location of potentiometers on BTS 10 R see page 16, drawing no. 14642. For location of potentiometers on BTS 10 RL see page 17, drawing no. 17903.

- RP1 - Input gain
velocity or current
fully CW $\hat{=}$ unity gain.
- RP4 - Velocity offset adjust
zero speed adjust for zero command
- RP3 - Velocity feedback gain
has to be adjusted to reference speed.
Fully CW $\hat{=}$ max. gain.
- RP5 - Velocity loop gain adjust
adjusts the frequency response of the velocity control loop.

Turning RP5 clockwise results in an increasing high frequency gain with possibly negative effects (motor-heating). It is extremely important to observe TP5 with an oscilloscope when adjusting RP5. For most applications there is no need to increase the AC-gain and RP5 is set to fully CCW.

- RP6 - Peak current adjust
sets peak current level which can be measured on TP5.
Fully CW $\hat{=}$ max. I_{pk}

- RP11 - It current limit adjust
sets current limit level.
Fully CW $\hat{=}$ I nominal.

Note: RP1, RP3, RP5, RP6 and RP11 can be substituted by fixed resistors on headers J2 and J3.

BTS 10 R/RL - TESTPOINTS

To allow effective set-up of the amplifier and its control loop several testpoints are accessible on the front side as well as on the backpanel (BTS 10 R - see page 16; BTS 10 RL - see page 17). Since most signals have alternating waveform it is recommended to use an oscilloscope for measuring purposes. All signals are related to TP8 (GND).

Caution: To avoid ground loops and interference it is strongly advised to isolate the measuring equipment from neutral (earth).

TP9: PWM signal
20 Vpp, 10,5 kHz triangle
(for test purposes only)

TP1: Actual rms current phase U
 $I_{pk} \approx 10,0$ V

TP2: Actual rms current phase V
 $I_{pk} \approx 10,0$ V

TP3: Actual rms current phase W
 $I_{pk} \approx 10,0$ V

Note: For torque calculations referring to the actual current the formula is:

$$T = 3 \text{ KT} \frac{V_{TP} \cdot I_{pk}}{10,0} \quad (\text{for rotating motorshaft only})$$

where T = Motortorque (Nm)

KT = Torque constant per phase (Nm/A)

V TP = Voltage on TP 1, 2 or 3

I_{pk} = peak rms current rating of amplifier BTS 10 R/RL
($I_{pk} \approx 2 \cdot I_{nom.}$)

TP5: $I_{command}$

This is the output signal of the velocity control loop
9,25 V max. \approx amplifier's peak current.
The voltage level is proportional to rms output current.
TP5 is the major testpoint to look at during set-up. The voltage level can be easily converted to accel/decel torque or friction by using the motor torque constant.

BTS 10 R/RL - TESTPOINTS (CONTINUATION)

The signal waveform is DC with a superimposed alternating component. As a general rule, current saturation should be avoided at all times in position controls. The AC component must be kept as low as possible since this leads to heatdissipation in the motor (see potentiometer RP5).

Note: On BTS 10 R, TP 5 shows the current command before it limiting. Be sure, that it limit is off - otherwise current-reading will be false.

TP6: Velocity command signal (or current command when 1:1 input on ST 4/2 taken low) shows input signal after attenuator RP1

TP7: Actual velocity

This signal is derived from the resolver to digital converter and is used as velocity feedback. Standard output 2,5 V/krpm (R38 = 221 k Ω) for 4000 rpm motors. For 6000 rpm motors R38 = 150 k Ω and V TP7 = 1,33 V/krpm, for 2000 rpm motors R38 = 422 k Ω and V TP7 = 5,0 V/krpm.

Accuracy: \pm 5 %

Ripple: typ. 1 % @ 10 V

Offset: \pm 150 mV max.

Note: To avoid RDC saturation, the voltage level at TP7 should not exceed \pm 10,0 V.

Testpoints on backpanel:

TP1: $I_{command}$ = 9,65 V \approx I_{peak} rms (see also TP5)

TP2: see TP3

IDENTITY HEADERS J2 AND J3

On the Identity Headers all important potentiometers can be substituted by fixed resistors (see page 16 for BTS 10 R; see page 17 for BTS 10 RL).

Also the frequency response components for the velocity and current loop are located here.

Header J2

For the velocity loop and its variable components on J2 please refer to the drawings on pages 16 and 20 for BTS 10 R and on pages 17 and 21 for BTS 10 RL.

Notes:

1. R 103 avoids setting of RP1 (RP1 set to fully CW)
2. R 101 avoids setting of RP3 (RP3 set to fully CW)
3. RP5 = 20 k Ω
4. RP6 = 20 k Ω
5. Standard values: R101, R103 = 22,1 k Ω
R93 = 332 Ω , R94 = 332 k Ω , C19 = 47 nF

Header J3

Here are the PI components for the current loops of phase U and phase V.

Proportional gain = R43 and R44 (150 k Ω , 100 k Ω on RL)

Integral gain = C17 and C11 (4,7 nF)

Note: For most applications the standard values will give good performance of the current loop.

Its functioning can be verified on TP1 through TP3:

The current waveform should be smooth and not have excessive 10,5 kHz (PWM) components.

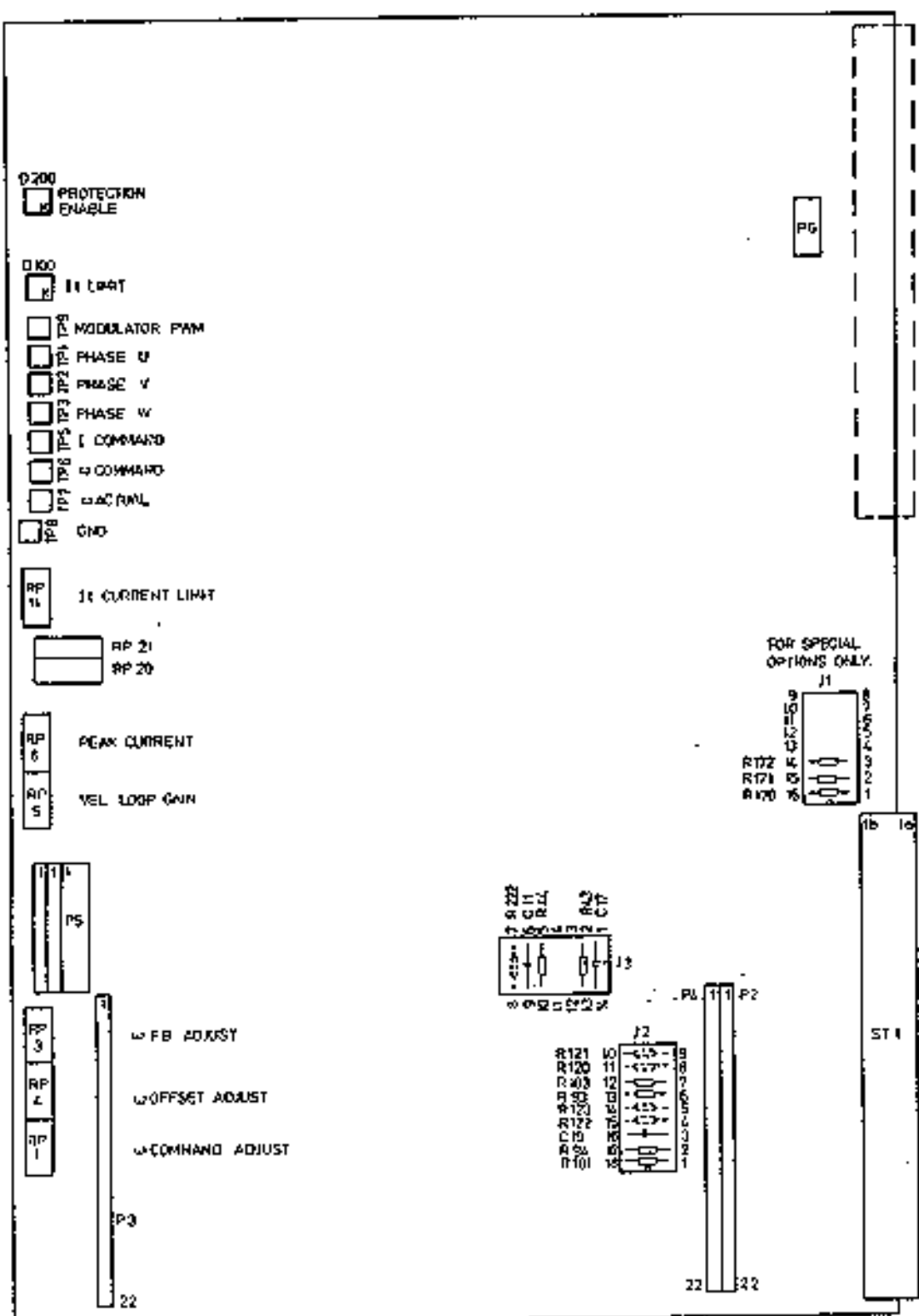
The substitution of RP 11 - It limit is R 222.

On BTS 10 R, R 222 is located on header J3; on BTS 10 RL, R 222 is located near J3.

It limit = R 222 (with RP11 removed)

I limited = $\frac{R\ 222}{R\ 222 + 20\ k} \cdot I_{max}$ (R222 = 20 k Ω max.)

LOCATION OF TESTPOINTS, POTENTIOMETERS AND COMPONENT HEADERS
ON BTS 10 R CONTROL CARD

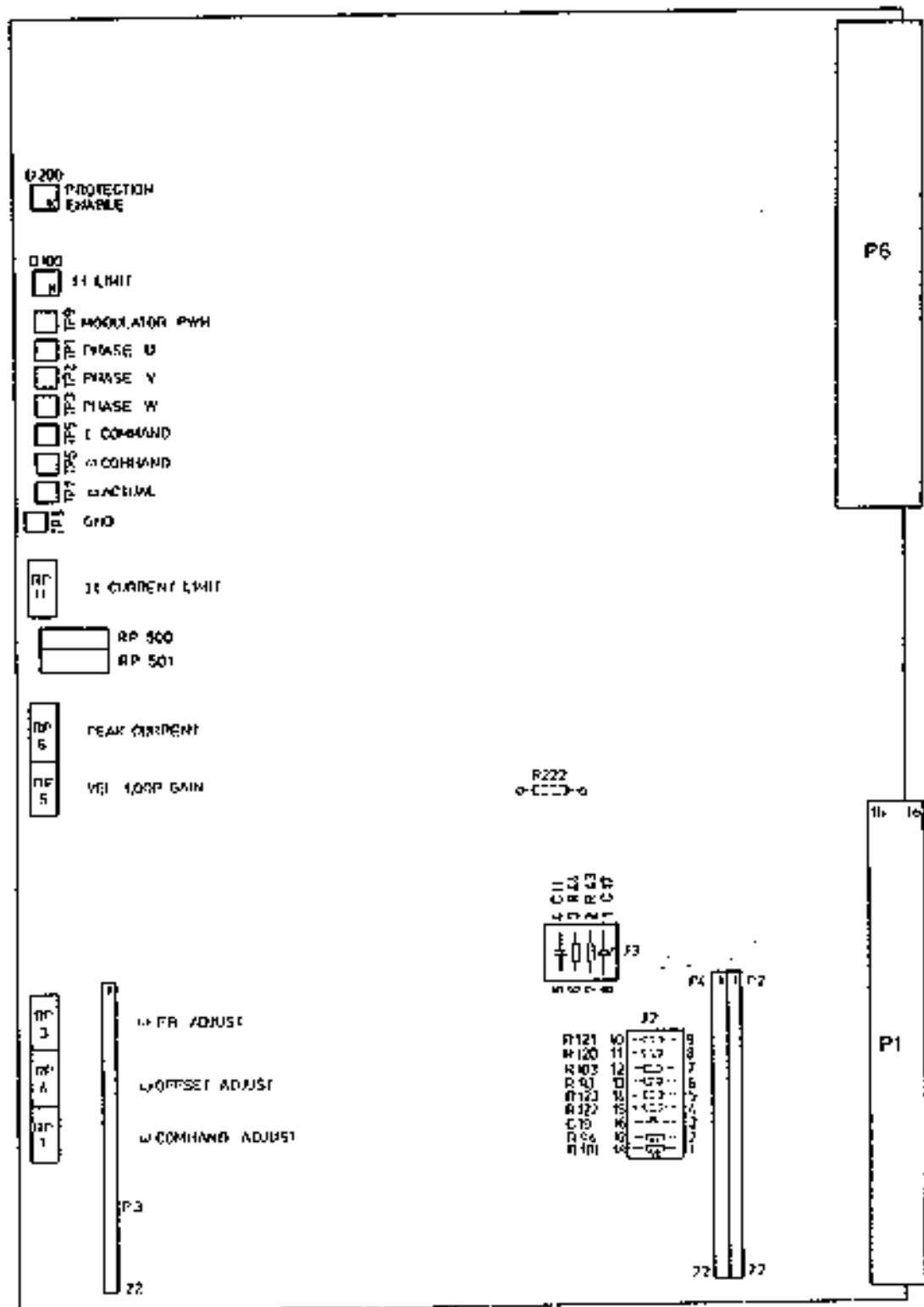


PROTECTIVE FUSIBLE	INDICATOR	SCALE	14642
BTS 10R CONTROL CARD VARIABLE COMPONENTS			
DATE	SCALE	REV. NO.	
15/11/80	14642	1	
CHKD			
BY			

EATON/DOES/RRR

FOR SPECIAL
OPTIONS ONLY.

LOCATION OF TESTPOINTS, POTENTIOMETERS AND COMPONENT HEADERS ON BTS 10 RL CONTROL CARD



PART NUMBER 17903A	REVISION 1	DATE 15 10 68	DRAWN BY A	CHECKED BY A
BTS 10 RL CONTROL CARD VARIABLE COMPONENTS				
<small> THIS DRAWING IS THE PROPERTY OF RAYDON ASS. IT IS TO BE USED ONLY FOR THE PROJECT AND QUANTITY SPECIFIED HEREON. IT IS NOT TO BE REPRODUCED OR TRANSMITTED IN ANY FORM OR BY ANY MEANS, ELECTRONIC OR MECHANICAL, INCLUDING PHOTOCOPYING, RECORDING, OR BY ANY INFORMATION STORAGE AND RETRIEVAL SYSTEM, WITHOUT THE WRITTEN PERMISSION OF RAYDON ASS. </small>				
RAYDON ASS.				

BTS 10 R/RL - I/O HARDWARE AND FUNCTION

INPUTS

Velocity or current differential Input
 $V_{in\ max.} = \pm 10\ V_{DC}$

CW Limit
 high = enable
 $V_{in\ max.} = +5 \dots +30\ V_{DC}$

CCW Limit
 high = enable
 $V_{in\ max.} = +5 \dots +30\ V_{DC}$

Note: CW/CCW Limits disable amplifier, no active braking.

Drive Disable
 high = enable
 $V_{in\ max.} = +5 \dots +30\ V_{DC}$

1 : 1 Current control, active low.
 Sets velocity loop gain to unity and velocity (tacho) feedback to zero for use of current amplifier only.

Resolver Sine S 4

Resolver Sine S 2

Resolver Cosine S 3
 Resolver Cosine S 1
 Signal waveform sinusoidal
 7.2 kHz, 10 Vpp

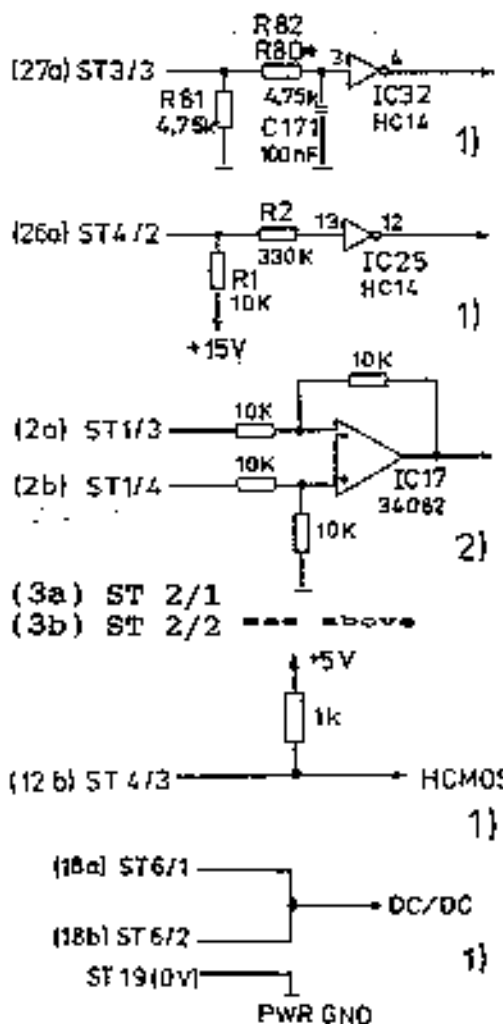
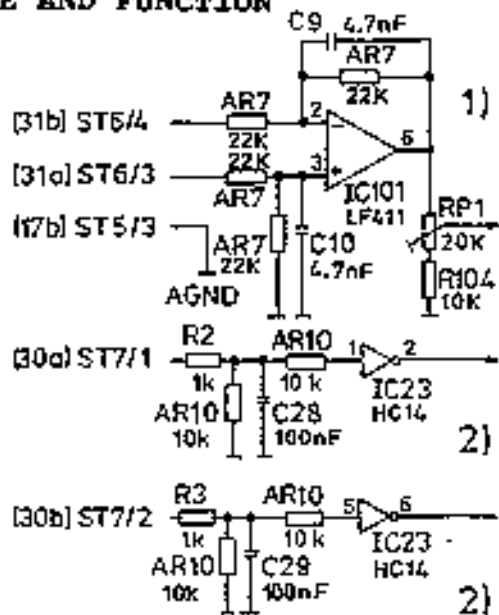
It Inhibit Test

Note: For test purposes only, low disables electronic fusing.

+ 24 V_{DC} Input for Control logic supply (optional)

Inputrange + 18 ... + 60 V_{DC}

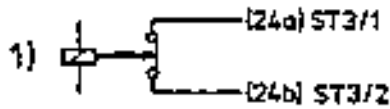
Inputpower 40 W



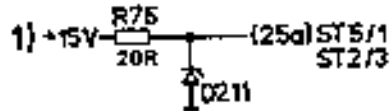
- 1) On Control Card
- 2) On Resolver Card
- *) For BTS 10 RL

BTS 10 R/RL - I/O HARDWARE AND FUNCTION

OUTPUTS



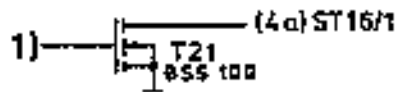
Fault relay contacts, open when fault.
max. load: 48 V_{DC} @ 100 mA



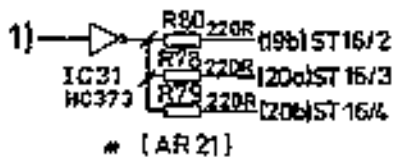
+ 15 V @ 20 mA



- 15 V @ 20 mA



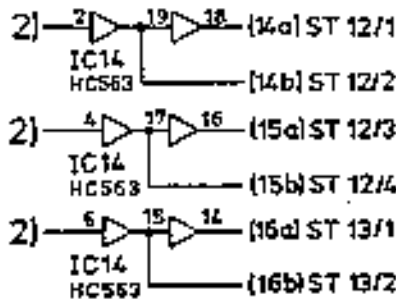
It warning
max. load + 30 V @ 50 mA
active low



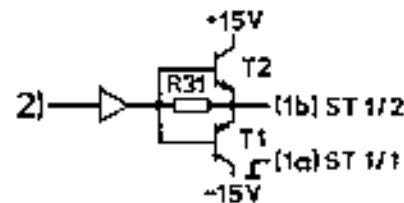
F0 Error code
F1 5 V output
F2

F0	F1	F2	
0	0	0	OK (BTS 10 in happy)
0	0	1	Overtemperature
0	1	0	Encoder failure
0	1	1	Electronic Fuse
1	0	0	Overvoltage
1	0	1	Resolver fault
1	1	0	Overcurrent
1	1	1	IT warning, electronic
			Supply error 15 sec.

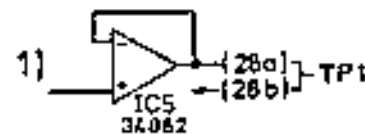
Note: IT warning not latched, all others are



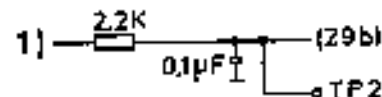
CHC / Encoder outputs
CHB / V_{OH} ≥ + 4,5 V CW ROTATION:
CHB V_{OL} ≤ + 0,2 V
CHA / I_{OUT} ≤ 5 mA
CHA Not short circuit proof



Resolver Reference R 3 Signal waveform
Resolver Reference R 1 sinusoidal
7,2 kHz,
21 Vpp



Current command signal
9,65 V_{DC} = I_{PK}
load ≥ 10 kΩ

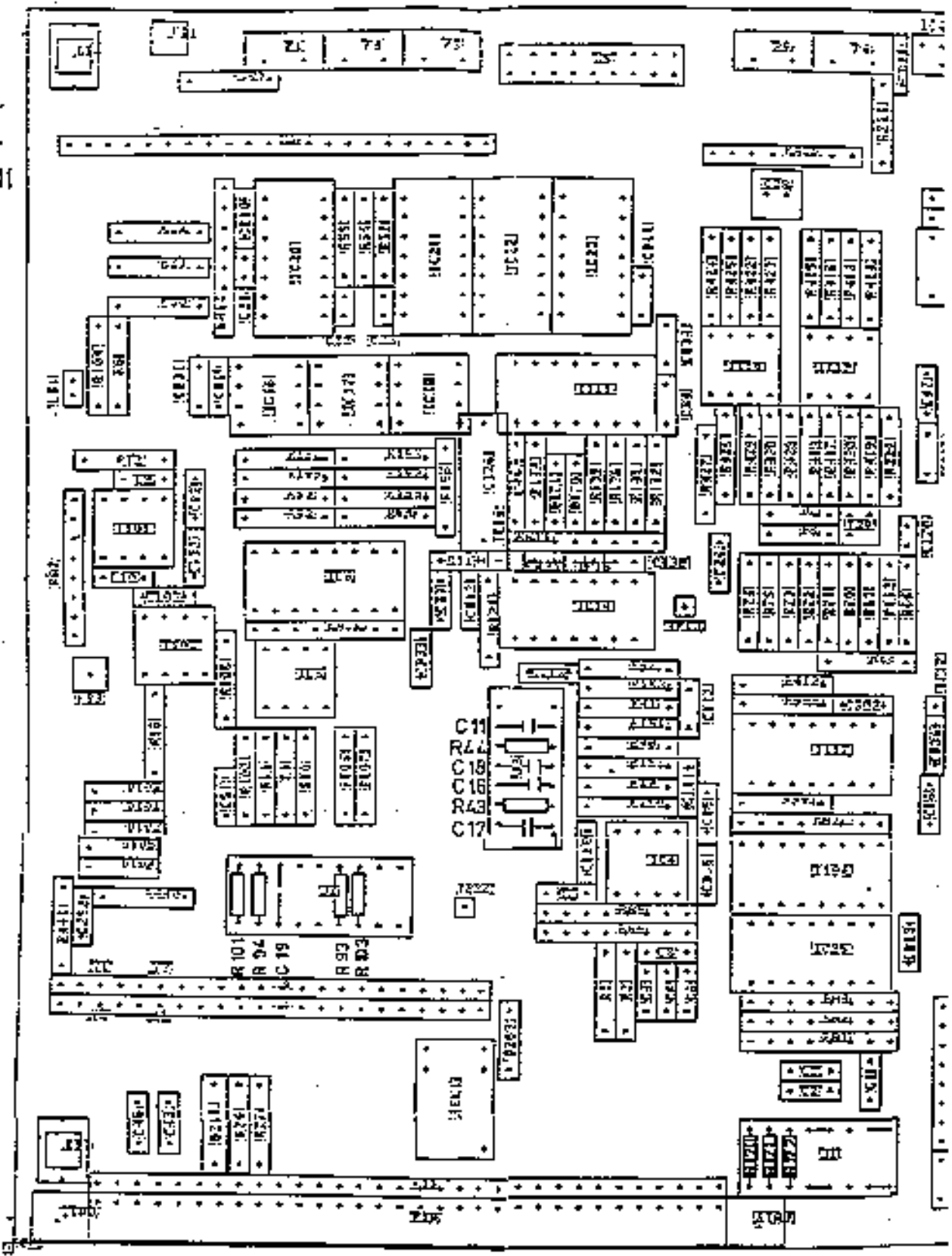


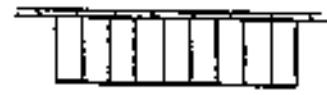
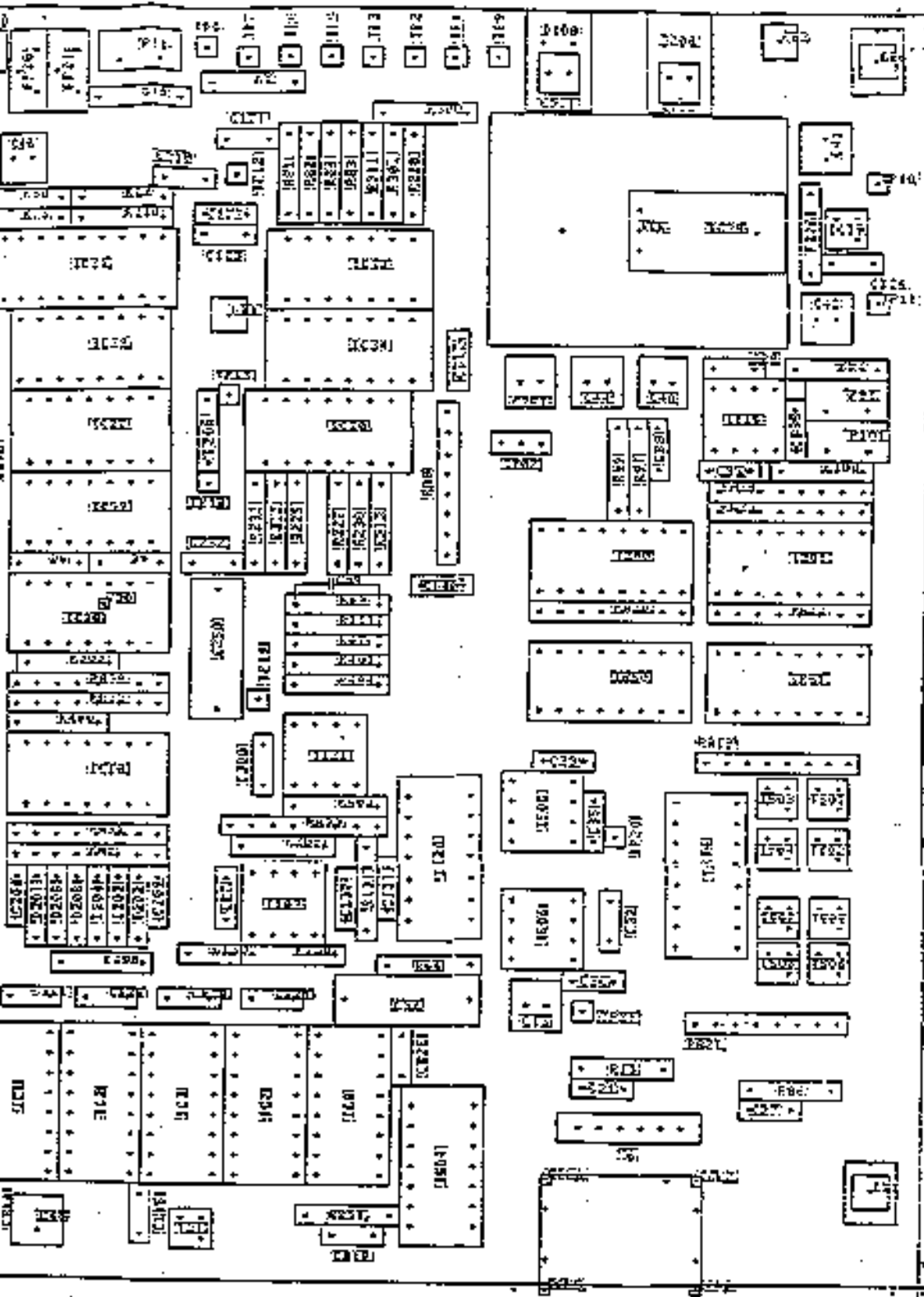
Phase current
I_w actual
10,0 V = I_{PK}

Note: TP 1 and TP 2 on backpanel.

1) On Control Card
2) On Resolver Card
*) For BTS 10 RL

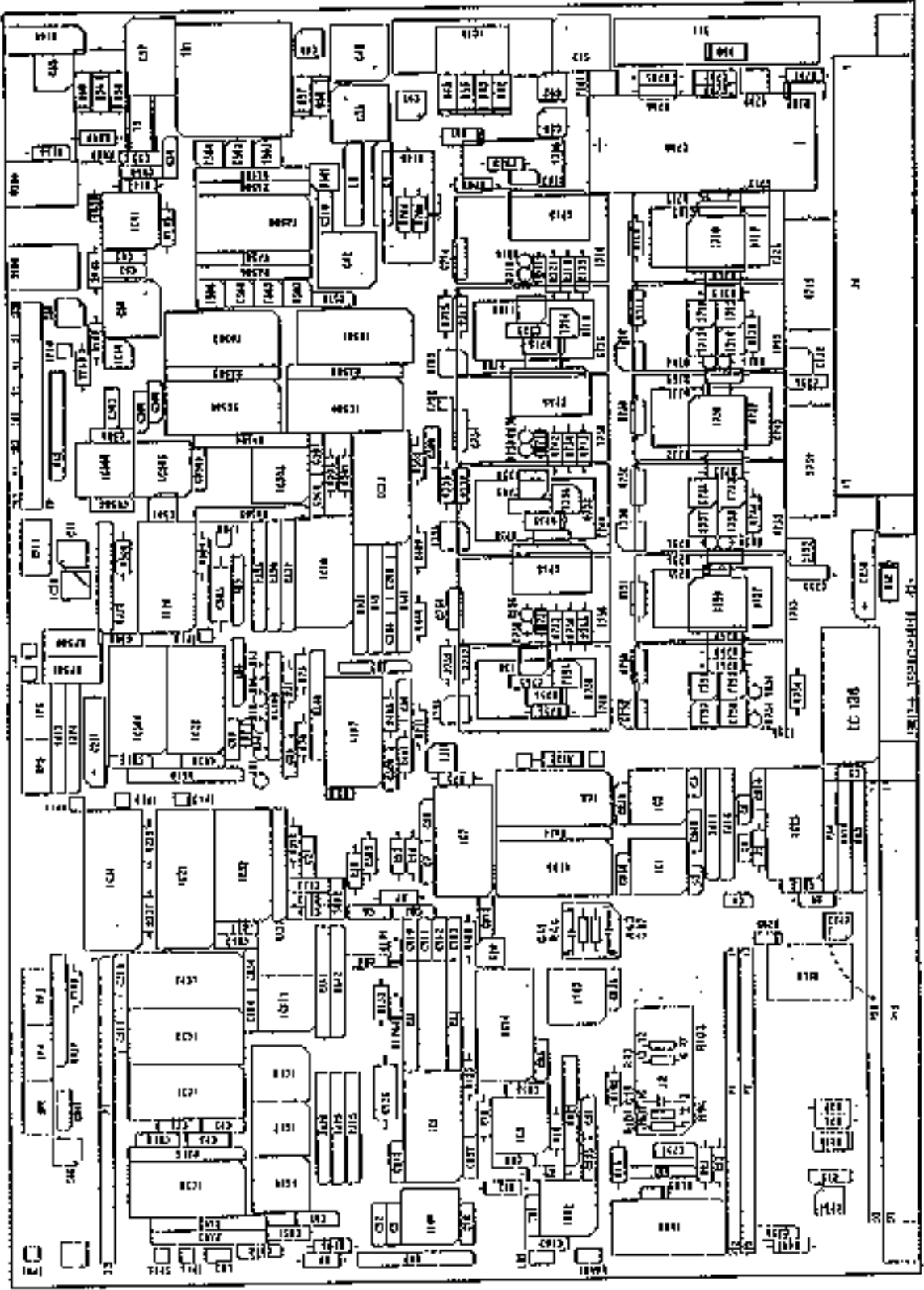
STAND: 175.88 ft
5.7.88 ft
29.9.88 Ml



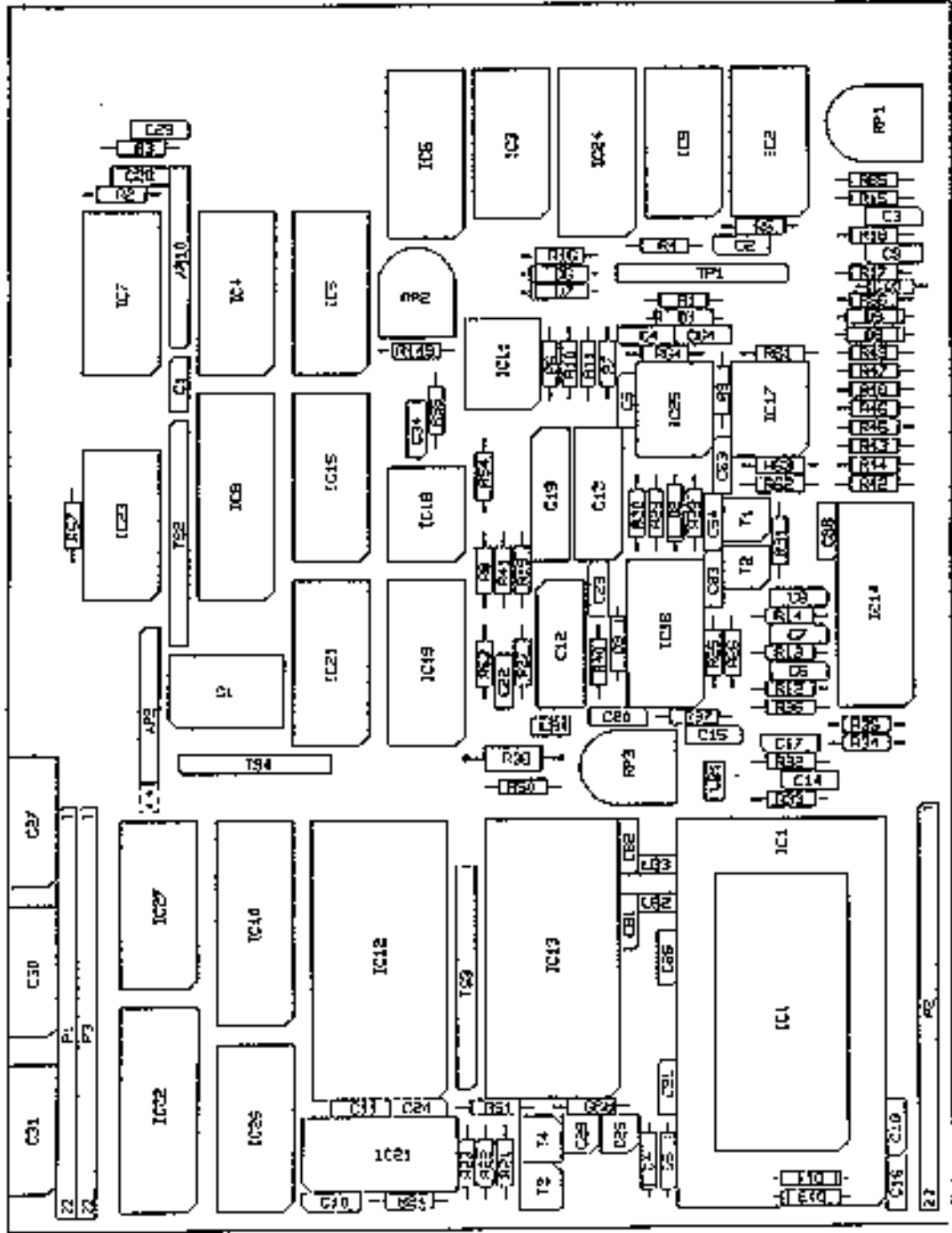


P5 SOLDER SIDE
 FOR TR44,50,51
 CUT PINS 1MM
 SHORTER

SURFACE ROUGHNESS		TOLERANCES		MATERIAL		PROTECTIVE FINISH	
TITLE BTS 10/1 CONTROL CARD COMPONENT LAYOUT				SCALE		DRAW. NO. 13809 C	
1968	DATE	NAME	REV. NO.	PROPRIETARY NOTICE SALTER <small>The design, layout, and/or other information contained herein is the property of SALTER INDUSTRIES, INC. and is not to be disclosed to any other party without the written consent of SALTER INDUSTRIES, INC.</small>			



PROJECT NO: 17531B DATE: 11/10/81 DRAWN BY: [Name] CHECKED BY: [Name]	PROJECT NAME: BIS 10RL COMPONENT LAYOUT	SCALE: 1/8" = 1'-0"	DRAWING NO: 17531B RAIDOR ASR
--	---	---------------------	---



STAND: 23.12.88 *ML*
 STAND: 17.01.89 *MI*
 TO: 5.89 *ML*
 26. 5.89 *ML*

NOTE: ACTUAL COMPONENT PLACEMENT
 MAY DIFFER FROM SHOWN
 COMPONENT LAYOUT
 R 38 ON SOLDER POINT

SURFACE MOUNTABLE		TELEPHONE		W/TELEPH		PROTECTIVE COVER	
VIA		BTS 10720 P-10R		CART 3		16070 B	
COMPONENT LAYOUT							
REV	DATE	BY	CHKD	REV	DATE	BY	CHKD
01				1			
02				2			
03				3			
04				4			
05				5			
06				6			
07				7			
08				8			
09				9			
10				10			

BALDOR ARM

BPS 10-200-R

POWER SUPPLY FOR BTS 10 R/RL SERIES AMPLIFIERS

Together with an external 3-phase isolation-transformer the BPS 10 R represents the 200 V DC power-supply. Its function besides fullwave rectification and filtering also includes a power shunt or regeneration. The regeneration circuitry limits the DC-Bus voltage level during deceleration of the motor with its load thus preventing an over-voltage shut down on the BTS 10 R/RL. On the frontplate there are two indicators, one for the 200 V DC supply, the other for the activity of the regeneration.

Input for 200 V DC output: 3 x 140 V AC nominal

Regeneration level: 275 V DC (Pl set and sealed ex works)

Loadresistors:

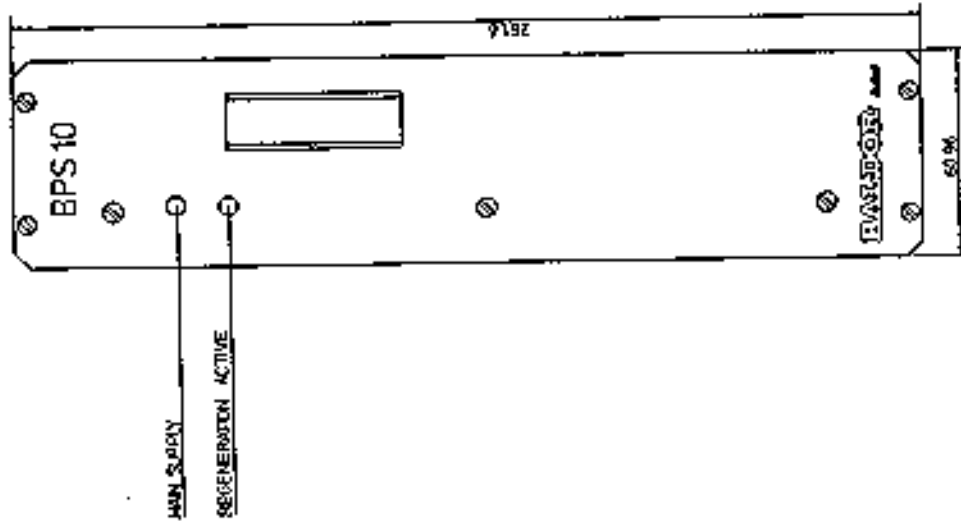
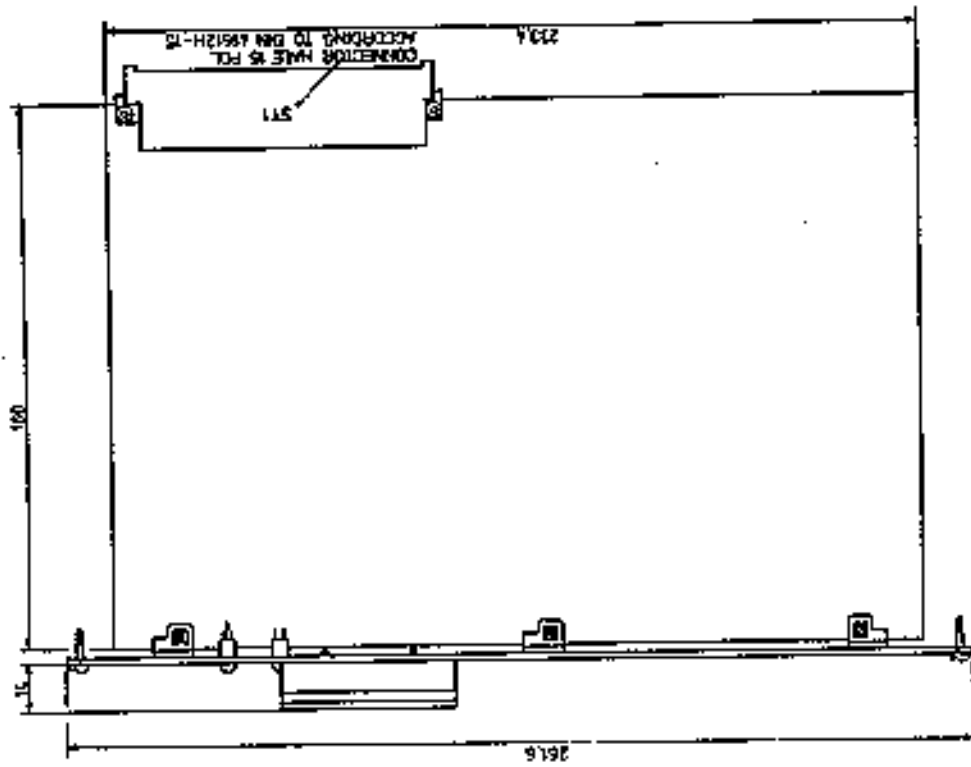
For all BPS 10 R versions an internal loadresistor with 80 W continuous powerrating is included. The peak power dissipation should not exceed 4 kW for time intervals shorter than 1 sec.

For applications where higher powerratings are needed an external resistor may be connected to ST 17 (+ Vcc/R REG), in this case the internal resistor (R18) has to be removed.

External resistors are available with 320 W powerrating (16 kW @ \leq 1 sec).

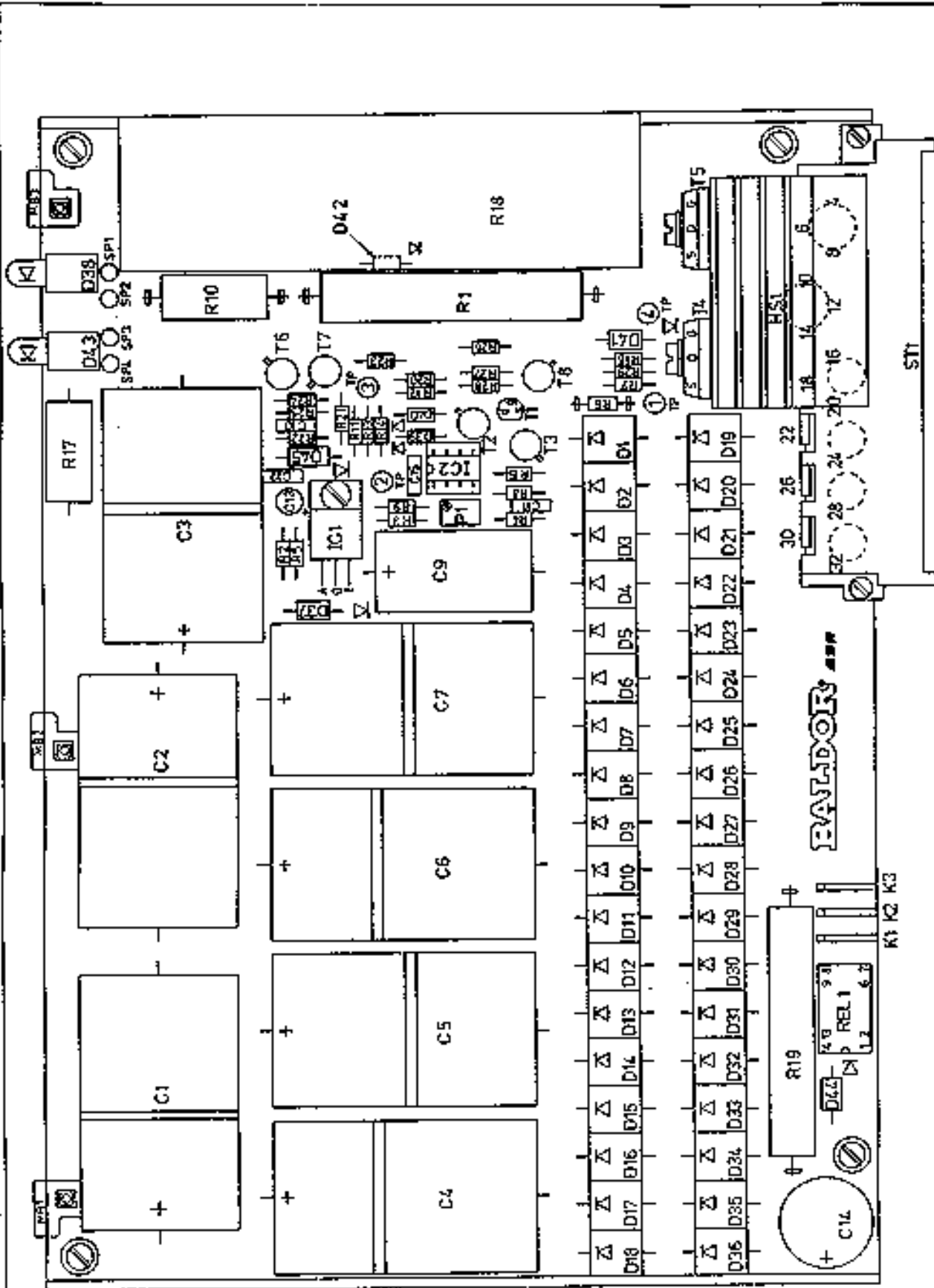
Note: The switching current (20 A) may not be increased, hence the resistor value must be \geq 14 Ω .

14400B



BPS 10
FRONT PANEL
MOUNTING DETAILS TO PCB

SCALE	1:1
FIG. NO.	14400B
BAIRDON A.S.B. SERVICE	

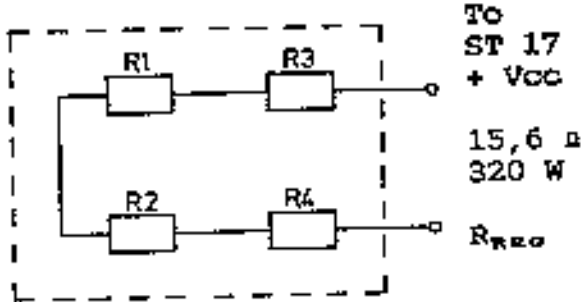


REV	DATE	BY	CHKD	APP'D
1				
BPS 10, 10B, 10R POWER SUPPLY COMPONENT OVERLAY				
QTY	UNIT	REVISION	DATE	BY
1	PCB	1		
14476G				
BALDOR				

NOTE:
 1. M51 IS MOUNTED ON SPACERS
 2. COMPONENTS SHOWN THIS WAY ARE MOUNTED ON SOLDER STUDS.
 3. ON BPS 10R, D36L3 ARE MOUNTED ON A SEPARATE PCB ATTACHED TO THE HOUSING FRONT WALL. THEN WIRED BACK TO THEIR RESPECTIVE SOLDER POINT ON THE POWER SUPPLY BOARD

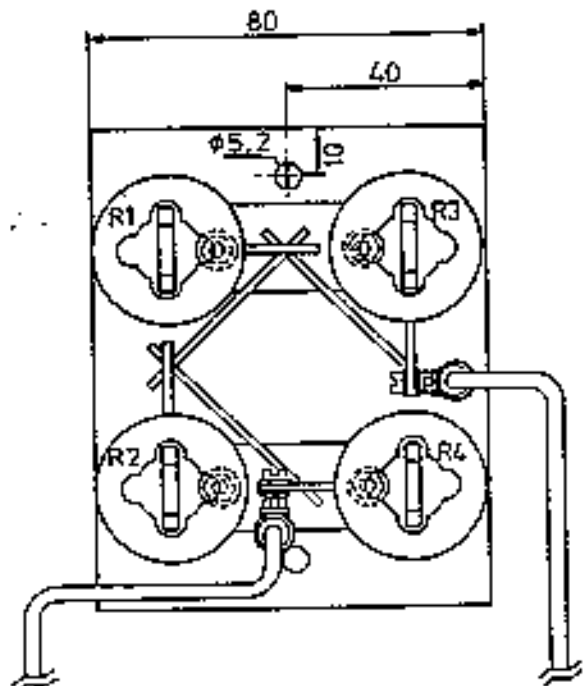
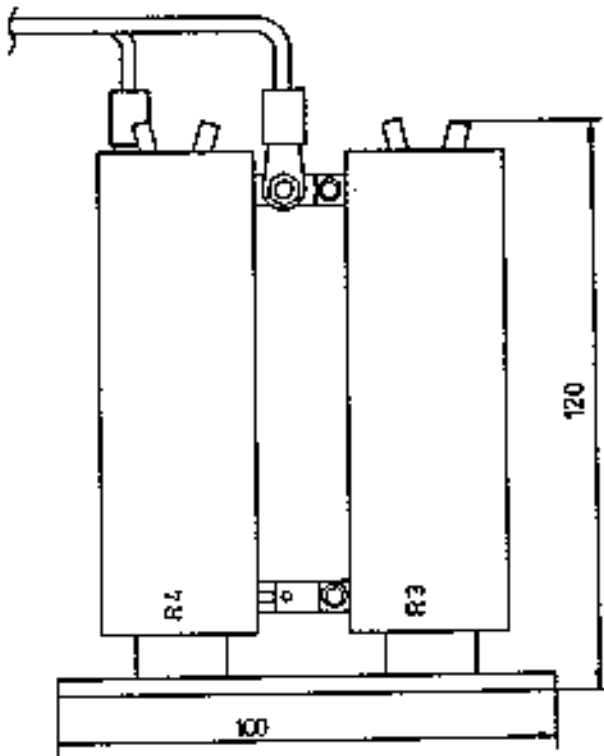


BPS 10 R-EXTERNAL LOAD RESISTOR



R 1...4 = 3,9 Ω/80 W
I_{SWITCH} = 17,5 A
14352A

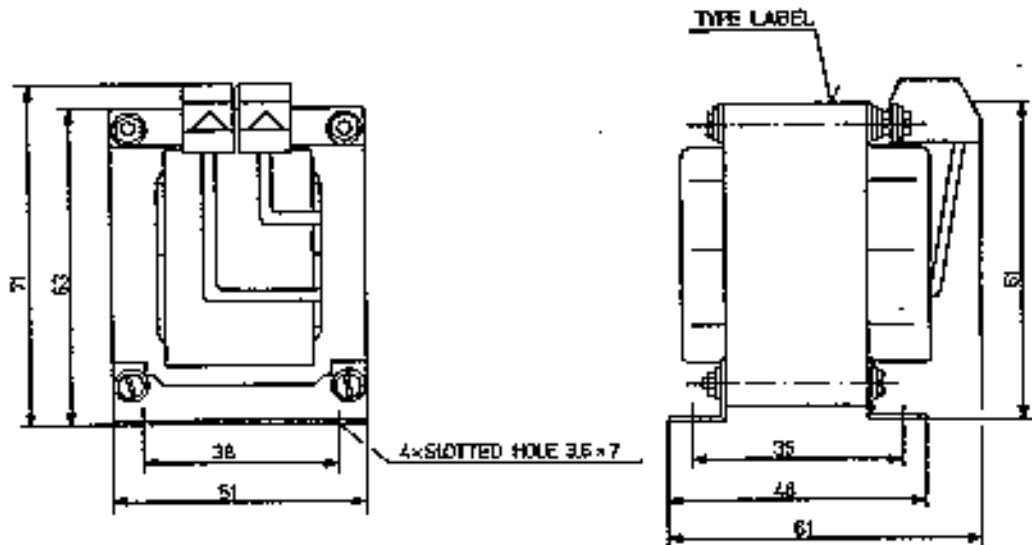
ASSEMBLY DRAWING AND DIMENSIONS



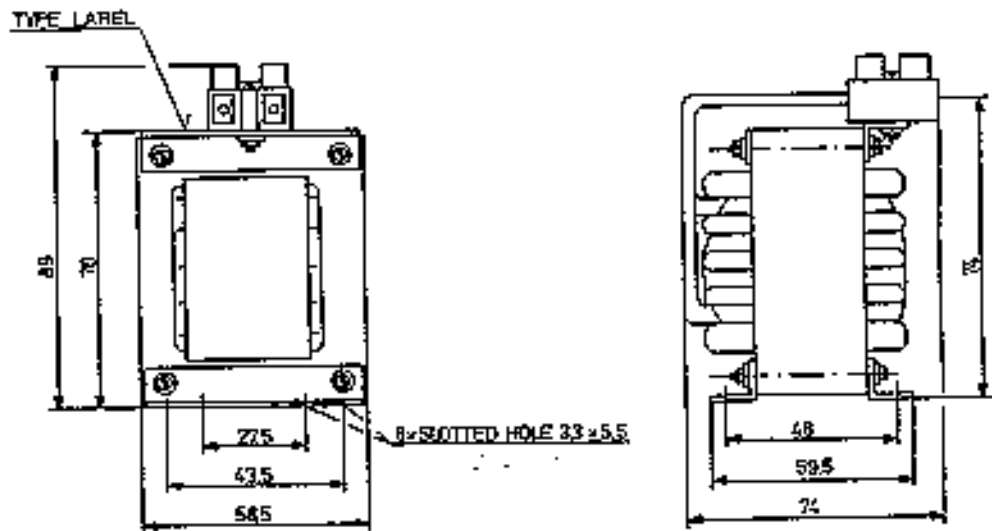
BTS 10 R/RL - PROTECTION CHOKES

The following chokes are available to protect the amplifier against shorts between the outputs and to ground. One choke in each of the three phases to the motor is needed for full protection.

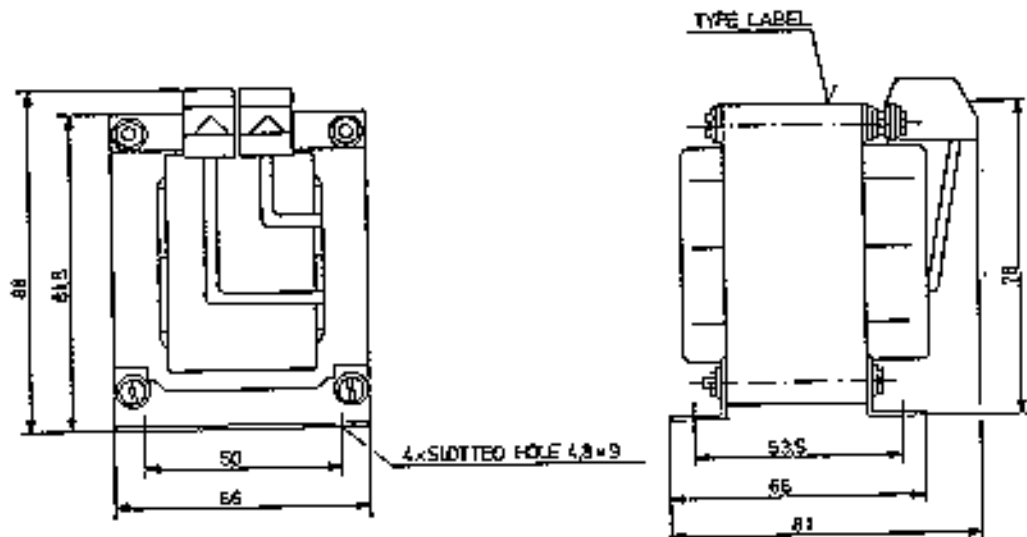
L 100-6
15528A
1 mH/5 A



L 040-15
12956A
400 μH/15 A



L 040-20
15527A
400 μH/20 A



USER NOTES

1. 24 V-Option

The Control Supplies are normally generated from the 200 V_{DC} - BUS supply.

For some applications it is necessary to keep the control electronics on stand-by (ex. position information).

This can be achieved by using a supplementary external 24 V supply. In this case the internal supplies will be generated from the 24 V.

Consequently the BUS supply can be varied in a wide range from 0 to nominal.

This feature is not standard and cannot be fitted in the field.

2. S-Option

With a few changes it is possible to upgrade the BTS 10 R/RL to a S-BTS 10 R/RL.

- Remove resolver card.
- Remove frontplate.
- Cut out pin 12 of connector P4.
- Insert μ SMCC (S-Option).
- Install S-BTS 10 R/RL frontplate (available as spare part).

3. Current Offset Adjust (BTS 10 R only)

The current offsets are adjusted ex factory at an ambient temperature of 25° C.

At higher ambient temperatures a significant DC-component may be introduced in the motor windings due to thermal drift causing additional torque ripple.

Adjustment procedure:

- Remove BTS frontplate, insert amplifier in rack.
- Connect ST 4/2 (1 : 1) to DGND.
- Remove wiring to ST 6/3 and ST 6/4.
- Power on (amplifier enabled).
- Check TP5 with DVM to be 0 Volt.
- Connect DVM to TP1 (see page 16) and TP8 (GND).
- Adjust RP20 (see page 16) until $V_{TP1} = 0,0 V_{DC}$.
- Connect DVM to TP2 and adjust to Zero with RP21.
- Check TP3 = 0,0 V_{DC}.
- End.

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