MOTION UNDER CONTROL

Technical Description

and

Commissioning Guide

TWR
DC BRUSHLESS SERVODRIVES

Issue 11E, Rev. 3.

This handbook is valid for TWR34 (Rev. D) and TWR12 (Rev. B).

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TWR/TB layout
Standard transformer connections and dimensions

N.B. Circuit diagrams of all option cards are available on request. These can be of considerable assistance during commissioning.

Every effort has been taken during the preparation of this handbook to avoid errors. However should the user recognize mistakes or wish to recommend improvements, MACCON will be grateful for such information. MACCON also reserves the right to make any corrections to this handbook without prior notification.

This handbook is valid for:

TWR34 (Rev. C), TWR34-D (Rev. C), TWR12 (Rev. B).

It is also valid for the new revisions TWR (Rev. D) and TWR12 (Rev. C). These incorporate minor layout changes but no fundamental circuit modifications.

INTRODUCTION

The TWR servodrives have been especially designed to exploit the advantages of DC brushless servomotors. A series of plug-on control and commutation options allow for the adaptation to the majority of standard feedback devices and available types of brushless DC servomotor.

DESCRIPTION

1 System Environment1 System Environment

1.1 Properties of Brushless Servomotors1.1 Properties of Brushless Servomotors

DC brushless servomotors offer the user considerable advantages in comparison with conventional DC brushed motor technology. The particular advantages are:

- The motor is more reliable; it has a minimum of moving parts as there are no brushes that have to be replaced regularly. The life of the motor is only limited by the quality of its bearings. There are no further problems due to brush wear and the resulting commutator shorts.
- The operating curve is nearly square (speed against torque) i.e. the available torque does not drop off with speed due to the commutation limits of the conventional DC servomotor.
- The rated operating current may flow indefinitely and also at standstill (no local commutator damage possible).
- A high-energy density can be achieved as the thermal losses in the windings are incurred in the motor housing and can be better dissipated. In the conventional DC servomotor heat losses occur primarily in the rotor where it is not possible to cool efficiently.
- A lower moment of inertia is achieved as the rotor can now be hollow. This further adds to the dynamic performance of the motor.

1.2 Special Features of TWR Brushless Drives1.2 Special Features of TWR Brushless Drives

The TWR amplifiers derive main and auxiliary power from a single DC-bus voltage and contain all power and control electronics needed for full torque and speed control of 3 phase, synchronous servomotors (they can also be configured for control of conventional DC servomotors by using 2/3rds of output bridge). A choice of amplifiers is available to cover continuous power ratings of 100W to 5Kw, with peak ratings 2 times higher. They have a high efficiency and are protected against standard faults and It overloading. Switching frequencies of 10.5Khz as well as special modulation techniques keep motor losses and EMI to a minimum.

The main functional blocks of the TWR brushless (abbreviated BL) servo-drive are shown in the diagram (Appendix C) for the standard BL tachometer and sector encoder (magnetic hall-effect sensor) commutation option.

In designing these drives particular care was taken to ensure a compact, economic and modular design. It was therefore decided to limit the mechanical size to a 19-inch frame, double-eurocard design and the operating voltages to less than 270V DC. The necessary isolating transformer being cheaper than potential isolation between the control and power electronics (particularly in multi-axis systems). A new version of the TWR34 is however planned for the future, which will have complete power-stage isolation and will be able to operate at 340V.

The use of plug-on options requires a wider module. On the TWR34/12/06 models a 10mm wider front plate is used for all options other than 01.

In a standard 19 inch rack between 4 and 12 modules (including power supplies) can be accommodated:

TWR34 series:	7 drives of 65mm or 6 of 70mm width (wide modules). Note that the TWR34, 22.5A drive has a total width of 106mm, 4 units can be accommodated in a standard 19 inch rack.
TWR12/06:	12 drives of 35mm or 9 of 45mm width (wide modules)

TWR34 and 12 drives can be operated between 20 and 260V (depending on type) at RMS-continuous currents of 2 to 22 amps, with RMS-peak currents factor 2 higher (absolute peak is 2.8 times higher).

TWR06 drives can be operated between 20 and 150V (depending on type) at RMS-continuous currents of 2 to 3,5 amps (peak = continuous).

Peak currents can be demanded for up to 2.5 secs before It limiting occurs.

The TWR brushless servodrives operate with all standard positioning systems. Stiffness, bandwidth and dynamic speed range are fully comparable with the performance achievable with conventional servo-systems.

The amplifiers can be adapted to the following motor and feedback device types.

1.3 Listing of Standard and Plugable Options1.3 Listing of Standard and Pluggable Options

Standard

OPTION 01 TWR/RLG:	motors/tachometers with trapezoidal back-EMFs and sector encoders (Hall-effect or magnetic shutter devices). Tachometer requires center-tap.

Plugable (require wide module dimension in TWR34/12/06 series)

OPTION 02; TWR/2RN:	motors with sine-wave back-EMF and 2 pole resolver (R/D converter with 12 Bit resolution). An older version (Option 2A) with inverted component layout for compact module width is still available on request.
OPTION 03; TWR/ENC:	motors with sine-wave back-EMF, hall-effect devices and incremental encoder (velocity control requires tachometer).
OPTION 04; TWR/ENT:	motors with trapezoidal back-EMF, hall-effect devices and incremental encoder. The current version of this option has an inverted component layout for compact module width.
OPTION 05; TWR/TAC:	motors with sine-wave back-EMF, hall-effect devices and STEGMANN Tacoder.
OPTION 06; TWR/APO:	motors with trapezoidal back-EMF, hall-effect devices and potentiometer position feedback (velocity control is also derived from the potentiometer). The control signal is analog position.
OPTION 07; TWR/IND:	motors with sine-wave back-EMF, hall-effect devices and incremental INDUCTOSYN feedback.
OPTION 08; TWR/ENC-PV14:	motors with sine-wave back-EMF, hall-effect devices and incremental encoder. The phase currents are generated with high resolution (velocity control requires tachometer).
OPTION 09; TWR/ASK:	motors with sine-wave back-EMF, analog (sine-wave) hall-effect devices (velocity control requires tachometer).

OPTION 12; TWR/2RN-P16: motors with sine-wave back-EMF and 2 pole resolver (R/D converter with 16 Bit resolution). The phase currents are generated with high resolution.

OPTION 13; TWR/IMAS: motors with sine-wave back-EMF and 2 pole resolver (R/D converter with 12 Bit resolution). This option is also able to multiplex EUCRON IMAS absolute position sensors. The absolute position information is available to the host control via an SSI-interface.

It is not essential to use the same form of back-EMF stated. However this will provide the better performance.

1.4 Common Technical Data

1.4 Common Technical Data

Operating bus voltages:		
	TWR34/12/06-48	20 - 60V DC
	TWR34/12-200	150 - 260V DC
	TWR06/100	60 - 160V DC
Undervoltage limit:		
	TWR34/12/06-48	15V) DC/DC
	TWR34/12-200	90V) Converter
	TWR06/100	50V) only
Overvoltage limit:		
	TWR34/12/06-48	80V
	TWR34/12-200	285V
	TWR06/100	180V
Relay contact ratings:		
	TWR34/12/06	1Amp/240V AC or 30V DC
Fault output rating (from TWR backplanes):		
		25V dc/20mA o.c.
Current form factor:		
		better 1.01 achievable
Current loop bandwidth (45 deg. phase shift):		
	TWR34/12	ca. 2Khz
	TWR06	ca. 1KHz
Typical input drift:		
	Tach/tachoder	0.01 rpm/EC
	Resolver	0.02 rpm/EC
Dimensions (without backplane):		
	TWR34	233.4 x 170 x 60mm
	TWR34 (wide)	233.4 x 170 x 70mm
	TWR34-22Amp (wide)	233.4 x 170 x 106mm
	TWR12/06	233.4 x 170 x 35mm
	TWR12/06 (wide)	233.4 x 170 x 45mm
Housing (in rack):	IP20	

Amplifier connectors:		
	power	DIN41612, H15
	control	DIN41612, B64
Backplane connectors:		
	power	M6 screw terminals
	motor/earth	M5 screw term, 15pin sub-D
	feedback	9 pin sub-D
	control	25pin sub-D, 12 pin screw terminal
Cooling:		
	TWR34/12	forced air ventilation above 7A
	TWR06	convection
Operating temperature:		
	TWR	0 - 45EC nominal, 45 - 55EC with 20% derating
Weight:		
	TWR34	1.7 Kg
	TWR12	1.1 Kg
	TWR06	0.7 Kg

2 Types2 Types

2.1 Type Designations2.1 Type Designations

The following basic types of brushless drive amplifier are available in the TWR series:

Type	***Bus Voltage V. DC***	***Six step continuous/ Sine-wave RMS current Amps***	***Peak Current Amps***
TWR34/48-15	20-60	15	42
TWR34/48-22	20-60	22.5	63
TWR34/200-5	150-260	5	14
TWR34/200-10	150-260	10	28
TWR34/200-15	150-260	15	42
TWR34/200-22	150-260	22.5	63
TWR12/48-3	20-55	3.5	10
TWR12/48-7	20-55	7	20
TWR12/200-2	150-260	2.5	7
TWR12/200-5	150-260	5	14
TWR06/48-3	20-55	3.5	5
TWR06/100-2	60-160	2.0	3

The TWR34/12 200V models can be adapted for operation down to 100V (100 to 200V).

Power supplies are also available for the three drive series:

Type	***Bus voltage***	***Cont. current***	***Regeneration voltage***	***current***

TWN34/48-40	18-60V	40A	70V	20A
TWN34/200-20	110-260V	20A	275V	10A
TWN34/200-40	110-260V	40A	275V	20A
TWN12/48-20	18-60V	40	70V	20A
TWN12/200-20	110-260V	20A	275V	10A
TWN06/100-20	60-160V	20A	170V	10A

Options are generally identified by family:

TWR34/R	TWR34 style backplane with H15 Power connector
TWR34-56/R	TWR34 style backplane with power screw connector for copper rails (as TWR56/R)
TWR12/R	TWR12/06 style backplane with H15 power connector
TWN34/R	TWN34 H15 power connector
TWN12/R	TWN12/06 H15 power connector (identical to TWN34)
R/TWR34-x	19 inch rack for TWR34 drives etc.
(1/2)R/TWR34-x	Half 19 inch rack for TWR34 drives etc.
R/TWR12-x	19 inch rack for TWR12/06 drives etc.
(1/2)R/TWR12-x	Half 19 inch rack for TWR12 drives etc.

unless otherwise stated these racks will include a corresponding TWN-module slot (at left of rack). An additional suffix (yyy) indicates a specific customer option of the rack, often in combination with other products such as positioning systems.

2.2 Manufactured Options2.2 Manufactured Options

Suffix -24V: The TWR drive series, 200V and 100V models, can be ordered with a 24V auxiliary input supply voltage (20-60V). The 24V supply voltage is required to supply the internal DC/DC converter. With this option it is possible to maintain the auxiliary supplies, +/-15V and +5V even when the main bus voltage has been switched off for safety reasons. This can be of importance when these supplies are needed externally or when the drive fault code can only be interrogated after bus turn-off or when position has to be continuously monitored (by starting a machine for example). 48V Models can be configured at any time in this way.

Suffix-P: The TWR drive series can be configured solely with personality modules instead of using potentiometers. Only the LEDs and the velocity offset potentiometer are accessible then from the front (special front panel). Personality modules must be specified for the application with regard to:

- current loop settings
- velocity loop PI settings and current limit
- tach gain and configuration

This option is of particular interest in large production series with identical adjustments. This is a customized option.

All of these options should be specified on ordering as they are not generally suited for field retrofit.

2.3 Characteristics of Options2.3 Characteristics of Options

The following control and commutation options are also available as already listed in 1.3. These can be exchanged and retrofitted in the field if necessary:

Standard

OPTION 01; TWR/RLG: The armature current is switched clockwise from phase to phase; at any one time 2 phases conduct current. This configuration also works with motor/tachometers with sine-wave back-EMF, however with higher torque ripple. TWR34/12 models require a center-tapped BL Tachometer, preferably with trapezoidal characteristics. TWR06 models can also be configured with sine-wave tachometers in one of three 30 degree shifted alignments to the motor; a center-tap is not needed (standard INLAND BETH configuration).

Plugable (require wide module - 10mm width increase)

OPTION 02; TWR/2RN: A sine-wave armature current is generated in each motor phase. The applied R/D converter has a resolution of 4096 steps per revolution, the number of electrical cycles being chosen to suit the motor (number of poles/2). A tachometer signal with high bandwidth and low ripple is derived directly from the resolver signals. Incremental encoder quadrature and zero pulses are made available for the host control or external positioning system (a resolution of 1024 and less can be simulated). This option has the great advantage that only one very robust pick-up device is needed at the motor. The standard version of this option is normalized for operation up to 4000 rpm.
Other normalization should be defined at ordering. Alternative encoder resolutions up to 1024 can also be specified (1024, 1000, 900, and 600 are standard on TWR models). This option also offers the facility of speed and direction dependent phase advance to improve high speed torque. Limit switch inputs are available.

OPTION 03; TWR/ENC: A sine-wave armature current is generated in each motor phase in 2 x encoder steps per revolution, the number of electrical cycles being chosen to suit the motor. On switch-on this option requires sector signals (hall-effect) to turn the motor until the first encoder zero pulse is seen, thereafter sine-wave currents can be generated. The alignment of the encoder zero pulse with the start of an electrical commutation cycle has to be set up by the user. The ratio of encoder pulses to the number of poles has to be set up by the user. This option should be supported by a brushless or conventional DC tachometer or digital velocity control. It also offers the facility of speed and direction dependent phase advance to improve high speed torque. The encoder and zero channel signals are made available to the host control. Limit switch inputs are available.

OPTION 04; TWR/ENT: This option generates a tachometer signal from an incremental encoder using the simple principle of frequency to voltage conversion. In order to keep jitter at stand-still to an acceptable level, the DC-gain should be decreased by about a factor of 10. The sensitivity of tach signal generation depends on the resolution of the encoder used as well as from scaling jumpers on the option card. The encoder quadrature and zero channel signals are also made available to the host control. Limit switch inputs are available.

OPTION 05; TWR/TAC: This option includes all the functions of option 3/ENC but additionally includes the facility of generating a highly stable, linear and wide-bandwidth tachometer signal from the tacoder. This signal has also extremely low ripple and is well suited for the control of precision brushless torque motors and for applications requiring a feed-back device with a large internal diameter. The tacoder uses a conventional encoder disc and phototransistors but the photodiode is now an array that simulates a rotating light source, allowing a high bandwidth, velocity signal to be generated at standstill and eliminating the need for a separate tachometer. Limit switch inputs are available.

OPTION 06; TWR/APO: This option supports the analog positioning of a hall-effect commutated motor with potentiometer feedback. The analog command signal is interpreted as a position command. The position feedback signal is also differentiated to provide velocity stabilization. It is especially suited to rotary actuator applications for movements up to about 300 degrees. Limit switch inputs are available.

OPTION 07; TWR/IND: A sine-wave armature current is generated in each motor phase in 4096 steps per revolution, the number of electrical cycles being chosen to suit the motor (number of poles/2). A tachometer signal with high bandwidth and low ripple is derived directly from the INDUCTOSYN signals. Incremental encoder quadrature and zero pulses referred to a cycle of the INDUCTOSYN are made available for the host control or external positioning system (resolutions of 1024/cycle and less can be simulated). This option has the great advantage that only one very robust pick-up device is needed at the motor. The standard version of this option is normalized for operation up to 3500 cycles/min. Other normalizations and the number of motor poles should be defined at ordering. Limit and reference switch inputs are available. Phase advance is not available with this option.

OPTION 08; TWR/ENC-PV14: This option is developed for high precision applications. The current command signals are generated with 14 bit. To achieve the 14 bit resolution an encoder with a high number of cycles is necessary (min. 60.000 counts per electrical cycle of the motor). Using an encoder with less pulses the max. available current resolution is set by Dip-Switches. To synchronize the current sine-wave to the back-EMF of the motor sector signals (hall effect) are required. The alignment of the encoder zero pulse in reference to the back-EMF is realized with an electrical pulse shifter. It is possible to shift the zero pulse in 0.1E (mechanical) steps by 14 bit resolution.
The option is designed for torque control system. For stability reasons it is possible to close the velocity loop by using a brushless or conventional DC tachometer. The encoder and zero channel signals are made available to the host control. Phase advance is not implemented. Limit switch inputs are available.

OPTION 09; TWR/ASK: Similar to the TWR/ENC option. However the phase current commands are generated totally with analog circuitry with unlimited resolution and without any initialization requirements. Limit and reference switch inputs are available. Phase advance is not available with this option.

OPTION 12; TWR/2RN-P16: A sine-wave armature current is generated in each motor phase in 16384 steps per revolution. Other characteristics are similar to the standard TWR/2RN option.

2.4 Order Information2.4 Order Information

The order numbers for the brushless drive amplifiers themselves are structured as in the following example:

TWR34/200-15-02-750-24V

34	drive series
200	nominal dc-bus voltage
15	continuous current rating
02 or 2R8	resolver commutation option 2; 2R8 indicates 2 pole resolver and an 8 pole motor
750	special encoder resolutions
24V 24V	auxiliary power, if required

See previous section for a full list of option numbers.

The brushless drive power supply modules are designated similarly:

TWN34/200-40

34	drive series (i.e. module width)
200	nominal dc-bus voltage
40	continuous current
	all units with regeneration

2.5 TWR34/D Systems2.5 TWR34/D Systems

These are special customer models with resolver feedback and special ramping and interlock functions.

TWR34/D (TWR34/48-15-2R12-1024-P)
This model was specially developed for operation with INLAND MOTOR RBH motors and ARTUS pancake resolvers at an operational voltage of 48V. The control card incorporates special ramping and interlock functions. All control and servo-adjustments with the exception of offset are made via personality modules and jumpers.

The resolver option used on this unit is designed for operation with 12 pole motors and 2 pole resolvers. It generates 5V incremental encoder signals with 1024 ppr resolution. The resolver option is fitted on the basic control card; no additional card is necessary

These units are used with the R/TWR34-6/D rack and STV-DORN/A power supply unit.

Technical Data: as 1.4 with the exception of:

Operational voltage	48V +/- 12V
Undervoltage limit	32V
Overvoltage limit	80V

Special Functions: special ramping and interlock functions can be chosen by setting jumpers accordingly:

BR5	choice of indexer- and ramp-operation
BR6	positive limit switch
BR7	negative limit switch
BR8	brake and disable on limit switch
BR9	disable immediately or on stand still
BR10	brake and disable on no fixed speed
BR11	polarity of Enable signal
BR13	20 times slower acceleration in ramp mode

Connections: the standard connections for the TWR34 series apply with the following differences or comments:

Enable the polarity of this signal can be chosen by setting BR11, the standard configuration is for positive operation.

Brake Enable(-) this signal also has the function of Indexer Enable(-)

Fault codes these correspond to the standard TWR34 coding.

Commissioning: the first stage of commissioning consists of setting the correct personality modules and jumpers. A further optimization of the servo-performance is not necessary as all significant parameters are determined by the personality modules.

Service and Fault Finding: all the standard fault descriptions for the TWR with resolver option apply to these units. The fault code can be evaluated using a test box (see drawing in Appendix C).

3 Accessories3 Accessories

3.1 TWN34/12/06 Power Supply Card3.1 TWN34/12/06 Power Supply Card

This card has been designed to rectify and smooth a 3 phase supply of up to 180V/50 or 60Hz. There are six versions of this card for different nominal bus operating voltages - 200, 100V and 48V nominal - and different currents. These cards have a continuous current rating of 40 or 20 Amps but blower cooling is recommended for operation above 20 Amps. The card only takes up the depth and width of one TWR34/12 rack position respectively.

The card further has as standard an overvoltage protection circuit (regeneration), which dumps motor braking energy from the motor into an internal resistor (approximately 20 or 10 Amps, corresponding to an energy of 4 or 2 kWsecs). If required for safety reasons, this resistor can be external to the card. A relay contact provides an external warning by opening if the regeneration circuit is operated for more than ca. 400 msecs. It is recommended that an external regeneration resistor is fused to avoid the risk of overload or burn-out should the bus voltage exceed the regeneration threshold for any long period.

In place of the power supply card it is also possible to use combined transformer/rectifier units (see 3.3). The card connections and circuits are given in the appendices.

3.2 STV Power Supply Units3.2 STV Power Supply Units

In order to save rack space it can be of an advantage to integrate the transformer and power supply together in an external unit. So far the following units have been configured at customer request:

STV-020-48 (STV-DORN/A)	2 KVA unit with 48V DC output
STV-050-48	5 KVA unit with 48V DC output
STV-030-60-R	3 KVA unit with 60V DC output
STV-050-150-R	5 KVA unit with 150V DC output
STV-070-150-R	7 KVA unit with 150V DC output

These units do not include regeneration protection circuitry unless specified (through suffix -R).

3.3 Option-R, 19-Inch Rack3.3 Option-R, 19-Inch Rack

This option includes the mechanical frame for up to 6 TWR34 or 11 TWR12/06 units and a corresponding power supply card. The rack is also fitted with the number of backplanes otherwise specified and their power interconnections (TWR34/12/R or TWN34-56/R and TWN34/12/R). The frame has standard 19-inch width and 6 unit height (483 x 266 x 240 mm overall). See Appendix C.

3.4 Option-LV, Blower Unit3.4 Option-LV, Blower Unit

TWR34/12 units above 7 Amps should be blower cooled. The LV blower is 19-inch mount, 1 height unit in size and requires a 220V single phase supply (110V available on request). Versions with 2 or 3 blowers are available (LV2 and LV3). Technical data:

Dimensions:	483 x 43.6 x 199mm
Power requirement:	45 Watts/blower
Air volume:	c. 80 l/sec (no back-pressure)
Max. static pressure:	7.2/8.6mm water
Noise level:	c. 50 dB

3.5 DT-Transformers3.5 DT-Transformers

See Appendix C

IMPLEMENTATION

4 Configuration of a TWR-System4 Configuration of a TWR-System

4.1 Choice of Commutation4.1 Choice of Commutation

Practically any 3 phase brushless servomotor can be adapted to a TWR series amplifier, independent of whether it has a sine-wave or trapezoidal back-EMF characteristic. A motor with sine-wave back-EMF still has only about +/- 8% torque ripple when driven in 6-step current control mode (standard commutation option 01/ RLG). It is also possible to drive trapezoidal back-EMF motors with sine-wave currents to reduce noise and to provide high speed phase advance.

Using the correct commutation scheme with the corresponding back-EMF results in equal performance (ratio of torque to thermal losses of winding). The higher harmonic content of the block (6 step) currents and phase lag in trapezoidal commutation generally leads to higher iron losses at high speed however.

A significant difference is however seen in the torque achievable with the same peak current. A sine-wave back-EMF motor has only 86.6% of the torque of the comparable trapezoidal back-EMF motor.

$$M_{Trapezoidal} = Km \times I \qquad M_{Sine} = 0.866\ Km \times I$$

where I is peak current and Km is the torque constant (equal to the peak value of back-EMF voltage divided by motor speed in Radians/sec). The value of this constant can easily be established by trial.

Apart from this torque advantage the trapezoidal back-EMF technique has mainly disadvantages:

A. At high speeds the effective torque constant drops. This is due to the limited current rise rate achievable with falling voltage across the windings (supply less back-EMF) as well as the shorter commutation time itself. Overall these effects lead to a rotation of the current vector and a reduction of the effective current-time product and therefore to a drop in available torque.

B. The adjustment of the hall-effect switches is extremely critical. It is practically impossible to adjust them that all commutation points are free from torque disturbances. Sudden torque changes cannot be fully compensated by even the stiffest of velocity controllers. The use of trapezoidal back-EMF for commutation is therefore not to be recommended for critical applications, e.g. grinding machines.

C. Owing to the temperature sensitivity of hall-effect devices the motor cannot be exposed to extreme environments (although in the meantime special versions for operating temperatures up to 150 deg. C are available). This type of sensor (combined with BL-tachometer) also requires 9 lines instead of the 6 needed for a resolver in the case of sine-wave commutation.

D.

4.2 Choice of Bus Voltage and Currents4.2 Choice of Bus Voltage and Currents

Once the choice of motor and motor winding has been made for the application (see Appendix A) the right choice of driver current rating and bus voltage should be made by the following steps.

First of all the continuous RMS-current demand on the amplifier should be established, making sure this does not exceed the rating given by the motor manufacturer for the type of cooling applicable. In order to establish the RMS current requirement, the worst case operating cycle must be analyzed by braking it into time segments with constant current demand T1,I1 ... Tn,In.

$$I_{RMS} = \sqrt{\frac{I15.T1 + I25.T2 + ... + In5.Tn}{T1 + T2 + ... + Tn}}$$

This current must not exceed the nominal rating of the TWR amplifier. I1 to In must not exceed the peak rating of the TWR amplifier (about 2 x nominal). The peak current may be demanded in such cycles typically up to 2 secs at any one time. Currents can be directly related to torque by the torque constant (Km in Nm/Amp, as in the case of standard DC motors). In the case of the TWR56 amplifiers the RMS rating of the motor may be exceeded by making use of the 2 stage RMS limiting facility.
The next step is to establish the bus voltage. This must be large enough to overcome the back-EMF, the resistive and inductive voltage drop across the motor and its cabling and the voltage drop over the amplifier stage itself. These components can be calculated as follows:

Back-EMF	=	Motor constant x Max. speed (V/Rad/sec x Rad/sec)
Voltage drop	=	Peak current x (armature and cable resistive resistance)
Voltage drop inductive	=	2 x 3.142 x commutation frequency x armature inductance (This reactance is at 90 degrees to resistive component)
6V	=	Voltage drop to be allowed for across amplifier switches

This voltage must be available at the bus under the worst loading and supply conditions.

4.3 Minimum Motor Inductance4.3 Minimum Motor Inductance

The current control loops of the TWR amplifiers have been optimized in order to operate satisfactorily even with motors with low inductance. Problems need only be expected with an extreme mismatch of motor and drive ratings; in particular when the motor rating considerably exceeds that of the drive. The TWR drives use "parallel" modulation techniques which effectively double the switching frequency seen by the motor and filter inductances. This improves the form factor considerably and further avoids unnecessary switching noise from the inductances while only low stationary torque is being demanded.

The following minimum inductance values are recommended for the TWR family at 200V bus voltage, in order to achieve the specified form factor of 1.01 at 50% motor max. speed. Inductance values up to factor 10 less may generally be used without trouble. The thermal losses will however be higher.

Cont. current rating (Amps)	2,5	5	7	10	20	30	40
Minimum inductance (mH)	4	2	1	0.5	0.3	0.2	0.1

4.4 It Considerations4.4 It Considerations

Compared to fast conventional DC-servomotors BL-servomotors have considerably higher thermal time constants. This is due to the higher mass and lower thermal resistance to the environment of the armature (which is now in the stator and not the rotor). This characteristic can be exploited to improve the dynamic performance of the system (lower inertia of smaller motor).

The TWR34 and 12 drives only have a single stage It-overload protection characteristic. If the full peak current is demanded for 2.5 secs., the current command is limited to half this value. If more than nominal current but less than peak current is demanded the period until current limiting is correspondingly longer. After a 3.5 ... 5 seconds period of It-limiting the units are switched off (Electronic Armature Fuse). If the current command is reduced below nominal before the end of the period, the It-protection circuitry recovers with an intrinsic time-constant.

The TWR06 is not It-protected as the driver is able to provide peak current continuously.

4.5 Power Supply Selection4.5 Power Supply Selection

A guide has already been given in establishing nominal drive bus voltage and current ratings. In selecting power supply components the required current in all axes to be supplied must be summed under consideration of the simultaneous power requirement. In making this calculation account may be taken of the fact that nominal current is only required from the bus at maximum output voltage - in this regard the drives may be considered as switching regulators with an efficiency of 80 to 85%. The typical steps in establishing current demand are:

A. define highest mechanical load condition for each drive that is to be supplied. This includes acceleration and continuous duty torque at the highest speed these torques are to be demanded at. The power needed can then be calculated using the following approximate relationship:

$$\text{Watts} = (\text{Torque in Nm}) \times (\text{speed in units of 10rpm})$$

Alternatively the product of RMS armature current and back-EMF voltage at this speed can be taken.

B. define the worst condition of simultaneous power demand of all drives and sum the power requirements. Alternatively a factor for simultaneous power demand can be estimated:

$$\text{Total Power demand} = \text{Sum of worst case power demands} \times \text{simultaneous demand factor}$$

C. the power supply should then be dimensioned for a current:

$$I_p = \frac{\text{Power demand (watts)}}{0.8 \times \text{bus voltage}} \text{ Amps}$$

D. the current and power rating of the regeneration protection circuit should be checked:

The TWN power supply units are all fitted with regeneration (braking energy dump circuits). In dynamic systems, particularly those with high inertia loads it is important to check that the regeneration rating is adequate. Even a small amount of excess braking energy can lead to an overvoltage condition, which will cause the drives to switch-off in self-protection and load control to be lost. The regeneration current can be established in a similar way to normal current demand. However in this case frictional load and the additional power demand of other drives subtracts from the regeneration current to be absorbed. Again it is necessary to establish the worst-case condition.

$$I_r = \frac{0.85 \times \text{RMS armature voltage} \times \text{current}}{\text{bus voltage}} \text{ Amps}$$

(ignoring the effect of friction and other bus loads).

In order to check the actual power rating of the regeneration resistor the frequency of braking sequences must also be allowed for. In establishing power, the quickest method is to establish the mechanical energy to be destroyed and to relate this to time:

$$\text{Regeneration energy} = \frac{\text{Inertia} \times 2 \times (3.142)5 \times N5}{\text{Time} \times 3600}$$

$$\text{Resistor rating} = \frac{\text{Sum of regeneration energies}}{\text{Cycle time}}$$

Inertia in Kg.m² , N in rpm, time in secs

Once the power supply current rating has been established (bus voltage is already been known) the necessary transformer rating can be estimated. Transformers have the advantage that they can be overloaded by a considerable factor for a short period of time but they must be dimensioned that no thermal overload occurs. As the typical demand characteristic of a servo-system is one of short-term peak and low continuous demand, considerable size and cost savings are often possible in choosing the transformer. The recommended rating is 1.5 times the bus voltage times the continuous bus current requirement (which is usually considerably less than sum of drive current ratings).

5 Installation5 Installation

5.1 Mounting and Cooling5.1 Mounting and Cooling

The following general points should be considered before installing TWR units:

- At altitudes above 1500 meters the cooling conditions degrade considerably; it may be necessary to derate accordingly.
- As cooling air must be able to connect through the units freely, the environment must be kept free from corrosive chemical vapors, oil, steam, metal particles and dust. If necessary an air filter should be employed.
- TWR units should be handled with care to avoid damaging components, in particular the potentiometers on the top control card.
- n cabinet assemblies it should be especially ensured that ambient temperatures do not rise above 45 deg.C. If necessary forced air exchange must be allowed for. In blower cooling several TWR racks above each other, try to avoid passing hot air from one rack to the blower inlet of the next.
- Regeneration resistors (on or off card) should be mounted away from heat-sensitive equipment, preferably in a direct stream of cooling air.

5.2 Fusing5.2 Fusing

All amplifiers have internal fuses protecting their power and auxiliary converter stages. In the case of any severe fault there is no risk of subsequent damage occurring elsewhere in the system.

Under normal conditions there is no risk of these fuses failing. In case they have to be replaced for any reason however, the ratings are as follows. Because of the in-rush currents on switch-on a slow-blow characteristic is necessary:

Amplifier Type	***Power fuse***	***Auxiliary fuse***
34/200-22 /48-22	30 Amp	4 Amp
200-15 /48-15	20 Amp	4 Amp
200-10	15 Amp	4 Amp
200- 5	10 Amp	4 Amp
12/200- 5 /48- 7	10 Amp	2 Amp
200- 2 /48- 3	5 Amp	2 Amp

The 3-phase supply to the power supply card should also be fused, a rating being chosen to correspond to approximately 50% more than the worst case continuous current demand. External regeneration resistors can also be protected by a fuse (but not by a trip-out) with a current rating about 20% under the expected regeneration current level.

It is strongly recommended that TWR-units are switched in the primary circuit of the power transformer. Direct switching of DC-supply voltages in excess of 100V may cause excessive in-rush currents to the amplifier on turn-on and inductive voltage transients on turn-off. A series surge resistor in the power rail and additional capacitance across the amplifier bus supply may be used to compensate these problems.

5.3 Cabling5.3 Cabling

The motor armature (stator) cables carry switched modulated signals, which may produce some interference. To reduce this problem the motor leads should either be twisted or run in 3-core screened cable. Open loops should be avoided as they can generate large magnetic fields. Should external chokes be necessary (e.g. for very low inductance motors) to further reduce current ripple, these should be mounted as near as possible to the backplane connections. Chokes may also be needed for high voltage systems to reduce rate of voltage rise and possible disturbance to encoder and other signals (These are integrally included in TWR34, Rev. D drives). The value of inductance in all motor phases should be in the range of 10 - 20 :H; the chokes should be chosen with a saturation level in excess of phase peak current (plus 25% overshoot in the current-loop).

The wire cross-section of motor cables depends on the rated continuous current of the TWR driver. The following table shows the relevant data conforming to VDE0100 standards. Crimped and insulated cable connectors suitable for M6 stud mounting should be used to avoid the risk of short circuits.

Recommended motor cable sizes:

Driver Type	***mm5***	***AWG***
48-3, 48-7, 48-15,)	1,0	18
100-2, 200-2, 200-5,)		
200-10, 200-15, 200-22	1.5	16

All 3-phase supply lines to TWN34/12 card should have 1.5-2.5 mm5 cross-section.

Signal cables should have a minimum cross-section of 0.33 mm5 (22 AWG) for connection to the terminal strips on the TWR backplane. Signal cables should not be placed in the same cable duct as the power or motor armature cables in order to avoid undesirable cross-talk. Large loops should be avoided to prevent unnecessary inductive interference.

The tachometer feedback signal, the sector encoder (hall-effect), incremental encoder or resolver signals as well as analog control signals should be screened where possible. The screen of control lines should be connected with OV at the control. Resolver and feedback cable screens should be grounded at the amplifier.

It is very important to avoid creating earth loops when wiring up a system as these can cause instability or cross-talk between axes. Earth loops occur when any power stage current can cause voltage drops within the control or feedback signals. Often voltage drops of a few mV's are sufficient to cause total instability. In order to avoid earth loops it is recommended that a single earth connection is defined for all drives and controls in the system and that their potentials are referenced directly to this point, the drives and each control having individual connections to the earthing point. Often the 0V stud of the power supply connectors is used for this purpose. The frame should also be connected to this point as well as the mains earth wire to meet the standard safety regulations.

The installation wiring recommended for the TWR servo-amplifier is illustrated in Appendix C. This connection diagram shows the earthing point to be at the main control in this case but it has nevertheless taken account of the earth loop problem. It should further be noted that the motor frame is earthed in this diagram. It is also important that the motor housing has a defined and low resistance earthing connection to ground. If necessary an earth line should be put in parallel with the motor phase connections. This is an essential measure if the driver is to be used with an incremental positioning system as the switching voltages of the driver will otherwise be capacitively coupled into the positioning measuring channels. Earthing of the motor also reduces cross-coupling to the motor tachometer.

It is strongly recommended that 3-phase isolation transformers with primary fusing are used to supply power to TWR systems to ensure conformance with standard safety regulations (VDE) and to protect the output stage transistors from any mains transients.

USE

6 Commissioning6 Commissioning

6.1 Standard Procedure (OPTION 01 - RLG)6.1 Standard Procedure (OPTION 01 - RLG)

The following description assumes that the standard component settings of the amplifier can be kept as supplied. Under this assumption only a voltmeter is needed to check set-up values.

All amplifiers are carefully tested before dispatch. Mechanical damage in transit can however never be excluded, so care is advised in the first steps of commissioning.

Step 1: check secondary voltage of transformer supply
The power supply card should be pulled for this test. The maximum no load value (AC voltage, phase to phase) should not exceed:

Nominal bus (DC)	***Phase to Phase (AC/RMS)***	
	Maximum	Nominal
240V	190V	170V
200V	158V	142V
100V	79V	71V
48V	38V	34V

Step 2: check bus voltage
After turning off the main supply, plug in the power supply card and switch on with the amplifiers removed. The voltage of the DC-rail should not exceed the values:

Nominal bus (DC)	***Maximum value (*DC)**
240V	260V
200V	220V
100V	110V
48V	55V

The regeneration circuit should not operate under these conditions. I.e. the regeneration resistor should stay cold and the red LED on the power card should not light up.

Step 3: check individual drivers
First of all the connections to the control connector (P2) and the feedback connector (P1 or P4) should be doubly checked - in particular the jumper between pins 21 and 22 and the enable input to pin 15 (usually negative going, pin 12 also in the case of TWR34-D) - see Appendix C. A potentiometer can be set up between + and -15V to generate an analog control signal to **Ana In** (Pin 16) with **Ana Gnd** (pin 18) to **0V** (Pin 1) - see also TWR Test Box.

CHANGING THE POSITION OF JUMPER SB102 REVERSES THE POLARITY OF THE ENABLE SIGNAL TO THE TWR SERVODRIVES. IN THE STANDARD FACTORY CONFIGURATION PIN 15 MUST GO TO GROUND (OR BE LEFT OPEN) TO ENABLE. IF AN OPTION CARD IS USED, THE LIMIT SWITCH INPUTS MUST BE DRIVEN POSITIVE FOR THE DRIVER TO GENERATE TORQUE:

The user accessible potentiometers of the TWR driver are illustrated in Appendix C. Before switching on the driver these potentiometers should be pre-adjusted to avoid damage in case the unit is not wired up correctly. The functions and positions are from top to bottom:

- Peak current (RP6) nearly fully CCW for low current
- AC-gain (RP5) fully CCW for low gain
- Tach gain (RP3) middle position

- Offset (RP4)	factory position
- Command Input (RP1)	middle position

After plugging in the TWR servo-drive with these potentiometer settings, power should be reapplied and the green LED on the front end of the control card should light up; the motor should not yet move. On enabling the unit, a just audible switching tone should be heard. If a control voltage has already been applied to either of the command inputs, the motor should move accordingly within the limits of the available torque.

If the motor runs away and cannot be controlled by the command voltage then switch off and check motor, tachometer and hall-effect wiring. If the motor moves very erratically it is again necessary to check the wiring. If a red lamp lights up, either the supply voltage is too high, too low or one of the output phases is shorted to ground (fault condition decoded and indicated on test box). In the case of any other fault please consult the factory.

If problems occur at this stage, the 1:1(-) input can be operated (switch available on test box). This automatically converts the drive to current control, the tach feedback signal also being interrupted. In this way it is possible to check the motor and hall-effect phasing without any confusion from possible tach wiring faults. For the remaining tests 1:1 control should not be active.

Step 4: check peak current

having established that the motor runs and that the feedback polarity is correct (in case of encoder and resolver feedback refer to following sections) the peak current potentiometer can be turned up to its maximum value or to an angle proportional to the peak current required.

Step 5: check speed range

apply the highest velocity command voltage to be expected and set up input potentiometer (for **Ana In** or **Ana In 2** commands) for required maximum speed. If necessary the tach gain potentiometer must be turned CCW if the speed cannot otherwise be reached.

Step 6: setting up dynamic response

the dynamic response can only be optimized with the assistance of a storage oscilloscope or plotter. The standard procedure is first to monitor **Idc** while generating a square-wave input command (automatically generated by the TWR Test Box). By turning the AC gain potentiometer an optimum current response without extreme overshoot or extended oscillation can be achieved. If a peak current is needed, which is less than the specified limit of the unit, this can be set up by monitoring phase current directly with an ampere-meter or the Idc signal while adjusting the peak current potentiometer. Idc is a voltage output, which is normalized such that 9.65V is equivalent to peak current or 2.8 times RMS-nominal rating for TWR34/12 systems and 1.4 times RMS-nominal rating for TWR06 systems. When using options with limit switches the normalization of **Idc** drops from 9.65 to 9.25V.

6.2 Setting up OPTION 02 - 2RN6.2 Setting up OPTION 02 - 2RN

Commissioning procedure is similar as for Option 01 with the additional steps:

Setting up pole count and encoder resolution etc. (before Step 3)

This is done using the first three DIP switches of the 5 pole bank. With the standard PROM (IC12 15579) the settings are:

Pole pairs	***S1/1***	***S1/2***	***S1/3***
1	OFF	OFF	OFF
2	ON	OFF	OFF
3	OFF	ON	OFF
4	ON	ON	OFF
5	OFF	OFF	ON
66	ON	OFF	ON

7	OFF	ON	ON
8	ON	ON	ON

Encoder resolution is set with the upper two switches of the bank (IC13 15996):

Resolution	***S1/4***	***S1/5***
1024	OFF	OFF
1000	ON	OFF
900	OFF	ON
500	ON	ON

Other combinations are available on request (PROM exchange IC13 necessary)

Maximum speed should be set up via R38. 221K is the standard value for operation up to 4,000 rpm. 150K corresponds to a maximum speed of 6.000 rpm. The available voltage on TP 7 at max. speed is 10 V.

Velocity dependent phase advance can influenced by changing the value of R65 (next to RP1) or adjusting RP1.

NOTE: When retrofitting this option ensure that resistor arrays RA3,4 and RA 17 are removed on the base control card.

Resolver alignment (before Step 4)

The optimum resolver position is best set up by initially using 1:1 current control. There should be as many stable alignments of resolver to motor within one revolution as the number of motor poles. At the boundaries of these alignments hardly any torque will be produced. If it is not possible to get the motor to turn although it may have holding torque there is probably a phasing fault and the wiring should be checked (one of the three resolver circuits must be reversed in phase).

On activating tach control (1:1 turned off), with the resolver and motor aligned so as to produce controllable torque in the 1:1 mode, either the motor will run away or speed can be controlled. In the first case it is only necessary to realign the resolver to either of the adjacent alignment regions. The correct alignment is finally the mid-position between the limits of stable operation for the chosen alignment region.

If in doubt consult the factory to make sure that the resolver type chosen is compatible with this option (normal transmission ratio should be about 50%).

6.3 Setting up OPTION 3 - TWR/ENC and 5 TWR/TAC6.3 Setting up OPTION 3 - TWR/ENC and 5 TWR/TAC

The commissioning procedure is similar to 7.1 with the additional steps:

Setting up number of encoder counts to an electrical cycle of motor (before Step 3)
This relationship should be defined on ordering as certain ratios can only be realized by selecting the correct EPROM for IC21 and counter type (binary or decimal) for IC7. The corresponding jumper position of BR6 and of BR7 is set at factory. Depending on the motor and encoder type the following configurations are possible:

Encoder counts\motor pole	***4***	***8***	***12***	***16***
500	X	X	(X)	(X)
1000	X	X	X	(X)
1500	-	-	X	-
2000	X	X	X	X
2500	X	X	X	X
3000	-	-	X	-

4000	X	X	X	X
5000	X	X	X	X

X : possible
(X): possible, but pure sine
- : not possible

Other configurations possible. Please contact factory.

Binary encoders are also supported. With binary resolutions phase advance is not possible. Please contact factory.

BR2,3 and 10 are set accordingly depending on whether an encoder or a tacoder is being used. The encoder signals generated from a tacoder correspond to half the stated tacoder resolution; they are only valid up to a maximum frequency of 25 kHz.
When using an encoder BR8 (module fault) must be left open !

The initial steps of commissioning should all be made with BR5 closed as this enables sine-wave commutation to be suppressed until the encoder/tacoder has been correctly aligned. Using BR5 it should be immediately possible to drive the motor in the 1:1 mode (using test box). It should be checked that the phase current offsets are still correctly adjusted as the addition of this option may shift current control levels slightly.

While running the motor or turning it by hand check that the encoder pulses are being generated for the host control (test box). If necessary the effective polarity can be changed using BR1. The polarity of the tachometer signal generated from the tacoder pulses may now be checked. If this is incorrect turn both BR9 jumpers by 90 degrees and reinsert. Correct or incorrect polarity can be very quickly verified by switching off 1:1 control while commanding motion from the drive. If the motor accelerates instead of allowing velocity control from the command signal the BR9 jumpers must be changed.

Encoder reference alignment (before Step 4)

Assuming that the ratio of encoder counts to electrical cycles has been set up correctly it is only necessary to establish that the counter counts with the correct polarity (can be changed by BR4) and that the sine-wave commutation is aligned with the hall-effect pattern. Both of these factors can be best established by using a storage oscilloscope to compare the command current patterns on TP1 and TP3 as well as TP2 and TP4. By changing the position of BR4 and the alignment of the encoder reference pulse it is possible to get the sine-wave current pattern to overlap the hall-effect pattern in phase and polarity (if the counter chain is set up wrongly, this will be seen immediately by this method). When this alignment has been established, BR5 can be removed and the motor should run smoothly with sine-wave current control.

Phase advance

By high speed applications and high inductance motors with low supply voltages it can be of advantage to activate the phase advance facility. This facility makes better use of the high speed torque capabilities of the motor by compensating phase losses of the system according to motor speed. This is done by turning R22 clockwise in the ratio of the phase advance required. Establishing the correct positron requires some extensive measurements but a first approximation can be achieved by trying to get the lowest possible Idc signal for the high speed load point to be optimized. Please note, that phase advance is not available with binary encoder !

Tacoder Monitor

Using a tacoder BR2 and BR3 are set in position 2-3 for BR2 and 1-2 for BR3. It is possible to set BR8 for error indication (module fault).
A highly stable, linear and wide-bandwidth tachometer signal is derived from the Tacoder signals. The normalization of this tach signal is 2.2V/1000rpm (for a tacoder with 1000 pulses/rev). A Tacoder with 500 pulses/rev. produces a tach signal with an amplitude of 1.1V/1000rpm.
The offset of the tach signal is adjustable with R50.

6.4 Setting up OPTION 4 TWR/ENT6.4 Setting up OPTION 4 TWR/ENT

This option can be commissioned by the same procedure as for Option 01. However it may be necessary to reverse the tach polarity by turning the alignment of the two encoder polarity jumpers by 90 degrees (LO1/2).

In setting up the maximum velocity in step 5 it may be necessary to renormalize the sensitivity of the frequency to voltage converter using BR 4 - 7.

To reduce standstill jitter of motors controlled by this option we recommend that R93 on personality module J2 is increased from 330R to 3.3Kohms whenever the reduction in proportional gain can be accommodated.

6.5 Setting up OPTION 6 - TWR/APO6.5 Setting up OPTION 6 - TWR/APO

The potentiometers RP1 and RP2 are initially set to their outer limits as these act as electronic limit switches. The option also supports limit switches. Both these types of limits reduce the torque command to zero and thus cause the motor not to generate and torque.

Special Connections at Backplane

Signal	***Connector Designation***	
+ 10 V Output	P5	5
- 10 V Output	P5	3
Analog Position Feedback	P5	8
Position Command 'high end'	P2	17
Position Command 'low end'	P2	18

The setting-up of the option is limited to the following steps:

- Set up frequency response of electronic tachometer circuit via C4
- Set up frequency response of the position amplifier using R23 and C10
- Scale the velocity command signal as required using RP4
- Set up tach gain, AC-gain and current limit to suit the application. NB when the option is mounted on a TWR RP1 on the base control card is no longer effective. All other potentiometers have their standard function.

6.6 Setting up OPTION 7 - TWR/IND + IND/PA6.6 Setting up OPTION 7 - TWR/IND + IND/PA

Commissioning procedure is similar to 7.2 with the additional steps:

Initial Set-up of Pole Count and Encoder Resolution

With this option it is not possible to set up the number of motor poles by a DIL-switch (compare option 02). The adaptation of a high resolution INDUCTOSYN to the electrical cycle of the motor is implemented by means of special divider PROM. As this PROM has to programmed in the factory it is necessary to define the Motor/Sensor combination on ordering. As there is a multitude of applications no list of the possible combinations can be given here. It is necessary to enquire if the intended combination is possible. The jumper and switch positions are then defined along with the PROM.

Changes to the Encoder Resolution.

The encoder simulation circuit operates with a maximum resolution of 16 bit, being equivalent to 65536 increments per electrical cycle. With a 100 pole INDUCTOSYN the maximum achievable resolution is thus 3,276,800 increments or 819,200 pulses per revolution.

Resolution	***BR1***	***BR2***
16 bit	BR1/1	BR2/1
14 bit	BR1/2	BR2/2
12 bit	BR1/3	BR2/3
10 bit	BR1/4	BR2/4

The maximum achievable product of velocity and resolution is governed by the tracking rate of the resolver/digital converter. A 100 pole INDUCTOSYN combined with a 12 pole motor can achieve the following speeds, depending on converter resolution:

Resolution	***max. Speed***
16 bit	11.25 Rpm
14 bit	45.00 Rpm
12 bit	180 Rpm
10 bit	not possible

Wiring and Commissioning of a TWR/INDUCTOSYN System:

The high resolution and extreme precision of an INDUCTOSYN sensor is only achieved at the price of an extremely low transmission ratio across the sensor; output signals with a few :V have to be processed. For this reason a pre-amp is used between the INDUCTOSYN and the TWR as close to the sensor as possible (Option TWR-IND-PA). This pre-amp amplifiers increases the output signals to a level of about $2V_{RMS}$ (voltage depends on rotor position). Because of the high level of amplification it is important to maintain a symmetrical and well screened system with no earth-loops. All signal pairs should be individually screened and the screen earthed just at one end.

The system is commissioned in the following sequence:

Check all adjustments according to documentation supplied with the option.

The TWR should be fitted into the 19" Rack using a TWR34/EC or TWR12/EC extender card, The TWR/TB should be connected to P2.

The test box should be set to 1:1 current loop operation - command to `internal' - enable to `off'
- command (amplitude) to about zero - waveform to DC.

Turn on supply. The test box should indicate no fault - the auxiliary supply LEDs 5V/+15V/-15V should light up.

By rotating the motor shaft by hand the presence of encoder pulses can be checked.

The amplitude of the signals received from the INDUCTOSYN pre-amp can be checked with an oscilloscope at the option test points TP1 (sine) and TP 2 (cosine). Maximum amplitudes of $2V_{RMS}$ ($2.7\ V_{peak}$) should be measured - this voltage depends on the position of the shaft. If the peak voltage not reach peak, the channel amplification in the INDUCTOSYN pre-amp can be adjusted by the multi-turn pots RP01 (sine) and RP011 (cosine).

`Enable' THE motor, it should begin to turn. As soon as the option has synchronized the green LED (LED1 on the option card) should illuminate - the sine-wave phase currents are automatically triggered by the first signal edge from the Hall-effect (SYN-V). If the LED does not light up, check the wiring - motor or INDUCTOSYN phases should be reversed (sine and cosine) - switch the oscilloscope to X-Y operation an observe TP1 and TP2 on the option card (Lissaju!). Let the motor turn slowly - if the phasing is correct just **one** vector can be seen, that rotates around the center of the screen. If the phasing is incorrect **two** vectors can be observed. Both these vectors should be brought into alignment by adjusting the Cermet pots C5/C15 on the pre-amp. This fine adjustment is mostly necessary with long cables or asymmetrical wiring.

Speed control can now be activated (`1:1'off).

The high loop gain of the overall system may cause the velocity amplifier to oscillate. In this case the PI compensation may have to be modified (personality module J2).

6.7 Setting up OPTION 8 - TWR/ENC-PV146.7 Setting up OPTION 8 - TWR/ENC-PV14

The meaning and function of the jumpers and switches on this card are as follows. These must be set up according to the application. In addition PALs are used on this option which have to be programmed at the factory according to the number of motor poles and the resolution of the encoder employed.

Jumpers

BR401 **closed**: synchronization of the sine-wave commutation occurs at the first reference pulse
BR401 open: the first Hall-effect edge is used for synchronization.
BR402 closed: loss of encoder pulses cause the module to generate a fault and to disable the drive
BR402 **open:** loss of encoder pulses causes the module to revert automatically to Hall-effect commutation.
BR601 1-2 closed: operation with brushless tach velocity control
BR601 2-3 closed: operation with brush tach velocity control
BR 701 **1-2/3-4**: encoder A pulse precedes B when motor rotates clockwise
BR 701 1-3/2-4: encoder B pulse precedes A when motor rotates clockwise
BR 702 **1-2/3-4**: Z-pulse is active high
BR 702 1-3/2-4: Z-pulse is active low

SW 301 1-3 choice of max. resolution

SW301/3	***SW301/2***	***SW301/2***	***Resolution***
OFF	OFF	OFF	14 Bit
OFF	OFF	ON	13 Bit
OFF	ON	OFF	12 Bit
OFF	ON	ON	11 Bit
ON	OFF	OFF	10 Bit
ON	OFF	ON	9 Bit

SW 301/4 manual selection of sine-wave/hex commutation

SW301/4 **open**: hex commutation
SW301/4 closed: sine-wave commutation

SW 301/5 suppression of sine-wave commutation

SW301/5 **open**: no suppression
SW301/4 closed: sine-wave commutation is suppressed

SW 101 -103 electronic reference pulse shifter

SW103: MSB, shifting in large steps
SW102: shifting in small steps
SW101: shifting in very fine steps
Note that only values between 000 and EA5 Hex may be set.

During the initial stage of commissioning, jumpers etc. are set to the according to the configuration in bold lettering above. SW301 is set up in the factory according to the encoder resolution and SW101-103 are initially set to 000.

Commissioning proceeds in the normal way with the drive in 1:1 gain mode. The specific steps required to set up the -PV14 option are as follows:

- with the TWR disabled the axis can be rotated by hand to check that the encoder reference pulse is being detected (LED on Test Box)
- the TWR is enabled and a torque command is given to get the motor to rotate (in hex-commutation)
- a dual-beam oscilloscope can be used to observe the phase currents at the test-points TP501 (SIN-U) and TP505 (HEX-U)
- by changing the value of the reference pulse shift counter (SW101-103) the sine-wave (SIN-U) should be shifted until no discontinuities in the wave-form are visible
- HEX-U should now be in phase with SIN-U
- TP 503 (SIN-V) should now be compared with TP506 (HEX-V), these should also be in phase. If not (180E difference) the encoder counter polarity must be reversed (BR701) and SIN-U readjusted
- fine synchronization is now possible by observing TP Z-ADJ. The oscilloscope should be triggered by the falling edge of this signal. This signal is low for about 60E of the motor's electrical cycle. If the reference shifter is set up correctly, the Z-pulse should appear in the middle of the low period of this signal. If necessary adjust with SW101-103. The adjustment should be checked for both directions of rotation and a middle setting established if necessary
- the drive can now be operated in sine-wave commutation by switching SW301/4 to ON

6.8 Setting up OPTION 9 - TWR/ASK6.8 Setting up OPTION 9 - TWR/ASK

Set up procedure and detailed documentation is available on request

6.9 Setting up OPTION 10 - TWR/GAL6.9 Setting up OPTION 10 - TWR/GAL

A special suffix to this manual on the TWR/GAL option is available on request (see also GALIL DMC100 manual)

6.10 Setting up OPTION 12 - 2RN-P166.10 Setting up OPTION 12 - 2RN-P16

The following set-up components and switches are available:

Tachometer Scaling

This is set up with R38 on the option card - next to P8 - (it can further be influenced by a resistor on the personality module J2 of the base card). A 10 V Tach signal will normally be produced at the following speeds:

10V Tach signal at	***Value of R38***
6000 RpM = 100 Rps	0 Ohms (standard setting)
4000 RpM = 67 Rps	4.99 Kohms
2000 RpM = 33 Rps	20 Kohms

Tachometer Gain

Tachometer gain can be finely tuned with RP2 (+/- 20%). The gain is set to 1% in the factory. The Tachometer symmetry and R/D converter offset potentiometers do not have be readjusted by the user.

Phase Advance

This is adjusted via:

- potentiometer RP1 (50 Kohm) on the resolver card
- R65 on the resolver card (next to RP1).

The standard value of phase advance is in the range of 350 to 520:s

Number of Poles

This is set up as on other the other TWR-resolver options via S1/1, /2 and /3 (see Option 02). These switches can also be fitted to the personality module instead of the resolver card.

Encoder Resolution

S1/4 and /5 have no function on this particular resolver option. Resolution in modified by complete exchange of IC13 (Type 27C512). Resolutions up to 4 x 16383 are available but the higher resolutions are only achievable by limiting maximum speed. The available resolutions before quadrature are:

360, 400, 500, 512, 900, 1000 (standard), 1024 (max. speed 6000 Rpm)

1250, 2000, 2048, 2500, 3600, 4000, 4096 (max. speed 3510 Rpm)

5000, 8192, 10000, 10800, 16384 (max. speed 877 Rpm)

The position control counter must be able to accommodate encoder frequencies of up to 140 Khz. The index-pulse is only a quarter encoder (one count) step wide.

The steps of commissioning correspond to the description for the standard resolver option 2. When retrofitting this option ensure that resistor arrays RA3, 4 and 17 are removed on the base control card.

6.11 Setting up OPTION 13 - TWR/IMAS6.11 Setting up OPTION 13 - TWR/IMAS

Set up procedure and detailed documentation is available on request

6.12 Potentiometers6.12 Potentiometers

Attached you can find a list of all accessible potentiometer of the drives. The location of the potentiometer is given in Appendix C:

RP1 - Input gain
velocity or current input scaling
fully cw = unity gain

RP4 - Velocity offset adjust
zero speed adjust for zero command

RP3 - has to be adjusted to reference speed or stability
fully cw = 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 possible 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 fully ccw.

RP6 - peak current adjust
sets peak current level which can be measured on TP5
fully cw = max. current

RP11 - It current limit adjust
sets current limit level
fully cw = It limit is equal to the nominal current

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

6.13 Test Points6.13 Test Points

To allow effective set up of the amplifier and its control loop several test points are accessible on the front side. The location of the test-point on TWR drive see Appendix. 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 (only for test purposes)

TP1 - Actual rms current phase u
Ipeak = 10.0 V

TP2 - Actual rms current phase v
Ipeak = 10.0 V

TP3 - Actual rms current phase w
Ipeak = 10.0 V

TP5 - IDC. This is the output of the velocity control loop (9.25 V = peak current of the amplifier

The voltage level is proportional to rms output current. TP5 is the major test-point 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.
The signal waveform is DC with 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 heat dissipation in the motor (see potentiometer RP5)

Note: On TWR 12 and 34, TP5 shows the current command after It limiting !

TP6 - Velocity command signal (or current command when 1:1 input on P2/13 taken low) shows input signal after attenuator RP1

TP7 - Actual velocity. This signal depends on the installed option. Note: To avoid saturation, the voltage level at TP7 should not exceed +/- 10 Volt.

6.14 Establishing Variable Components6.14 Establishing Variable Components

After setting up the drives, it is sometimes necessary to optimize the control or current loop for best performance. All components to optimize the frequency response of the velocity and current loop are located on personality modules. The location on the control board see Appendix. For most applications the standard values will give good performance.

For the velocity loop the following components are variable:

R103 scaling of the command signal (avoids setting of RP1)
R101 scaling of the feedback signal (avoids setting of RP3)

R94 proportional gain of the velocity loop
C19 integral gain of the velocity loop
R93 static gain
C51 high bandwidth limitation

For the current loop the following components are variable:
R43/44 proportional gain of the current loop
C11/17 integral gain of the current loop
6.15 TWR34/12/06 Personality Modules**6.15 TWR34/12/06 Personality Modules**

The personality module for the velocity loop (J2):
1 - 18 : R101 standard value 22k1 1%
2 - 17 : R 94 standard value 332k 1%
3 - 16 : C 19 standard value 47nF 10%
4 - 15 : R instead of RP5
5 - 14 : R instead of RP5
6 - 13 : R 93 standard value 332R 1%
7 - 12 : R103 standard value 22k1 1%
8 - 11 : R instead of RP6
9 - 10 : R instead of RP6

The personality module for the current loop (J3):
1 - 14 : C 17 standard value 4nF
2 - 13 : R 43 standard value 150k 1%
3 - 12 : not used
4 - 11 : not used
5 - 10 : R 44 standard value 150k 1%
6 - 9 : C 11 standard value 4nF
7 - 8 : R 222 instead of RP11

SERVICE

7 Routine Maintenance7 Routine Maintenance

No specific routine maintenance measures can be recommended except for ensuring that the TWR-units are kept free of dirt and dust. Foreign bodies of this kind are attracted by the high voltage potentials present during operation and may cause short-circuits or limit the circulation of cooling air.

8 Fault Finding8 Fault Finding

8.1 TWR34/12/06 Test Points and Fault Indications8.1 TWR34/12/06 Test Points and Fault Indications

See 6.13 and Appendix

8.2 TWR/TB Test Box and TWR/EC Extender Card8.2 TWR/TB Test Box and TWR/EC Extender Card

The TWR Test Box and Extender Card (TWR34/EC and TWR12/EC) can be of great assistance during commissioning and fault finding. See Appendix

8.3 Current Offset Adjustments8.3 Current Offset Adjustments

The velocity ripple at low and mid speeds can be very dependent on the quality of the phase current offsets. It is strongly recommended that these are optimized on commissioning, particularly after exchanging or adding commutation options. The most practical method is to run the TWR in velocity control (internal or external via a digital position loop) at a constant low speed while observing the Idc current command at its test point. The current measuring offset potentiometers should be adjusted interactively to minimize the limits of current command ripple. Alternatively the tach signal or the following error in the position controller can be monitored.

8.4 TWR34/12/06 Current Controller Adjustment8.4 TWR34/12/06 Current Controller Adjustment

On the TWR34/12/06 units the PWM current loop amplifier characteristics can be influenced by changing fixed components on J3. It is generally sufficient to adjust R43 and 44 to compensate for voltage, current and inductance differences. The recommended value is:

$$R43 = R44 = 0.6 \times \frac{\text{Peak current x T-T Inductance}}{\text{Bus Voltage x Equivalent time constant}} \times 44 \text{ Kohm}$$

in the units Amps, H and Volts. The equivalent time constant is 70 x 10-6 sec..

8.5 It Limit Current Adjustment8.5 It Limit Current Adjustment

The current limitation is a protection against motor overload. Depending on the application the It limit is variable. To adjust the It -limitation it is necessary to calculate the power consumption of the motor. In the most application it is not necessary to adjust the It limit.

8.6 TWR34/12/06 with Standard DC Servos8.6 TWR34/12/06 with Standard DC Servos

The TWR series of drives was developed for the control of 3-phase brushless servomotors. Several modifications are needed in order to operate standard DC-servomotors with commutators:

- the current controller for phase V is disabled by removing R44 and C11 on the personality module J3 - pin 5 and 6 of J3 should be connected together (not essential but recommended)
- commutation configuration is fixed: the Hall-effect sensor input for phase U (SYN-U) must be wired externally to 0V; i.e. Pins 1 and 4 of **P4** or 6 and 9 of **P1** on the backplane must be joined together. The Hall-effect sensor inputs for phase V (SYN-V) and W (SYN-W) automatically go to +15 V because of the internal pull-up resistors
- the DC-motor is connected between Phases U and W of the power stage.

8.7 Fault Finding Procedure8.7 Fault Finding Procedure

Fault	***Possible cause and solution***
* No response (no green LED)	* No bus voltage * No 24V auxiliary supply (24V option) * Motor cable severed * Auxiliary supply fuse blown * Enable and/or Brake control not active
* Power stage switches but no torque generated	* Current control jumper (pins 21,22) on backplane connector P2 not linked * one of four jumpers on P3 (option card connector) missing
* Motor locks or oscillates only in a position	* Wrong motor phase sequence * Resolver wrongly adjusted
* Motor jumps or runs very roughly	* Rotor position sensor or tachometer is badly connected * Current offset badly adjusted
* Motor has torque (possibly with drift) but does not turn	* Command signal missing or command potentiometer turned fully CCW * Limit switch inputs activated * Pole number of commutation PROM does not correspond to motor * Resolver phasing inverted (motor locks in one position)
* Motor runs only at high speed	* Resolver wrongly connected or adjusted * If DC-Tach or ENT option is used, tach polarity is wrong * Tach not connected * 1 to 1 input operated
* Loud "pinging" noises, also at stand-still	* Resolver cable not screened * Motor housing and 0V-bus not grounded
* Audible rumbling	* Control or 0V-bus not earthed * Control lines not screened
* Motor drifts in same direction on being loaded	* Earth loop in command input (not differentially

	connected) * Interference in region of input amplifier e.g. at current input * Command lines not screened * 0V-bus not grounded
* Motor has preferential positions	* phase current offsets need adjustment * Amplifier over-dimensioned for motor used (offset adjustment too coarse)
* Motor runs irregularly, particularly at high speed	* Resolver impedance too low * Resolver converter incorrectly adjusted
* Amplifier turns itself off after braking (with over-voltage condition)	* Regeneration circuit not effective (threshold or blown fuse)
* Motor does not reach speed	* DC bus voltage too low * Readjust Tach or Command pot * Increase current loop gain, R43, R44
* Motor whines also when stationary	* Torsional resonance, reduction by limiting bandwidth (increase C19) * Resolver with insufficient transfer ratio
* Control loop instable (overshoot)	* Control time constant too small (increase C19) * Dynamic gain too low (turn gain pot CW)
* Control loop inadequately stiff	* Control time constant too large (reduce C19), if necessary reduce bandwidth (increase C19 and turn gain pot CW)
* In position loop, motor oscillates +/- 1 increment	* Static gain too high, (increase integration C19)
* Overshoot in position loop	* Too little amplifier gain (turn up AC-gain pot and decrease integration C19 if necessary) * Position controller gain is too high * Phase lag in position measuring system
* Motor runs hot at speed	* Bus voltage too low for commanded speed * Electronic tach signal from resolver or encoder options limiting (> 8V); renormalize system
* Amplifier turns itself off on step command (with overcurrent condition)	* Motor inductance too low * Reduce current loop gain, components on J3 * Reduce peak current if possible

APPENDICES

A. Compatible MotorsA Compatible Motors

A.1 ANORAD ANOLINE LA, LB, LC, LF and LM SeriesA.1 ANORAD ANOLINE LA, LB, LC, LF and LM Series

ANORAD ANOLINE motors use sine-wave back EMF. The commutation information is derived from standard hall effect or sine-hall effect devices.

Phase A	blue
Phase B	black
Phase C	brown
H-E +5 to 24V	red
H-E A	white
H-E B	blue
H-E C	orange
H-E 0V	black

A.2 BALDOR-ASR BSM-SeriesA.2 BALDOR-ASR BSM-Series

For general purpose, high performance applications requiring a conventional, industrial style, housed motor the Baldor BSM motors are strongly recommended. These motors use sine-wave back-EMF and resolver feedback; they therefore offer excellent low speed and high speed performance and are thermally very robust. Motor and feedback connections are:

Phase A	black 1	
Phase B	black 2	
Phase C	black 3	
R1	red	resolver plug - pin1
R3	blue	resolver plug - pin2
S1	green	resolver plug - pin3
S3	yellow	resolver plug - pin4
S2	pink	resolver plug - pin5
S4	grey	resolver plug - pin6
Gnd	screen	resolver plug - PE

A.3 BAUMγLLER DS-SeriesA.3 BAUMγLLER DS-Series

available on request

A.4 ENGEL. BSM-SeriesA.4 ENGEL. BSM-Series

available on request

A.5 HATHAWAY HT-SeriesA.5 HATHAWAY HT-Series

Motor and feedback connections are:

Phase A	red
Phase B	white
Phase C	black
H-E +5 to 24V	blue
H-E A	brown
H-E B	orange
H-E C	yellow
H-E 0V	green

A.6 INLAND MOTOR RBE-SeriesA.6 INLAND MOTOR RBE-Series

The TWR servoamplifiers are especially suited to exploit the high dynamic performance of the INLAND MOTOR RB motors. Because of the many special windings available it is generally necessary to contact MACCON before finalizing the choice of TWR model and bus voltage. The following general power categorization applies:

TWR06 series:	RB00500 - RB01503
TWR12 series:	RB01205 - RB04501
TWR34 series:	RB03002 - RB06202

Motor and feedback connections are:

Phase A	red
Phase B	white
Phase C	black
H-E +5 to 24V	blue
H-E A	brown
H-E B	orange
H-E C	yellow
H-E 0V	green

A.7 ISOFLUX ACOM-SeriesA.7 ISOFLUX ACOM-Series

Motor and feedback connections on request.

A.8 MOORE REED BMR-SeriesA.8 MOORE REED BMR-Series

For general purpose, high performance applications requiring a conventional, industrial style, housed motor the MOORE REED BMR-series of motors is strongly recommended. These motors use sine-wave back-EMF and resolver feedback; they therefore offer excellent low speed and high speed performance and are thermally very robust. Motor and feedback connections availble on request.

A.9 PAPST PAModyn-SeriesA.9 PAPST PAModyn-Series

For continuous stall torques of 0.2 to 1.0Nm the PAPST PAModyn motors with integrated hall-effects and hp HEDS-encoder offer an excellent price/performance ratio. These motors can be driven by the TWR06 and TWR12 amplifiers using the /ENT or the /GAL options. Motor and feedback connections are:

motor phase	motor connector
phase A	pin 1
phase B	pin 2
phase C	pin 3
thermal switch	pin 4
thermal switch	pin 5

sensor signal	sensor connector
H-E +5 to 24V	pin 8
H-E A	pin 1
H-E B	pin 12
H-E C	pin 11
H-E 0V	pin 5
encoder A-pulse	pin 6
encoder B-pulse	pin 9

A.10 PITTMAN Elcom-SeriesA.10 PITTMAN Elcom-Series

For continuous stall torques up to 0.4Nm the PITTMAN Elcom motors with integrated hall-effects and hp HEDS-encoder offer an excellent price/performance ratio. These motors can be driven by the TWR06 and TWR12 amplifiers using the /ENT or the /GAL options. Motor and feedback connections are:

Phase A	brown
Phase B	red
Phase C	orange
H-E +5 to 24V	violett
H-E A	grey
H-E B	blue
H-E C	white
H-E 0V	black

A.11 RAGONOT SB-SeriesA.11 RAGONOT SB-Series

For high-performance applications requiring a conventional, industrial style, housed motor the RAGONOT SB-motors are strongly recommended. These motors use sine-wave back-EMF and resolver feedback; they therefore offer excellent low speed and high speed performance and are thermally very robust. Motor and feedback connections on request.

A.12 SIEMENS 1FT-SeriesA.12 SIEMENS 1FT-Series

Of the major European manufacturers, SIEMENS offers possibly the widest range of motors suited for use with the TWR servoamplifiers. The nominal speed of the motors is only reached however at the full 240V bus voltage. Motor and feedback connections on request.

A.13 SHIN MEIWAA.13 SHIN MEIWA B-Series

Motor and feedback connections on request.

A.14 SEM BMF/BMR-SeriesA.14 SEM BMF/BMR-Series

Motor and feedback connections on request.

A.15 Standard DC-ServomotorsA.15 Standard DC-Servomotors

The TWR 34 and 12 series amplifiers can be configured to operate with standard DC-servomotors of the appropriate voltage and current rating. Only 2/3rds of the output bridge (phases U and V) and only one current regulator are needed. The tachometer and current control personality modules have to be set up in this case as described as follows.

This feature can be of interest when a mixed system of motors should be served by one family of drives to simplify logistics.

B ConnectionsB Connections

B.1 TWR Power and Motor Phase ConnectionsB.1 TWR Power and Motor Phase Connections

The TWN34/12/06 power supply card connections are:

4,6 and 8	+ bus voltage (110-260V or 18-60V)
10,12 and 14	- bus voltage (ground)
16,18	external regeneration resistor
20	not used
22,24	Transformer Phase 1
26,28	Transformer Phase 2
30,32	Transformer Phase 3
Spade connectors	regeneration monitor relay contact

On the TWR34-56/R back plane the connections to the DC bus are made via copper bus bars and M6 screw connections (+ and 0V) - see Appendix C. On the TWR34, 12 and 06 models the DC-bus is wired up with fast-on spade connectors directly into a DIN H15-connector block (delivered as part of backplane option) - see Appendix C:

+ voltage to fast-on connectors pins 4,6 and 8 (1st,2nd,3rd)

0V to fast-on connectors 10,12 and 14 (4,5,6th)

On the TWR34-56/R back plane the connections to the motor phases and motor earth are made via M5 screw terminals:

Phase 1, A or U to U (INLAND RBE color red)
Phase 2, B or V to V (INLAND RBE color white)
Phase 3, C or W to W (INLAND RBE color black)

On the TWR34, 12 and 06 models the connections to the motor phases are made directly to the DIN H15 connector:

Phase 1, A or U to pins 16,18 and 20 (7,8,9th)
Phase 2, B or V to pins 22,24 and 26 (10,11,12th)
Phase 3, C or W to pins 28,30 and 32 (13,14,15th)
Earth can be connected directly to 0V (4,5 and 6th)

On all backplanes a 15-pin sub-D connector (sockets) has been added to allow for a single connection of motor phases, hall-effects and tachometer. The TWR34 backplane must first be linked to the H15-connector outputs for the motor phases to be connected. This connector (P4) has the following pinning:

1 and 9	0V
4	Hall-effect U or A
3	Hall-effect V or B
2	Hall-effect W or C
11	+15V
5	BL-Tach U or A
10	BL-Tach V or B
12	BL-Tach W or C
6 and 13	Motor U or A
7 and 14	Motor V or B
8 and 15	Motor W or C

This connector is only recommended for continuous motor currents of up to 6 amps.

B.2 TWR Tachometer, Resolver and Encoder ConnectionsB.2 TWR Tachometer, Resolver and Encoder Connections

When the joint motor/feedback connector cannot be used or in those cases when a resolver is employed, motor feedback connections should be made by the 9 pin sub-D connector (socket) on the TWR backplane (P1). The pin allocation is as follows:

1	+15V	
2	n.c. (-15V on backplanes TWR34/12/B)	
3	Tach phase W/C	or cosine +
4	Tach phase V/B	or sine +
5	Tach phase U/A	or ref +
6	Gnd (0V)	or screen
7	Hall effect phase W/C	or cosine -
8	Hall effect phase V/B	or sine -
9	Hall effect phase U/A	or ref -

In the case that the motor is equipped with a holding brake, the TWR34-56/R backplane has provision for direct brake operation via a screw terminal block - with TWR34/D only. This connector (P3) is also available on the TWR34 backplane and includes terminals for brake, limit switches from motor/axis as well as a 24V auxiliary supply. The connector has following allocation from top to bottom:

1	24V	(supply input, 24V option)
2	0V	
3	Positive limit switch	(only supported by TWR34/D
4	Negative limit switch	(and TWR options
5	+15V	
6	0V	
7	Brake relay	(only supported by TWR34/D)
8	Brake relay	(only supported by TWR34/D)
9	Control relay	
10	Control relay	
11	n.c.	(reference on Option 10/GAL)
12	+5V	

For encoder and Tacoder options an additional 9 pin sub-D connector (pin) P5 can be retrofitted on the TWR34/12 backplanes.

1	0V	
2	+5V (TWR34/12), can be jumpered +15V (TWR34/12/B)	
3	Encoder A /Tacoder F0	)
4	Encoder A(-)/Tacoder F0(-)	)
5	Encoder B /Tacoder F1	) inputs
6	Encoder B(-)/Tacoder F1(-)	)
7	Encoder/Tacoder Z(-)	)
8	Encoder/Tacoder Z	)
9	-15V (TWR34/12/B)	

B.3 TWR Control ConnectionsB.3 TWR Control Connections

All TWR servoamplifiers are controlled via a 25 pin sub-D connector (P2) with the following pin allocation. The minor differences between TWR56 and TWR34/12/06 are directly indicated:

	TWR34/D	***TWR34/12/06***
1	0V	0V
2	+5V (100mA)	+5V (300mA)
3	A	A
4	A(-)	A(-)
5	B	B
6	B(-)	B(-)
7	Z(-)	Z(-)
8	Z	Z
9	F0	F0
10	F1	F1
11	F2	F2
12	Free Brake(-)	n.a.
13	1:1	1:1(-)
14	Drive Fault(-)	Drive Fault(-) open collector
15	Enable (-)	Enable(-)
16	Ana In 2	Ana In
17	Ana In 1 (not 34/D)	n.a.
18	Ana Gnd	Ana Gnd
19	+15V(100mA)	+15V(100mA)
20	-15V(100mA)	-15V(100mA)
21	Iin	Iin
22	Iout	Iout
23	Neg. fixed vel.	Current monitor
24	Pos. fixed vel.	Tach monitor
25	+24Vin	+24Vin

(-) indicates a logically inverted condition

IN ORDER THAT A TWR AMPLIFIER BECOMES ENABLED IT IS ESSENTIAL THAT PINS 21 AND 22 ARE CONNECTED TOGETHER AND THAT PIN 15 (AND PIN 12 IN CASE OF TWR34/D) IS SHORTED OR DRIVEN TO OV (assuming SB102 to be in standard position).

The nearer meaning of these signals is described as follows:

A, A(-), B, B(-), Z and Z(-) are the simulated incremental encoder outputs generated by the resolver commutation options and the tacoder option.

F0, F1 and F2 are the fault codes generated to help identify the cause of driver shut-down. These lines are in tri-state when no fault occurs. The meaning of this code is:

F2	*F1*	*F0*	
0	0	0	no fault, TWR is operational
0	0	1	overvoltage
0	1	0	undervoltage
0	1	1	overcurent
1	0	0	overtempeature
1	0	1	failure from option
1	1	0	electronic armature fuse
1	1	1	It limit active (TWR34/12)

Free brake(-) releases brake in TWR34-D systems. An interlock circuit ensures that the amplifier cannot operate until this signal has been applied.

1:1 this logic signal causes the input circuit to be switched straight through, eg in systems requiring direct torque control. This function also disables the integrating capacitor which can be important when operating the drive against a fixed load in order to avoid current drift.

Drive fault (-) indicates any of the F0, F1 or F2 conditions. This is an open collector output that must be terminated to a positive voltage (+25V, 20mA max.)

Enable(-) must be switched to 0V or must be left open for the amplifier to operate. Changing the position of SB102 (TWR34/12/06) reverses the polarity of this signal; in this case the input must be driven from a positive voltage for the drive to be enabled.
TWR 34/D has an internal enable logic. Truth table is available on request.

Ana In 1 and 2 are the input velocity signals to the amplifier, differentially connected with the **Ana Gnd** line. **Ana In 2** has a fixed scaling (10V corresponding to max speed). **Ana In** and **Ana In 1** can be scaled by potentiometer or personality module. Unused **Ana In** inputs should be shorted to **Ana Gnd** to avoid common mode interference (TWR56/R BR1)

Iin and **Iout** are the input to the current/torque modulator and output of the velocity amplifier section of the drive respectively. They must be connected for the drive to operate. They are externally accessible in order that external current limiting is possible.

Negative and **Positive Fixed Velocity** are logical inputs for the TWR56 amplifiers which enable the motor to be operated despite limit and enable conditions. The velocity is dictated by a fixed resistor value. Consult factory for further details if needed.

+24V can be used to supply the amplifier's internal auxiliary converter if this low voltage option has been specified.

B.4 Interfacing with Positioning SystemsB.4 Interfacing with Positioning Systems

The configuration of the control connector (P2) on TWR backplanes makes the interfacing to positioning systems very simple. All significant signals can be cabled together:

Positioning system to amplifier
- Velocity command (Ana In)
- Enable
- Brake release

Amplifier to positioning system
- Encoder signals
- Total fault condition

- Fault codes

Supplies

- +/-15V and 5V are made available to the positioning system by the driver so that potentially isolated control circuits (D/A etc) may be driven without the need for additional supplies or DC/DC converters. A clear potential reference at the driver side is thus guaranteed to eliminate earth-loops.

The typical wiring between such systems is illustrated in the following table for the MACSYN system:

Signal	***MACSYN,P3***	***TWR/R,P2***
Digital Ground	1	1
A	3	3
A(-)	4	4
B	5	5
B(-)	6	6
Z(-)	7	7
Z	8	8
Drive Disable	10	15 (BR2 closed)
Velocity Command	11	16
Analog Ground	13	18 (BR1 closed)
Iin/Iout (jumpered)	21 and 22	

C DrawingsC Drawings ***see enclosure***