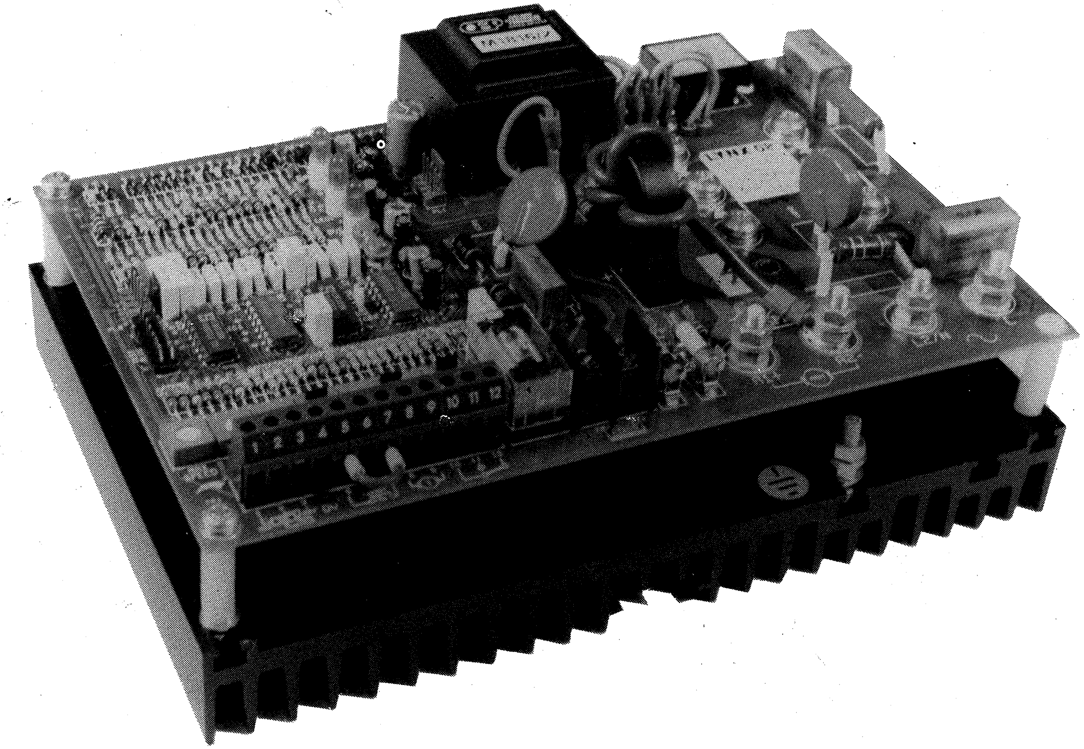
CONTROL
TECHNIQUES

LYNX SERIES

.55kW — 7.5kW
D.C. MOTOR SPEED CONTROLLERS

CONTROL
TECHNIQUES

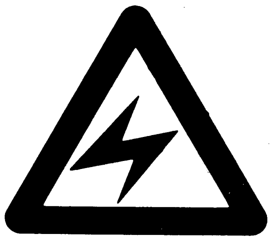


Instruction Manual

Code: 0176-5001
Ref: AK.4.88

HEALTH AND SAFETY AT WORK

Electrical devices can constitute a safety hazard.
It is the responsibility of the user to ensure that compliance of the installation with any acts and bye-laws in force. Only skilled personnel should install this equipment after reading and understanding this instruction manual. If in doubt refer to your supplier.



DANGER
ELECTRIC SHOCK RISK

Note: All efforts are made to ensure that the contents of this manual are accurate at the time of printing.
The Manufacturers, however, reserve the right to change the content and product specification without notice.

CONTENTS

PLEASE READ THESE INSTRUCTIONS BEFORE INSTALLATION.
IF IN DOUBT CONTACT YOUR SUPPLIER.

1. General

1.1 The LYNX series of DC motor speed controllers are designed for efficient speed control of conventional wound-field and permanent magnet motors in the .55 to 7.5kW range.

The series consists of 3 models each capable of 220/240 volt or 380/440 volt 50-60Hz supply operation.

The LYNX offers isolated control inputs in both armature voltage and Tacho feedback modes. A simple link system allows selection of mains supply voltage, motor armature voltage, tacho/AVF and speed/torque control.

LYNX offers fuseless on-board protection of the main power circuits by both sub-cycle electronic trip and conventional current limit. The field and control circuits are fused. A time overload trip is also incorporated.

Standard format is a chassis mounting module — IP00, although a comprehensive range of enclosures is available.

1.2 **WARNING** — Before selecting links or making connections to the LYNX ensure that the supply is disconnected. Although the control terminals of the LYNX are isolated certain areas of the units are *Live* with respect to earth.

As standard the LYNX is a uni-directional, non-braking controller. As an option a reversing logic card, type LC, is available for use with the chassis mounting LYNX, giving controlled reversing, dynamic braking and inching.

1.3 **SPECIFICATION**

Model	LYNX - 8	LYNX - 16	LYNX - 30
Lynx O/P Amps average	8	16	30
AC Inputs, Amps RMS	12	23	39
220/240V Supply - Motor kW	1.1	2.2	4.5
380/440V Supply - Motor kW	2.2	4	7.5
Typical Watts lost	22	48	75

Table 1

Motor Voltage DC	V arm	V field
Supply 220/240V AC	180	190/210
Supply 380/440 AC	320	340/370

Table 2

Supply Voltage
220/240 or 380/440 V AC +/− 10% 50/60Hz - two wire

Output Voltage
0-180V DC arm, 190/210 volt Field
0-320V DC arm, 340/370 volt Field

Enclosure
Chassis mounting IP00

Overload
150% of continuous current for 10 secs — trip action.

Operating Temp
Ambient −10°C to +40°C

Humidity
85% R.H. at 40°C. Non condensing

Altitude
Above 1000 metre derate 1%/100 metres

Control Method
Full wave bridge. Half controlled - phase angle

Weight
Approx. 2Kg.

1.4 **CONTROL INPUTS — ISOLATED**

Speed Reference
10Kohm potentiometer, 0 to +10 volts, input impedance 100K ohm filtered.

Run/Inhibit
N.O. Contact, closed to run, 0 to + 10 volt logic signal at 5mA.

Torque Control
Link selected. 10 Kohm potentiometer, 10 to 0 volts, input impedance 100Kohm, 10 volts in gives 100% torque.

Tacho Input
Link selected. DC input non polarity conscious. Note: maximum absolute input = 120 volts at maximum motor speed. See sec. 3.5.

1.5 **CONTROL OUTPUTS — ISOLATED**
+10 volt reference,
Potentiometer supply only, +10V at 5mA

Status Relay
Change-over contacts rated 240V AC @ 3 Amps. Volt-free.
Changes over at Power loss or trip.

1.6 **ADJUSTMENTS**

Maximum Speed
RV1. Approx 100% to 50% of maximum motor speed.

Minimum Speed
RV2. Approx. 0 to 50% of maximum preset motor speed.

Ramp Up
RV3B. Approx. 0.5 secs to 15 secs, linear.

Ramp Down
RV3A. Approx. 0.5 secs to 15 secs, linear.

I.R. Compensation
RV4 Optimises speed regulation against load change.

Current Limit
RV5. Approx. 0 to 100% of rated output current.

Stability
RV6. Optimises system stability.

Control Links
LK1. Tacho/AVF feedback
LK2. Torque/Speed control.
LK3. 240 (180)/415 (320) volts armature voltage selection. } Must be jointly
LK4. Line supply 220/240—380/440 volts. } selected.

1.7 PROTECTION

AC supply filter and transient supression. Adjustable electronic current limit with timed-overload trip. Sub-cycle current trip (5 x cont. amp rating).
Isolated control inputs
Fused control and field circuits. 2 Amps HRC.

1.8 DIAGNOSTIC

L.E.D. indication of:—
- POWER ON
- STANDBY/RESET
- OVERLOAD/PEAK CURRENT
- C/OVER STATUS RELAY

2. Installation

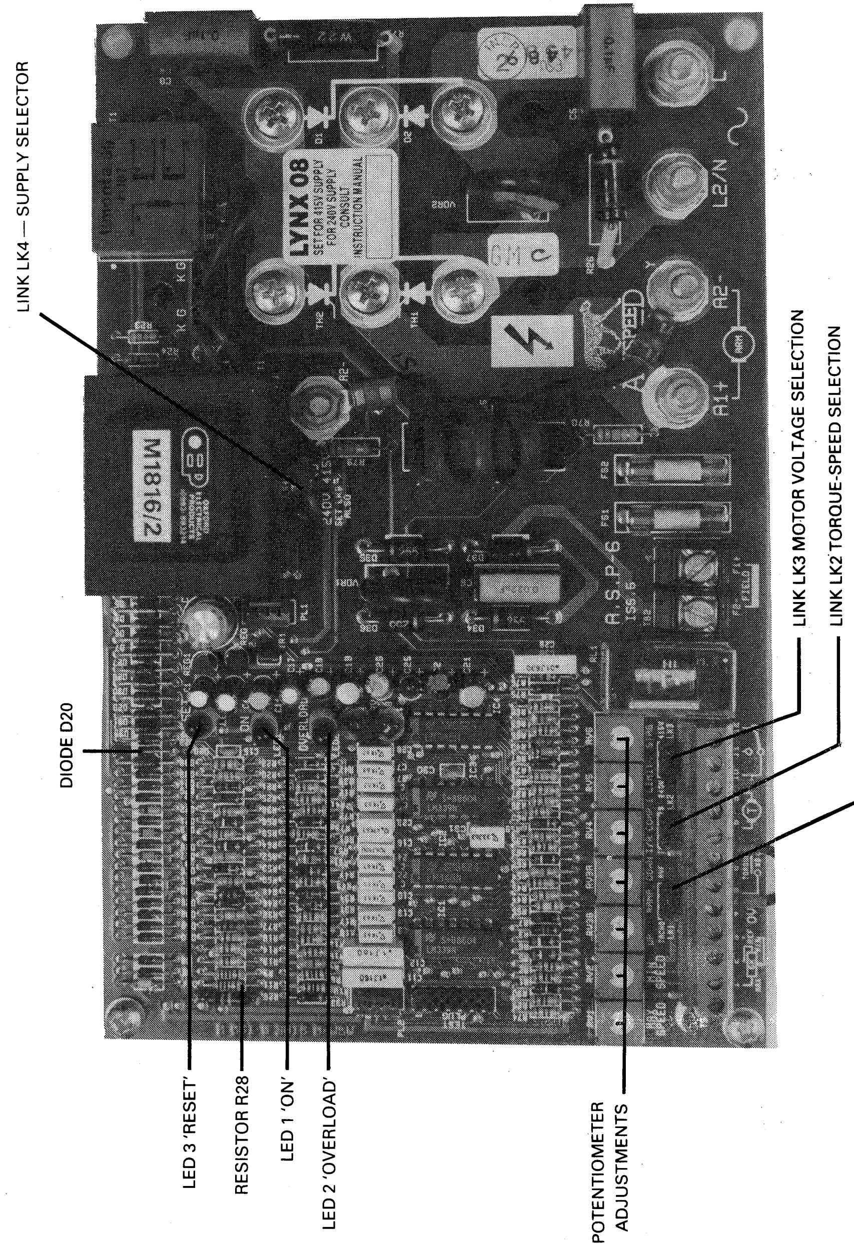


Fig. 1 Lynx Layout

2.1 ELECTRICAL

NOTE: Ensure the LYNX is disconnected from the supply before working on the unit.

POWER CABLING.
Only use cable with correct voltage and current ratings. A minimum of 600V AC rating is recommended. Input and output currents are listed in table 1.

INPUT FUSING.
The LYNX is not fuse protected on the incoming supply and circuit breakers or HRC fuses of the correct voltage and current ratings are recommended. See Table 1 for current ratings. Fusing of the DC supply to the motor is not recommended.

CONTROL SIGNAL CABLING
All control inputs to the LYNX are both low voltage and effectively isolated from power circuits. Signal cables may be screened and connected to earth near the LYNX. In any case avoid running signal cables close to power cables of any type.

SELECTOR LINKS
MUST be re-positioned with the LYNX switch off and disconnected for safety. Selector link detail is given in Sec. 3.1

Although the LYNX is very well protected and incorporates a high degree of electrical noise immunity, installations involving electrical welding, RF Induction heating etc. may benefit from the addition of a simple mains filter on the AC supply. Please consult your supplier.

MOTOR CHOKES
When specified for certain DC motors, must be wired in series with the motor armature.

Typical connection arrangements for the LYNX are detailed in Sec 2.2

For controlled reversing an option card, type LC is available for use with the LYNX.

STATUS RELAY
Terminals 10 & 12 of the Lynx are N.C. going open at power-up and closing at trip or power-loss conditions. Terminals 11 & 12 are closed when running.

2.2 CONNECTION

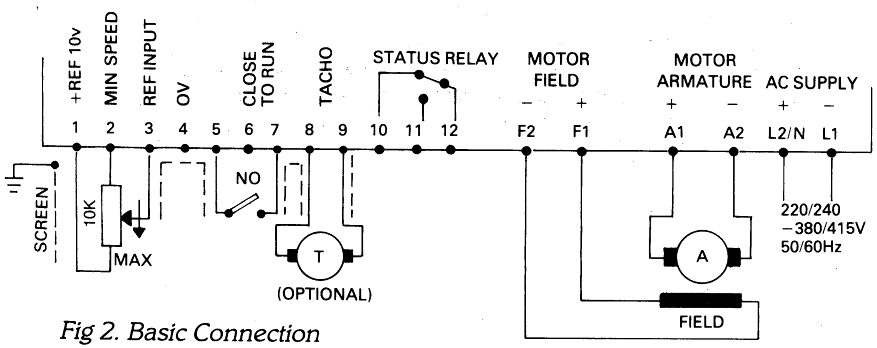


Fig 2. Basic Connection

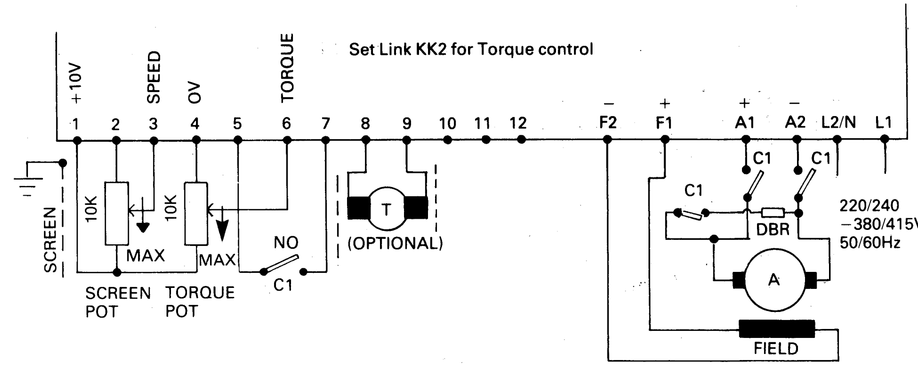


Fig 3. Torque Control & Dynamic Braking

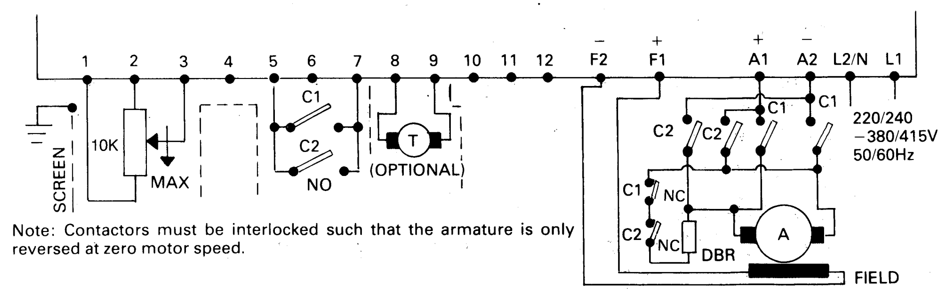


Fig 4. Reversing with Dynamic Braking

2.3 MECHANICAL

The following general guidelines should be used when installing any electronic equipment.

1. Mount the unit for best heatsink air-flow i.e. fins vertical, see page 10.
2. Mounting should be vibration-free.
3. Ambient temperatures should not exceed -10°C to +40°C.
4. Unit should not be mounted in areas of direct sunlight.
5. Installation is free from dust, corrosive gas and grinding fluid.

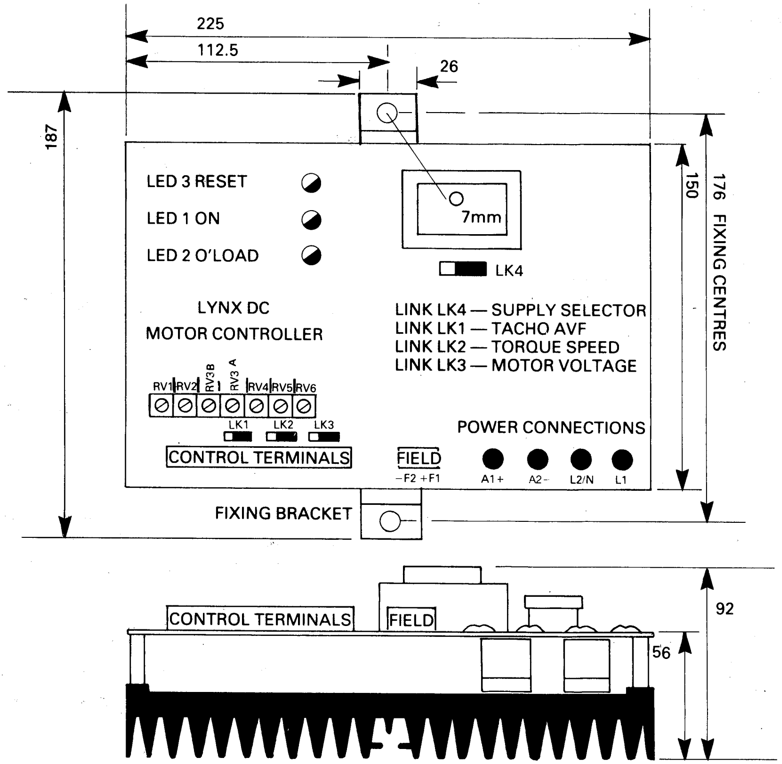


Fig 5 Dimensions — Module

2.4 MOTOR

Foot-mounted motors must be mounted on a level and rigid foundation and shims used where necessary to achieve this. During installation, all ventilation and conduit openings in the motor must be wrapped or otherwise protected against the ingress of dirt, moisture or other foreign matter. When fitting with couplings align shaft with driven machine to within +/− 0,25mm.

Do not hammer couplings or pulleys on the shaft. Before running the drive the following should be checked:

i) The insulation resistance between all windings and earth, with all LYNX connections removed, to make sure that the machine has not suffered any transit or storage damage.
ii) Check that all brushes are seated correctly on the commutator, move freely in the brush-boxes and that all brush springs are securely in position.
iv) Make sure all motor ventilation-openings are clear.
v) Motor chokes, when specified, are correctly wired.

3. Starting & Adjusting

WARNING

Although control inputs of the LYNX are isolated, certain areas of circuitry are not. Exercise extreme caution when adjusting the unit. It is recommended that the selector links are positioned initially, with the unit electrically disconnected.

3.1 CONTROL SELECTOR LINKS

TACHO/AVF FEEDBACK LK1
Link LK 1 can be positioned for either tacho or Armature voltage feedback - as marked on the printed circuit board. See Sec. 3.5 before switching on.

SPEED/TORQUE CONTROL LK2
Link LK2 is used to select normal speed control or torque control modes, positioning is as shown on the printed circuit board.

MOTOR VOLTAGE SELECTION LK3
A 240/415 volt selection can be made on link LK3. Actual motor armature voltages involved are 180 volt — when the LYNX is supplied from a 220/240 volt 2 wire supply, and 320 volt when a 380/440 volt 2 wire supply is utilised. Links LK3 & LK4 should be selected jointly.

LINE SUPPLY SELECTION LK4
Link LK4 allows mains transformer adjustment to either a 220/240 volt or 380/440 volt 2 wire 50/60Hz supply. Link LK3 should also be checked to ensure motor voltage compatability.

3.2 NO-VOLT RELEASE FEATURE

Although not normally utilised in the LYNX's module installation, a 'no-volt release' feature is incorporated. This can be employed by suitable connection to on-printed circuit board cable-connecter, ref. no. PL1. See fig 6. With the no-volt release feature selected the LYNX will power-up in a standby mode with its RESET LED lit. The run condition is then selected by momentarily closing pin numbers 3 & 4 on plug PL1. The motor will then run. Any interruption in line supply will leave the drive in the standby mode once more.

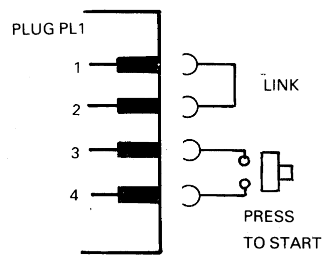


Fig. 6
No-volt Release

3.3 SWITCHING ON

Turn the speed potentiometer or speed reference for zero demand. Switch on the AC supply. The 'ON' LED will light. Terminals 5 and 7 must also be switched together to obtain the run condition. Slowly increase the speed demand and observe the motors direction or rotation. If incorrect, switch off the AC supply and reverse the connections to the motor armature. Re-start the drive and check operation of all functions. The 7 pre-set controls on the LYNX are factory set but may be customer adjusted in the following way:—

3.4 ADJUSTING PRESETS

MAXIMUM SPEED — RV1

With the speed demand input, on terminal 3, set for maximum speed, adjust the MAX SPEED potentiometer RV1 to give the required motor speed. Clockwise rotation increases speed. Ensure maximum motor armature voltage is not exceeded otherwise the drive may trip out.

MINIMUM SPEED — RV2

With the speed demand input, on terminal 3, set to zero speed, adjust the MIN SPEED potentiometer RV2 to give the required minimum motor speed. Clockwise rotation increases speed.

CURRENT LIMIT AND OVERLOAD — RV5

This control is used to set the maximum output current of the LYNX to approx. 150% of the motors nameplace current rating. Approx. maximum continuous output currents of each LYNX model are listed in table 1. Its important to ensure that available current is not too great for the motor. The overload threshold is approx. 110% of adjusted LYNX output current, a 150% overload giving an approximate 10 second trip time. Clockwise rotation of RV5 increases available output current. Reducing the output current setting also reduces the threshold of the overload system.

TO RESET THE OVERLOAD TRIP, REMOVE THE AC SUPPLY FROM THE LYNX FOR 1—2 SECONDS.

RAMP CONTROLS — RV3 A & B

These two controls set the deceleration and acceleration ramps respectively. Normal ramp characteristic is linear with a 0.5 sec. to 15 sec. range, although the motor may take longer to accelerate under current limit. Anti-clockwise adjustment gives longer ramps.

IR COMPENSATION — RV4

IR compensation improves the regulation of the drive when in armature voltage feedback. To set, the speed of the drive must be checked on no load and full load and the IR COMP potentiometer adjusted to give minimum speed drop. Turning the IR COMP potentiometer too far clockwise may cause instability. With Tachogenerator feedback the IR COMP potentiometer should be turned fully anti-clockwise.

STABILITY — RV6

This control sets the response of the drive. It should be adjusted clockwise to improve the stability or anti-clockwise to improve the response. Too fast a response will cause the system to 'hunt'.

3.5 TACHO FEEDBACK

The tacho connects to terminals 8 and 9. The tacho may be an AC type but DC types are preferred. The input to the feedback circuit are via a full-wave rectifier and therefore tacho-polarity insensitive. The scaling of the tacho-input is extremely important and provision is made on the printed circuit board of the LYNX to choose and fit the appropriate scaling resistor vis:—

Tacho feedback voltage max (not V/1000 r.p.m. rating)	Resistor R28 — Value
20 — 30V	33K ½W
30 — 50V	56K ½W
50 — 80V	100K ½W
80 — 120V (Factory fitted)	150K ½W

With tacho generator feedback, the max. speed potentiometer RV1 must always, during commissioning, be turned fully anti-clockwise before switching on, and then adjusted to give the correct speed. Failure to do this may cause the motor to overspeed and the controller to cut out. Ensure IR compensation preset RV4 is turned fully anti-clockwise.

3.6 REVERSING & DYNAMIC BRAKING

Fig. 4 shows the basic arrangement. The armature connection should only be changed over when the motor has reached standstill, this is greatly assisted by the dynamic brake arrangement shown, otherwise damage to the motor may occur.

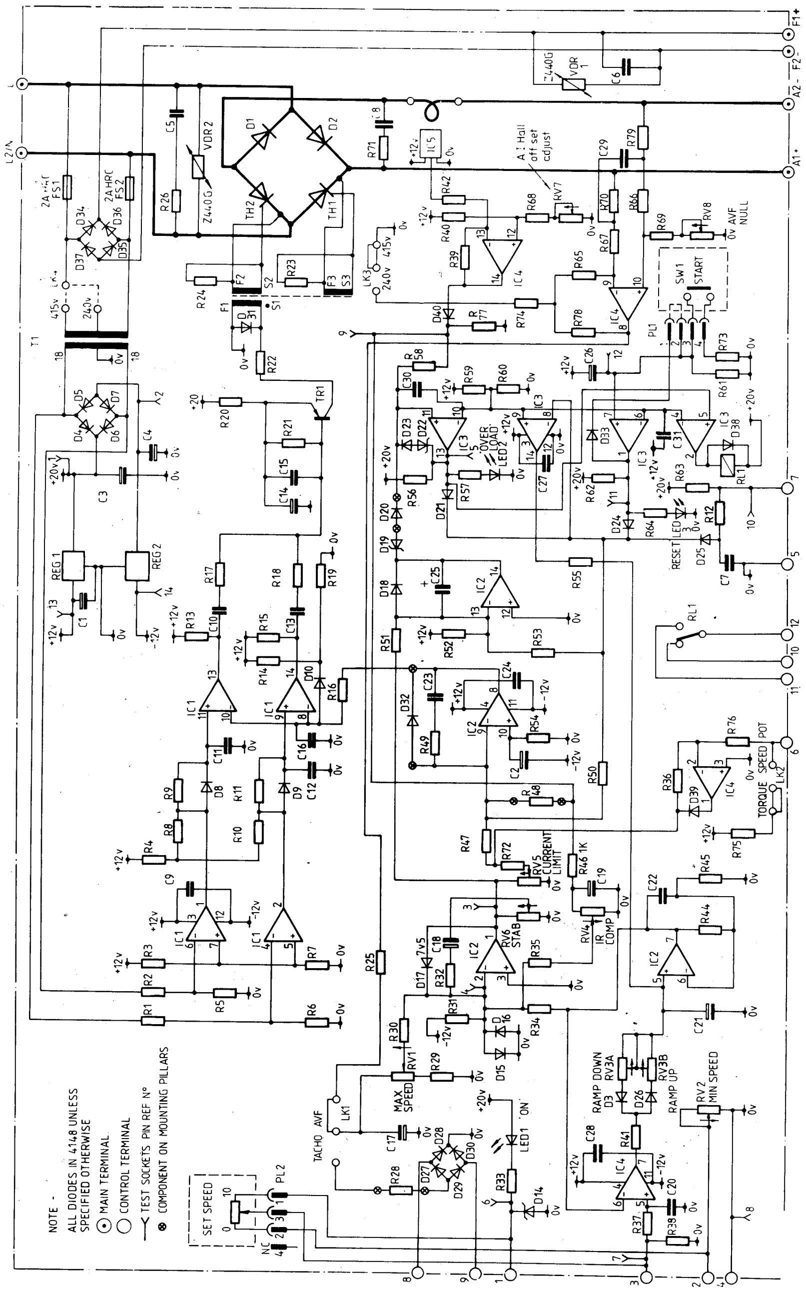
A special solid state control unit, type LC, is available which provides all the necessary interlocks for inch/run/forward/reverse and also has a zero speed detector that prevents contactor changeover while the motor is running.

3.7 TORQUE CONTROL

The armature current (torque) can be controlled with an external potentiometer as shown in fig. 3. The connection must be arranged so that with the potentiometer fully anti-clockwise terminal 6 is effectively connected to terminal 4. With the torque potentiometer at this setting, the internal current limit potentiometer (RV5) should be adjusted to give zero motor current, i.e. no rotation even with full speed demand. Clockwise adjustment of the torque potentiometer will then give control of armature current over a 0 to 100% range. Since the controller is now running continually in current limit it will trip unless the overload system is disabled, this is accomplished by removing diode D20. The speed control potentiometer, if not required, should be replaced by a wire link between terminals 1 & 3.

4. Circuit & Description

4.1 CIRCUIT SCHEMATIC



4.2 CIRCUIT DESCRIPTION

The LYNX combines conventional phase-controlled Thyristor technology with a comprehensive range of features to make a robust well-protected DC motor speed controller for use in drive systems. These features include control circuit isolation, torque control, status relay, high noise immunity and effective power circuit protection.

The circuit divides conveniently into 9 areas as follows:—

i) Main Power Stages — a full-wave half-controlled bridge is formed by Thyristors TH1, TH2 and rectifiers D1 & D2, D1 & D2 also form the freewheel path for commutated motor armature current. The incoming AC supply is effectively filtered by C5 & R26 which limit the dv/dt across the bridge. Overvoltage transient protection is given by varistor VDR2. The controlled DC output current to the motor passes through a pcb-mounted DC current transformer using Hall Effect monitoring, IC5, providing a fast, isolated, motor current monitor.

Armature voltage feedback is via an impedance isolated amplifier, IC4 pin 8, with programmable gain to ensure motor armature voltage matching. Pulse transformer PT1 gives gate trigger-pulse isolation.

Diodes D34-D37 form a separate full-wave, fused bridge for motor-field supply. Field circuitry is protected against high field-transients by capacitor C6 and varistor VDR1.

ii) Low-volt Power Supplies — Transformer T1 has a tapped primary and can be link selected — LK4 — to give operation on a 220/240 volt or 380/440 volt supply. The secondary supplies a 36 volt AC supply to rectifier bridge D4-D7. An unregulated +20 volt supply feeds the main thyristor trigger transistor TR1 and is also used to derive a +10 volt supply for the external speed potentiometer via zener D14 and R33. LED 1 indicates the 'ON' condition. Regulators 1 & 2 ensure stable + and −12 volt control supplied for integrated circuits. Capacitor C2 ensures a logical power-up sequence by holding the output of the current amplifier, IC2 pin 8 negative until control status is achieved. The incoming supply to transformer T1 shares 2 Amp HRC fusing with the field supply rectifier circuits.

iii) Trigger Synchronisation — Transformer T1 also feeds AC signals, in anti-phase, to comparators IC1 pins 6 & 4. Comparator outputs on IC1 pin 1 & 2 show 50% duty-cycle square-waves swinging +/− 10 volt, again in anti-phase with positive edges, rounded as diodes D8 & D9 charge C11 & C12 respectively via R4, R8 & R10 forming a "ramp". IC1 pins 11 & 10 and 9 & 8 form 'ramp/pedestal' comparators for the anti-phase signals via D8 & D9. The pedestal signal — a DC level, is provided by the output of the current amplifier IC2 pin 8 via R16.

The ramp/pedestal comparator outputs are therefore square waves of variable duty-cycle but synchronised in time and phase with the AC supply zero cross-over points. R13/C10 and R15/C13 form differentiators, the resulting trigger edges being fed to trigger drive transistor TR1 via R17 & R18. Transistor TR1 feeds the gate pulse transformer PT1 via R22. Although each thyristor receives a trigger-pulse in both half cycles only the thyristor with forward volts across its anode-cathode will conduct. Because the trigger signal is synchronised in time (i.e. phase angle) good control of the DC output voltage is achieved.

iv) Current Monitor — Motor armature current returning to the thyristor bridge fluxes a DC current transformer employing a fast, linear, Hall Effect device IC5. The Hall Effect signal is scaled by IC4 pin 14 where a positive swing represents a move towards current limit. The output of this current monitor is used to trip the over-current latch IC3 pin 13 via R58, also to give continuous current feed-back via R48 to the current amplifier IC2 pin 9 and via R46/C19, which form a filter, to provide an IR compensation term, adjustable by RV4, to the speed amplifier input IC2 pin 2 via R35. The Hall Effect device has an adjustable offset which is carefully preset at the factory on RV7. Do **not** readjust.

v) Ramp Circuit — Speed reference input voltage is fed via terminal 3, which requires a 0 to +10 volt DC signal. R38 ties the input down so that if the speed reference is lost the motor speed falls to zero. In effect IC4 pin 7 and IC2 pin 7 form a balanced loop integrator with capacitor C21/RV3A/RV3B introducing a controllable integration time in both up and down ramp modes. Loop gain is unity, consequently the ramped speed reference signal is fed to the speed amplifier input IC2 pin 2 via R34.

vi) Feedback Selection — The LYNX controller can be switched between normal armature voltage feedback (AVF) and tachogenerator feedback by link LK1. Armature voltage feedback is derived through IC4 pin 8 whose input looks differentially across the motor's armature voltage via a very high impedance source R67/66/70/79. This technique is known as impedance isolation, leakage currents to power circuitry being negligible. RV8 adjusts the null output of the system and is factory preset. It should **not** be re-adjusted. The output of IC4 pin 8 can be scaled down to suit 180 volt (240 volt AC supply) motors by selecting link LK3. Voltage feedback via resistor R25 and link LK1 (tacho-AVF) is filtered by C17 and scaled for maximum motor speed by RV1 to provide a balancing feedback term to speed amplifier input IC2 pin 2 via R30. This point is the summing point of required speed, from the ramp output IC2 pin 7 and the actual speed as indicated by the feedback. The speed amplifier output on IC2 pin 1 swings negative when an increase in speed is required, being clamped to a −7.5 maximum by zener D17. The stability of the total loop can be varied by changing the AC gain around the speed amplifier using RV6 — stability preset.

The speed amplifier output feeds off to the Ixt overload circuit and current limit potentiometer RV5 and is really a measure of demand. R47 feeds the current limit set point to the summing point of the current amplifier, IC2 pin 9, where it is compared with the current feedback via R50. The current amplifier output, IC2 pin 8, swings positive to increase the motor voltage (speed) via the 'ramp & pedestal, trigger amplifier IC1 pins 8 & 10. However if the motor current is too high then IC2 pin 8 swings negative, being clamped at −.5 volts by diode D32, reducing the motor voltage progressively to zero. The AC gain of the current amplifier is limited by R49 & C23. Re-positioning link LK1 selects the Tacho feedback mode. Polarity of the DC tacho is not important due to the tacho rectifier bridge comprising D27-D30 fitted for use in reversing systems. The output of the tacho bridge is negative going, as is the AVF feedback when selected. For use with low levels of feedback voltage, i.e 0 to 10 volts or so, it is useful to avoid the rectifiers D27-D30 to prevent a significant feedback voltage loss. In this case diode D27 & D30 should be fitted with shorting links and feedback voltage connected so that input terminal 8 is always negative and 9 is always positive polarity. Resistor R28 scales the tacho voltage into the circuit and should be of the correct value. See Sec. 3.5.

vii) Overload & Peak Current Trip — If the speed demand cannot be satisfied, i.e. current limit pot set too low, motor current too high or feedback lost the speed amplifier output, IC2 pin 1, swings fully to −7.5 volts. This negative level is fed via R51 to the Ixt integrator comprising IC2 pin 14, C25 and R51/52. The output integrates positively until D19 zeners giving an increased positive level on latch IC3 pin 11. The latch output, IC3 pin 13, swings to +10 volts zenering D22 and completing the latch action. LED 2 'OVERLOAD' comes on and the +10 volt latch output is fed via D21 & R50 to the current amplifier input quickly inhibiting the Thyristor trigger pulses. IC3 pin 14 swings to −10 volt resetting the speed reference input to zero demand via R55.

Peak current caused by shock loads etc. result in the same action of rapid shutdown. The presence of a trip condition also de-energises the status relay RL1 via the inverting action of IC3 pin 2 resulting in status relay drop-out, i.e. control terminals 10 & 12 closed.

Run-Inhibit Input — With LYNX control inputs 5 & 7 open, a positive level from R63 via R12 and D25, ensures a no-run condition via the action of IC3 pin 14, R55 on the ramp circuit and R50 on the current amplifier. With 5 & 7 closed these conditions are removed and motor speed will ramp up to set point. Input 7 is filtered by R12 & C7.

viii) No-Volt Release & Power-up Reset — At initial power switch-on C26 ensures that IC3 pin 1 swings high to reset the ramp and current amplifier. Once C26 has charged the motor is ready to run. If the no-volt release facility is to be used — see Sec. 3.2 — then the initial state of C26 causes IC3 pin 1 to latch high because of D33. Momentarily connecting plug PL1 pins 3 & 4 together will cause the circuit to de-latch ready for the run condition.

ix) Torque Control — Moving Link LK2 to the Torque position allows a 0 volt to 10 volt input reference signal to control the LYNX's output current over a 0 to 100% range respectively. As control input number 6 is taken towards zero volts inverting amplifier IC4 pin 1 contributes positively via R47 offsetting the load demand signal progressively with consequent reduction in available output current. Removing D20 disables the Ixt overload trip.

4.3 TEST INSTRUMENTATION

Take care when connecting test instruments, although the control inputs of the LYNX are isolated, power circuits are not. Remember also that neither the LYNX's output voltage or current are pure DC. This can give misleading results when using certain test instruments, in general though an electronic voltmeter will give reliable output voltage readings. Current readings taken from the AC supply will vary considerably from DC readings taken in the armature circuit. The relationship between the two varies with speed setting. Consequently when establishing motor load conditions it is best to measure DC armature current. A conventional "clip-on" test ammeter cannot be used for measuring in DC circuits; only use a true DC ammeter such as a Hall Effect probe.

5. Fault Finding

5.1 The following chart is not exhaustive but shows the general procedure to be adopted when fault finding.

Fault	Possible Cause	Action
Motor does not run at initial switch on	Fuses FS1/FS2 open circuit LED1 does not light.	Check all field circuits for shorts and earths.
	No speed reference	Check voltage on terminal 3.
	Stop/run input terminal 5 & 7 not closed.	Check control circuit
	LED 2 OVERLOAD is lit	Check correct presence of all selector links
		Check motor armature circuit for shorts and earth fault.
Motor runs for a while and stops LED2 OVERLOAD lights	Incorrect Current limit setting	Check and Adjust RVS.
	Motor overloaded	Check armature current is within motor rating.
	Field circuit faulty	Check motor field voltage and current.
Motor runs up to max speed and stops LED2 lights	Wrong tacho feedback voltage	Decrease max, speed pot RV1, check R28 value.
	Link LK1 missing Faulty Tacho Link LK3 incorrect motor voltage	Refit. Check voltage terminals 8 & 9 Check.
Motor runs at full speed only	Open circuit speed control pot	Check voltage at terminal 3 varies between 0 & +10v approx.
	Min, speed pot. set too high	Reduce.
Drive Unstable	Incorrect setting of stability pot. Too much IR compensation	Adjust RV6 for optimum stability. Adjust RV4 anticlockwise.

Notes