AMETEK® Aerospace & Defense Division

# MUIRHEAD AEROSPACE
# Synchros


*In motion to keep you moving*

# Contents

## Introduction

## Muirhead Aerospace

# Synchros

Synchros are used to transmit angular data electrically from one location to another where a high degree of accuracy is required. They are essentially variable transformers in which the coupling between windings varies with the rotor position relative to the stator. Several different types are produced to suit particular applications and whilst their external appearance is similar, the internal construction varies to optimise the units' functional requirements. Muirhead's pedigree and capability in the field of Synchros will ensure the most demanding specifications are met. Typical applications include remote positioning of low torque mechanisms, remote control by servo motor driven mechanism, remote digital measurement of angle via a suitable signal converter, remote pointer indication of angular position.

## Control Synchros

The design principle of a Control Synchro is to minimise errors in the output signal due to current loading, magnetic non-linearity and temperature rise, by the use of high impedance windings and special attention to the magnetic circuits. The Control Transformer which provides the error signal to a servo amplifier, can be considered a 'null detector and it is most often used in this way. However the 'null' is never zero due to residual voltages. This is due to stray couplings within the laminated stator that result in an in-phase voltage, a quadrature voltage, both at fundamental frequency, plus a number of harmonics. These residual voltage levels are quoted in the performance data tables for each unit.

## Differential Transmitters

It is sometimes necessary to add or subtract additional information from a Synchro Chain and Differential Transmitters serve this purpose. They are similar in construction to the other elements except for a 3-phase winding on the rotor.

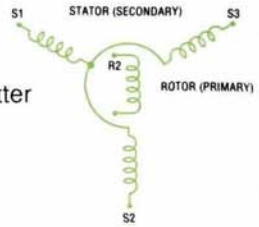
## Torque Synchros

The Torque Synchro is designed to provide a light torque output without additional servo components. Current is fed to both the Transmitter and the Receiver from the same source and the winding impedance values are considerably lower than the equivalent control elements. Torque is generated as a result of the interaction of the stator and rotor fields in the receiver which drives the rotor of the Receiver into alignment with that of the Transmitter. The torque / misalignment curve takes sinusoidal form through 360 degrees with maximum values of opposite polarity at 90 and 270 degrees.

## Winding Configuration

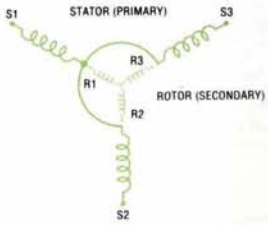
### Synchro Function

Control Transmitter
Torque Transmitter
Torque Receiver — Transmitter
Torque Receiver

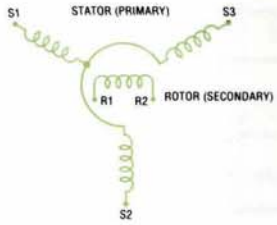



Control Differential Transmitter

Torque Differential Transmitter

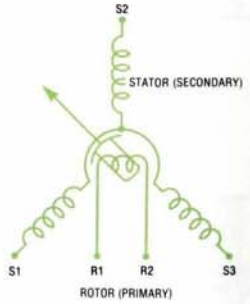



Control Transformer

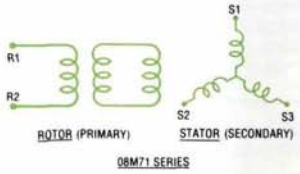



### Specialised Synchros

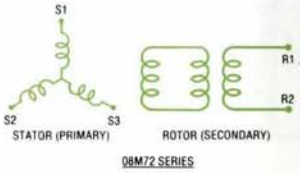
Indicating Receiver
*(See page 15)*



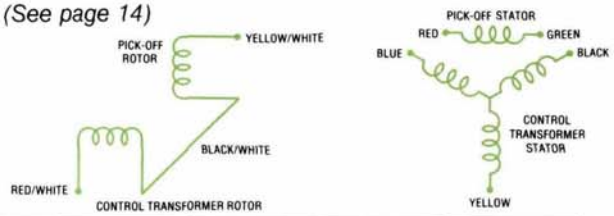

Brushless Control Transmitter
*(See page 14)*




*Brushless Control Transformer*
*(See page 14)*




Tandem
*(See page 14)*




### Note

Winding configurations are shown at zero shaft positions viewed from the terminal end. For example, in the wiring configuration for the Control Transmitter, voltage (R1 R2) is approximately in phase with voltage (S2 S1) and voltage (S3 S2).

Damping flywheels are fitted to size 15, 18, and 23 Torque Receivers/Transmitters. For size 08 and 11, damping is achieved by the use of high viscosity bearings.

## Mounting Hardware

Each synchro (except size 23) is supplied with a set of three mounting clamps, and where required, shaft nut and washers, together with terminal tags. In addition, Muirhead Vactric can supply at extra cost a variety of hardware. Full details are described in the Mounting Information leaflet. A reference table below shows some of the available choices.

PINION AND SOCKET WRENCHES
Please note that these parts are ordered separately.

| *Order Ref* | *Frame Size* | | | | |
|---|---|---|---|---|---|
| | 08 | 11 | 15 | 18 | 23 |
| Pinion wrenches F500/8 & F500/9 | | * | * | * | * |
| Socket wrench F500/21 | * | | | | |
| Socket wrench F500/51 | | * | * | * | |
| Socket wrench F500/52 | | | | | * |

* *Available*

**METRIC CONVERSION FACTORS**

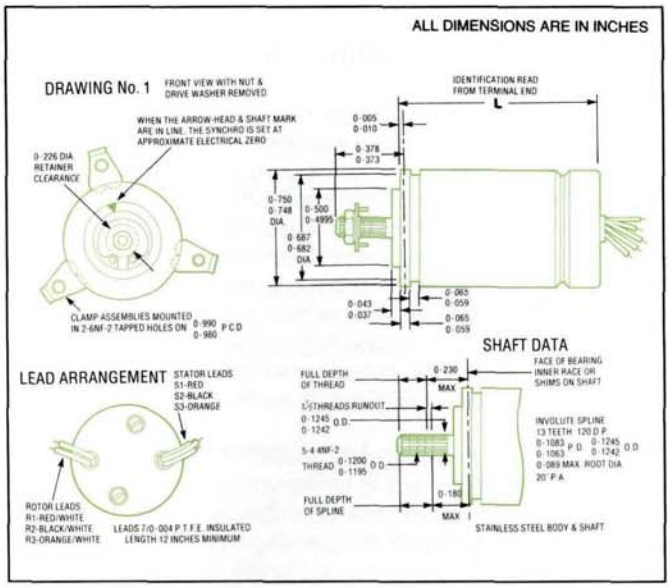
| | |
|---|---|
| Torque | 1 gcm = 0.098 mNm |
| Torque | 1 gcm = $1.389 \times 10^{-2}$ oz in |
| Torque | 1 oz. in. = 72.01 g cm |
| Inertia | 1 oz. in$^2$ = $1.829 \times 10^2$ g cm$^2$ |
| Weight | 1 oz. = 28.349 g |
| Distance | 1 in. = 25.4mm |

26V 400 Hz
EL 1790

## STANDARD HARDWARE SUPPLIED WITH EACH INSTRUMENT

| Item | Type No· | Detail Ref· |
|---|---|---|
| Clamp Assembly | F500/33 | A+B |
| Shaft Nut | F500/37 | A † |
| Drive Washer (Aluminium) | F500/38A | A † |

† SUPPLIED EXCEPT PLAIN SHAFT TYPES




AMBIENT TEMPERATURE RANGE:
-65°C + 150°C

Weight 50g (1.75 oz)
Rotor Inertia 1.1g cm² (0·006 oz in²)
Friction Torque 2.9g cm (0·04 oz in)
(Not applicable to Torque Receivers)

| SYNCHRO FUNCTION | Drawing & Hardware Detail Ref· | DESCRIPTION: TYPE DESIGNATION Military | Muirhead | NATO NUMBER 5990-99- | MILITARY SPECIFICATION | LENGTH (Dim·L) in inches max* | PRIMARY: TERMINALS | RATED VOLTS Volts | Amps max | NO LOAD INPUT Watts max | Ohms nom | D.C. RESISTANCE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CONTROL TRANSFORMER | 1-A | 26V08CX4(B1) | 08M1C1 | 947-3051 | EL 1790 | 1·350 | R1 R2 (ROTOR) | 26 | 26 | 0·111 | 0·95 | 60 |
| CONTROL TRANSFORMER | 1-A | 26V08CT4(B1) | 08M2C1 | 947-3052 | EL 1790 | 1·350 | S1 S2 S3 (STATOR) | 11·8 | 10·2 | 0·137 | 0·47 | 28 |
| TORQUE RECEIVER TRANSMITTER | 1-A | | 08M4A1 | 520-8549 | — | 1·350 | R1 R2 (ROTOR) | 26 | 26 | 0·3 | 3·2 | 26 |

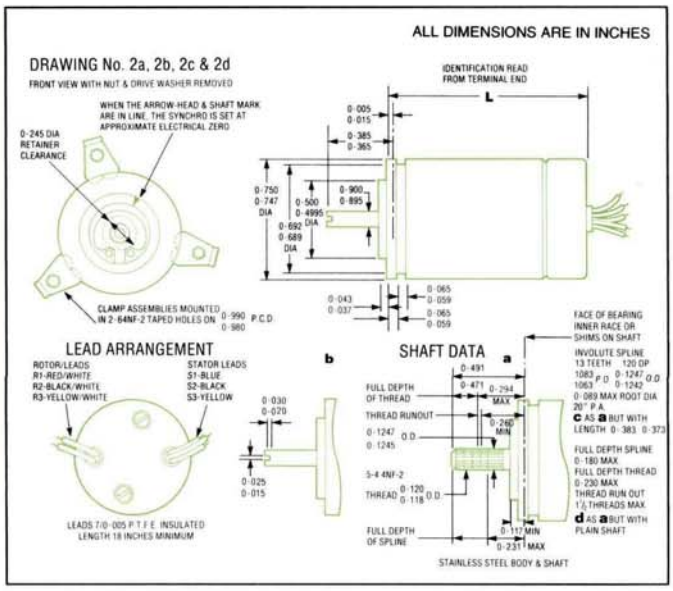
| SYNCRO FUNCTION | Drawing & Hardware Detail Ref· | DESCRIPTION: TYPE DESIGNATION Military | Muirhead | NATO NUMBER 5990-99- | MILITARY SPECIFICATION DEP STAN 59-27-2 | MIL-S 20708/ | LENGTH (Dim·L) in inches max | PRIMARY: TERMINALS | RATED VOLTS | Volts | NO LOAD INPUT Amps max | Watts max | D.C. RESISTANCE Ohms nom |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CONTROL TRANSMITTERS | 2a-A | 26V08CX4b | 08M1G1 | 972-7610 | — | 78A | 1·240 | R1 R2 (ROTOR) | 26 | 26 | 0·153 | 0·86 | 27 |
| | | * 26V08CX4C | 08M51C1 | 014-9848 | 078 | 78D | | | 26 | 26 | 0·153 | 0·86 | 27 |
| | 2b-B | 26V08CX4c | 08M1H1 | 519-5637 | DEF148/78 | 78C | | | 26 | 26 | 0·153 | 0·86 | 27 |
| | 2d-B | | 08M1P1 | 199-7029 | — | — | | | 26 | 26 | 0·153 | 0·86 | 27 |
| | 2d-B | | 08M1X1 | | — | — | | | 115 | 115 | 0·070 | 2·4 | 375 |
| CONTROL DIFFERENTIAL TRANSMITTERS | 2b-B | * 26V08CDX4C | 08M3N1 | 014-9850 | 080 | 80D | 1·240 | S1 S2 S3 (STATOR) | 11·8 | 10·2 | 0·108 | 0·3 | 25 |
| | | 26V08CDX4C | 08M3D1 | 519-5636 | DEF148/80 | 80C | | | 11·8 | 10·2 | 0·108 | 0·3 | 25 |
| CONTROL TRANSFORMERS | 2a-A | 26V08CT4b | 08M2G1 | 972-7611 | — | 79A | 1.240 | S1 S2 S3 (STATOR) | 11·8 | 10·2 | 0·023 | 0·057 | 104 |
| | 2b-B | * 26V08CT4C | 08M52L1 | 014-9849 | 079 | 79D | | | 11·8 | 10·2 | 0·023 | 0·057 | 104 |
| | 2b-B | 26V08CT4c | 08M2H1 | 519-5635 | DEF148/79 | 79C | | | 11·8 | 10·2 | 0·023 | 0·057 | 104 |
| | 2d.B | | 08M2T1 | 199-7030 | | — | | | 11·8 | 10·2 | 0·023 | 0·057 | 104 |
| TORQUE RECEIVER TRANSMITTERS | 2b-B | | 08M4L1 | 712-0795 | | — | 1.240 | R1 R2 (ROTOR) | 26 | 26 | 0·3 | 2 | 15·3 |
| | 2c-A | | 08M4C1 | | — | — | | | 115 | 115 | 0·070 | 2·4 | 375 |

# 26V & 115V, 400Hz MIL-S-20708 DEF 148 DEF—STAN 59-27 PART 2

AMBIENT TEMPERATURE RANGE:
-55°C to + 125°C

* Denotes that the Synchro is on the British Qualified products list to specification DEF STAN 59-27 (PART 2). It is also certified as conforming to NATO Electronics Parts Recommendations for Standardisation of Synchros (N.E.P.R. No. 22) which refers to USA Specification MIL-S-20708C. It is preferred for military applications. Qualification is subject to renewal every four years.

Weight 45g (1·6 oz)
Rotor Inertia 0·8g cm² (0·0045 oz in²)
Friction Torque 2·9g cm (0·04 oz in)
(Not applicable to Torque Receivers)



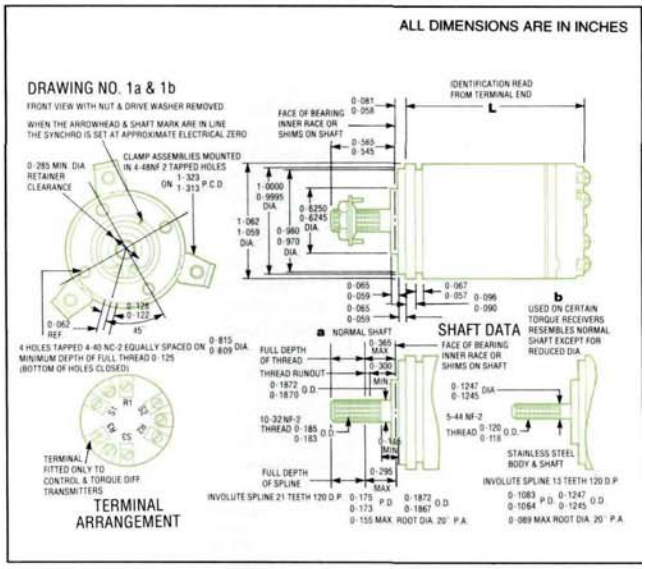

| TERMINALS | SECONDARY: NO LOAD OUTPUT Volts | Phase lead | VOLTAGE GRADIENT Volts/deg | D.C RESISTANCE Ohms nom | NOMINAL IMPEDENCE ohms Zro | Zrs | Zso | PERFORMANCE: ERROR mins Stator | Rotor | Receiver | mV RESIDUAL Fund | Total | MINIMUM TORQUE GRADIENT g cm · oz in | MAXIMUM CONTINUOUS torque g cm | displace-ment deg | PULL-OUT TORQUE g cm | SYNCHRO-NISING TIME secs 30° | C 175° |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S1 S2 S3 (STATOR) | 11·8 | 13 | | 19 | 77+j270 | 137+j39 | 17+j49 | 10 | | | 20 | 40 | | | | | | |
| R1 R2 (ROTOR) | 22·5 | 13·5 | 0·39 | 145 | 173+j564 | 253+j104 | 25+j93 | 10 | | | 30 | 60 | | | | | | |
| S1 S2 S3 (STATOR) | 11·8 | 18 | | 8·5 | 36+j88 | | 8+j20 | 10 | | 120 | Not Applicable | | 0·2 0·0028 | 6 | 23 | 12 | 1 | 2 |

| TERMINALS | SECONDARY: NO LOAD OUTPUT Volts | Phase lead | VOLTAGE GRADIENT Volts/deg | D.C RESISTANCE Ohms nom | NOMINAL IMPEDANCE ohms Zro | Zrs | Zso | Zss | PERFORMANCE: ERROR mins Stator | Rotor | Receiver | Fund | mV RESIDUAL Total | MINIMUM TORQUE GRADIENT Per degree g cm oz in | SYNCHRO-NISING TIME secs. 30° | C 175° |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S1 S2 S3 (STATOR) | 11·8 | 8 | | 10·8 | 32+j185 | 70+j23 | 9+j32 | 12·5+j2·7 | 7 | | | 20 | 30 | | | |
| | 11·8 | 8 | | 10·8 | 32+j185 | 70+j23 | 9+j32 | 12·5+j2·7 | 7 | | | 20 | 30 | | | |
| | 11·8 | 8 | | 10·8 | 32+j185 | 70+j23 | 9+j32 | 12·5+j2·7 | 7 | | | 20 | 30 | | | |
| | 11·8 | 8 | | 10·8 | 32+j185 | 70+j23 | 9+j32 | 12·5+j2·7 | 7 | | | 20 | 30 | | | |
| | 11·8 | 12 | | 6·5 | 500+j1890 | | 6·5+j17 | 86+j1·8 | 7 | | | 30 | 60 | | | |
| R1 R2 R3 (ROTOR) | 11·8 | 9·5 | | 34 | 33+j124 | 46+j14 | 24+j108 | 39+j14 | 7 | 7 | | 20 | 30 | | | |
| | 11·8 | 9·5 | | 34 | 33+j124 | 46+j14 | 24+j108 | 39+j14 | 7 | 7 | | 20 | 30 | | | |
| R1 R2 (ROTOR) | 22·5 | 8·5 | 0·39 | 440 | 607+j2900 | 800+j300 | 100+j506 | 140+j53 | | | | 25 | 30 | | | |
| | 22·5 | 8·5 | 0·39 | 440 | 607+j2900 | 800+j300 | 100+j506 | 140+j53 | 7 | | | 25 | 30 | | | |
| | 22·5 | 8·5 | 0·39 | 440 | 607+j2900 | 800+j300 | 100+j506 | 140+j53 | 7 | | | 25 | 30 | | | |
| | 22·5 | 8·5 | 0·39 | 440 | 607+j2900 | 800+j300 | 100+j506 | 140+j53 | 7 | | | 25 | 30 | | | |
| S1 S2 S3 (STATOR) | 11·8 | 10·5 | | 6·5 | 20+j92 | | 6·5+j17 | 86+j1·8 | 10 | | 120 | Not applicable | | 0·37 0·005 | 2 | 4 |
| | 11·8 | 12 | | 6·5 | 500+j1890 | | 6·5+j17 | 86+j1·8 | 10 | | 120 | Not applicable | | 0·32 0·004 | 2 | 4 |

# 26V & 115V, 400Hz MIL-S-20708 DEF 148 DEF-STAN 59-27 (PART 2)

AMBIENT TEMPERATURE RANGE: -55°C to +125°C

Weight 120g (4·2 oz)
Rotor Inertia 2·6g cm² (0·014 oz in²)
Friction Torque 3·6g cm (0·05 oz in)
(Not applicable to Torque Receivers)




| | SYNCHRO FUNCTION | Drawing & Hardware Detail Ref· | DESCRIPTION: TYPE DESIGNATION Military | Muirhead | NATO NUMBER 5990-99- | MILITARY SPECIFICATION DEF STAN 59-27(2) | MIL-S 20708/ | LENGTH (Dim·L) in inches max | TERMINALS | PRIMARY: RATED VOLTS | Volts | NO LOAD INPUT Amps max | Watts max | D.C. RESISTANCE Ohms nom |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 26V | CONTROL TRANSMITTERS | 1a-A | 26V11CX4b | 11M1G2 | 519-5600 | DEF 148/8 | | 1·732 | R1 R2 (ROTOR) | 26 | 26 | 0·130 | 0·56 | 21·2 |
| | | | | | 580-7649 | — | 8A | | | | | | | |
| | | 1a-C | * 26V11CX4C | 11M1X2 | 014-9804 | 008 | 8C | | | 26 | 26 | 0·130 | 0·56 | 21·2 |
| | CONTROL DIFFERENTIAL TRANSMITTERS | 1a-A | 26V11CDX4b | 11M3B3 | 519-5602 | DEF 148/9 | | 1·789 | S1 S2 S3 (STATOR) | 11·8 | 10·2 | 0·150 | 0·34 | 10·4 |
| | | | | | 580-9000 | — | 9A | | | | | | | |
| | | 1a-C | * 26V11CDX4C | 11M3M2 | 014-9805 | 009 | 9C | | | 11·8 | 10·2 | 0·150 | 0·34 | 10·4 |
| | † CONTROL TRANSFORMERS | 1a-A | 26V11CT4c | 11M2G2 | 519-5595 | DEF 148/7 | | 1·732 | S1 S2 S3 (STATOR) | 11·8 | 10·2 | 0·086 | 0·18 | 17·0 |
| | | | | | 972-6660 | — | 7A | | | | | | | |
| | | 1a-C | * 26V11CT4D | 11M52A2 | 014-9803 | 007 | 7C | | | 11·8 | 10·2 | 0·086 | 0·18 | 17·0 |
| | TORQUE TRANSMITTERS | 1a-A | 26V11TX4b | 11M9D2 | 519-5598 | DEF 148/6 | | 1·732 | R1 R2 (ROTOR) | 26 | 26 | 0·280 | 1·10 | 7·7 |
| | | | | | 972-6650 | — | 6A | | | | | | | |
| | | 1a-C | * 26V11TX4C | 11M9Y2 | 014-9802 | 006 | 6D | | | 26 | 26 | 0·280 | 1·00 | 7·7 |
| | TORQUE DIFFERENTIAL TRANSMITTER | 1a-A | | 11M5A2 | | — | — | 1·789 | S1 S2 S3 (STATOR) | 11·8 | 10·2 | 0·375 | 1·00 | 4·7 |
| | TORQUE RECEIVERS | 1b-B | 26V11TR4b | 11M4E2 | 519-5597 | DEF 148/5 | | 1·732 | R1 R2 (ROTOR) | 26 | 26 | 0·280 | 1·10 | 7·7 |
| | | | | | 972-6676 | — | 5A | | | | | | | |
| | | 1a-C | * 26V11TR4C | 11M4N2 | 014-9801 | 005 | 5C | | | 26 | 26 | 0·280 | 1·00 | 7·7 |

| | SYNCHRO FUNCTION | Drawing & Hardware Detail Ref· | DESCRIPTION: TYPE DESIGNATION Military | Muirhead | NATO NUMBER 5990-99- | MILITARY SPECIFICATION DEF STAN 59-27(2) | MIL-S 20708/ | LENGTH (Dim·L) in inches max | TERMINALS | PRIMARY: RATED VOLTS | Volts | NO LOAD INPUT Amps max | Watts max | D.C. RESISTANCE Ohms nom |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 115V | CONTROL TRANSMITTERS | 1a-A | 11CX4c | 11M1G1 | 519-5601 | DEF 148/2 | | 1·732 | R1 R2 (ROTOR) | 115 | 115 | 0·031 | 0·61 | 320 |
| | | | | | 972-6651 | — | 2A | | | | | | | |
| | | 1a-C | * 11CX4E | 11M1X1 | 014-9807 | 002 | 2C | | | 115 | 115 | 0·031 | 0·61 | 320 |
| | CONTROL DIFFERENTIAL TRANSMITTERS | 1a-A | 11CDX4a | 11M3B2 | 519-5603 | DEF 148/81 | | 1·789 | S1 S2 S3 (STATOR) | 90 | 78 | 0·049 | 0·73 | 200 |
| | | | | | 972-7576 | | 81A | | | | | | | |
| | | 1a-C | * 11CDX4B | 11M3M1 | 014-9811 | 081 | 81C | | | 90 | 78 | 0·049 | 0·73 | 200 |
| | † CONTROL TRANSFORMERS | 1a-A | 11CT4c | 11M2G1 | 519-5594 | DEF 148/1 | | 1·732 | S1 S2 S3 (STATOR) | 90 | 78 | 0·018 | 0·29 | 600 |
| | | | | | 972-7619 | — | 1A | | | | | | | |
| | | 1a-C | * 11CT4E | 11M52A1 | 014-9806 | 001 | 1D | | | 90 | 78 | 0·018 | 0·31 | 600 |
| | TORQUE TRANSMITTERS | 1a-A | 11TX4b | 11M9D1 | 519-5599 | DEF 148/4 | | 1·732 | R1 R2 (ROTOR) | 115 | 115 | 0·060 | 1·10 | 160 |
| | | | | | 972-6670 | — | 4A | | | | | | | |
| | | 1a-C | * 11TX4C | 11M9Y1 | 014-9810 | 004 | 4C | | | 115 | 115 | 0·060 | 1·00 | 160 |
| | TORQUE DIFFERENTIAL TRANSMITTER | 1a-A | | 11M5A1 | | — | — | 1·789 | S1 S2 S3 (STATOR) | 90 | 78 | 0·09 | 1·50 | 135 |
| | TORQUE RECEIVERS | 1b-B | 11TR4b | 11M4E1 | 519-5596 | DEF 148/3 | | 1·732 | R1 R2 (ROTOR) | 115 | 115 | 0·060 | 1·10 | 160 |
| | | | | | 972-6675 | — | 3A | | | | | | | |
| | | 1a-C | * 11TR4C | 11M4N1 | 014-9809 | 003 | 3C | | | 115 | 115 | 0·060 | 1·00 | 160 |

## STANDARD HARDWARE SUPPLIED WITH EACH INSTRUMENT

| Item | Type No· | Detail Ref |
|---|---|---|
| Clamp Assembly | F500/1 | A-B-C |
| Shaft Nut | F500/11 | A-C |
| Shaft Nut (Small shaft) | F500/37 | B |
| Drive Washer (Aluminium) | F500/10A | A |
| Drive Washer (Brass) | F500/10B | C |
| Drive Washer (Small shaft) | F500/38A | B |
| Terminal Lug | F3384 | A-B-C |

* Denotes that the Synchro is on the British Qualified products list to specification DEF STAN 59-27 (PART 2). It is also certified as conforming to NATO Electronics Parts Recommendations for Standardisation of Synchros (N.E.P.R. No. 22) which refers to USA Specification MIL-S-20708C. It is preferred for defence applications. Qualification is subject to renewal every four years.

† The voltage gradient for Control Transformers is 0·39 volt/degree (26V) and 1·0 volt/degree (115V).

| TERMINALS | SECONDARY NO LOAD OUTPUT Volts | Phase lead | D.C. RESISTANCE Ohms nom | NOMINAL IMPEDANCE ohms Zro | Zrs | Zso | Zss | PERFORMANCE ERROR mins Stator | Rotor | Receiver | mV RESIDUAL Fund | Total | MINIMUM TORQUE GRADIENT Fund g cm | degree oz in | MAXIMUM CONTINUOUS Torque g cm | displace-ment deg | PULL-OUT TORQUE g cm | SYNCHRO-NISING TIME secs 30° | - 175 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S1 S2 S3 (STATOR) | 11·8 | 4·5 | 7·1 | 34+j265 | 51+j21 | 7·7+j45 | 8·7+j3·2 | 7 | | | 12 | 19 | | | | | | | |
| | 11·8 | 4·5 | 7·1 | 34+j265 | 51+j21 | 7·7+j45 | 8·7+j3·2 | 7 | | | 12 | 19 | | | | | | | |
| R1 R2 R3 (ROTOR) | 11·8 | 5·7 | 15·9 | 17·6+j86 | 20·7+j8·7 | 12·2+j75 | 17·5+j8·5 | 10 | 10 | | 17 | 26 | | | | | | | |
| | 11·8 | 5·7 | 15·9 | 17·6+j86 | 20·7+j8·7 | 12·2+j75 | 17·5+j8·5 | 7 | 7 | | 17 | 26 | | | | | | | |
| R1 R2 (ROTOR) | 22·5 | 6 | 80 | 130+j716 | 151+j73·5 | 20+j128 | 27+j13·8 | 7 | | | 15 | 18 | | | | | | | |
| | 22·5 | 6 | 80 | 130+j716 | 151+j73·5 | 20+j128 | 27+j13·8 | 7 | | | 15 | 18 | | | | | | | |
| S1 S2 S3 (STATOR) | 11·8 | 3·8 | 2·9 | 13·7+j114 | 19·4+j8·7 | 3·1+j1·3 | 3·3+j1·3 | 7 | | | | | 0·61 | 0·0085 | 25 | 38 | 40 | | |
| | 11·8 | 3·8 | 2·9 | 13·7+j114 | 19·4+j8·7 | 3·1+j19·4 | 3·3+j1·3 | 7 | | | | | 0·55 | 0·008 | 25 | 38 | 40 | | |
| R1 R2 R3 (ROTOR) | 11·8 | 6·5 | 6·3 | | | 6·75+j30 | | 10 | 10 | | | | 0·3 | 0·0042 | | | | | |
| S1 S2 S3 (STATOR) | 11·8 | 3·8 | 2·9 | 13·7+j114 | 19·4+j8·7 | 3·1+j19·4 | 3·3+j1·3 | 7 | | 60 | | | 0·61 | 0·0085 | 25 | 38 | 40 | 1·5 | 2·5 |
| | 11·8 | 3·8 | 2·9 | 13·7+j114 | 19·4+j8·7 | 3·1+j19·4 | 3·3+j1·3 | | | 60 | | | 0·58 | 0·0085 | 25 | 38 | 40 | 1 | 2 |

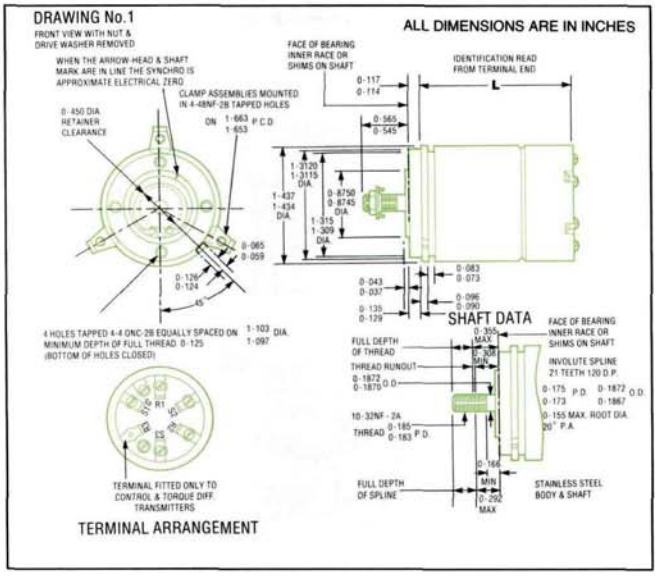
| TERMINALS | SECONDARY NO LOAD OUTPUT Volts | Phase lead | D.C. RESISTANCE Ohms nom | NOMINAL IMPEDANCE ohms Zro | Zrs | Zso | Zss | PERFORMANCE ERROR mins Stator | Rotor | Receiver | mV RESIDUAL Fund | Total | MINIMUM TORQUE GRADIENT Fund g cm | degree oz in | MAXIMUM CONTINUOUS Torque g cm | displace-ment deg | PULL-OUT TORQUE g cm | SYNCHRO-NISING TIME secs 30° | - 175° |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S1 S2 S3 (STATOR) | 90 | 4·5 | 348 | 550+j4070 | 725+j307 | 330+j2080 | 387+j147 | 7 | | | 45 | 75 | | | | | | | |
| | 90 | 4·5 | 348 | 550+j4070 | 725+j307 | 330+j2080 | 387+j147 | 7 | | | 45 | 75 | | | | | | | |
| R1 R2 R3 (ROTOR) | 90 | 4·7 | 450 | 450+j1930 | 487+j200 | 242+j1690 | 421+j211 | 10 | 10 | | 59 | 94 | | | | | | | |
| | 90 | 4·7 | 450 | 450+j1930 | 487+j200 | 242+j1690 | 421+j211 | 7 | 7 | | 60 | 90 | | | | | | | |
| R1 R2 (ROTOR) | 57·3 | 4·5 | 350 | 510+j3020 | 535+j302 | 700+j4900 | 900+j515 | 7 | | | 30 | 60 | | | | | | | |
| | 57·3 | 4·5 | 350 | 510+j3020 | 535+j302 | 700+j4900 | 900+j515 | 7 | | | 32 | 60 | | | | | | | |
| S1 S2 S3 (STATOR) | 90 | 6 | 135 | 285+j2140 | 370+j159 | 175+j1090 | 191+j76 | 7 | | | | | 0·61 | 0·0085 | 25 | 38 | 40 | | |
| | 90 | 6 | 135 | 285+j2140 | 370+j159 | 175+j1090 | 191+j76 | 7 | | | | | 0·61 | 0·0080 | 25 | 38 | 40 | | |
| R1 R2 R3 (ROTOR) | 90 | 6 | 310 | | | 180+j1030 | | 10 | 10 | | | | 0·3 | 0·0042 | | | | | |
| S1 S2 S3 (STATOR) | 90 | 6 | 135 | 285+j2140 | 370+j159 | 175+j1090 | 191+j76 | 7 | | 60 | | | 0·61 | 0·0085 | 25 | 38 | 40 | 1·5 | 2·5 |
| | 90 | 6 | 135 | 285+j2140 | 370+j159 | 175+j1090 | 191+j76 | | | 60 | | | 0·58 | 0·0080 | 25 | 38 | 40 | 1 | 2 |

# 26V & 115V, 60Hz & 400 Hz MIL-S-20708 DEF 148 DEF-STAN 59-27 (PART 2)

AMBIENT TEMPERATURE RANGE:
-55°C to +125°C
**-55°C to +150°C

**400 Hz:** Weight 200g (7 oz)
Rotor Inertia 10g cm² (0·055 oz in²)
Friction Torque 3·6g cm (0·05 oz in)
(Not applicable to Torque Receivers)

**60 Hz:** Weight: 340g (12 oz)
Rotor Inertia 22g cm² (0·12oz in²)
Friction Torque 3·6g cm (0·05oz in)
(Not applicable to Torque Receivers)
15M9D1 & 15M9E1 22g cm (0.3oz in)




| | SYNCHRO FUNCTION | Drawing & Hardware Detail Ref | DESCRIPTION: TYPE DESIGNATION Military | Muirhead | NATO NUMBER 5990-99- | MILITARY SPECIFICATION DEF STAN 59-27(2) | MIL-S 20708/ | LENGTH (Dim·L) in inches max· | PRIMARY: TERMINALS | RATED VOLTS | Volts | NO LOAD INPUT Amps max | Watts max | D.C. RESISTANCE Ohms nom |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 400 Hz | CONTROL TRANSMITTERS | 1-A | 15CX4b | 15M1G1 | 519-5608 | DEF 148/14 | | 1·640 | R1 R2 (ROTOR) | 115 | 115 | 0·082 | 1·41 | 96 |
| | | | | | 972-6686 | — | 14A | | | | | | | |
| | | 1-B | * 15CX4D | 15M1V1 | 014-9812 | 014 | 14E | | | 115 | 115 | 0·085 | 1·41 | 96 |
| | CONTROL DIFFERENTIAL TRANSMITTERS | 1-A | 15CDX4b | 15M3B1 | 519-5610 | DEF 148/16 | | 1·640 | S1 S2 S3 (STATOR) | 90 | 78 | 0·090 | 1·60 | 108 |
| | | | | | 972-6666 | — | 16A | | | | | | | |
| | | 1-B | * 15CDX4D | 15M3H1 | 014-9815 | 016 | 16D | | | 90 | 78 | 0·090 | 1·34 | 108 |
| | † CONTROL TRANSFORMERS | 1-A | 15CT4b | 15M2E1 | 519-5605 | DEF 148/15 | | 1·640 | S1 S2 S3 (STATOR) | 90 | 78 | 0·010 | 0·200 | 820 |
| | | | | | 972-6661 | — | 15A | | | | | | | |
| | | 1-B | * 15CT4C | 15M2P1 | 014-9814 | 015 | 15E | | | 90 | 78 | 0·010 | 0·200 | 820 |
| | | 1-B | 15CT4c | 15M2H1 | | — | 15D | | | 90 | 78 | 0·010 | 0·200 | 820 |
| | TORQUE TRANSMITTER | 1-A | 15TX4b | 15M9C1 | 972-6671 | See Note 1 | | 1·640 | R1 R2 (ROTOR) | 115 | 115 | 0·200 | 3·1 | 40 |
| | TORQUE DIFFERENTIAL TRANSMITTERS | 1-A | 15TDX4b | 15M5B1 | 519-5612 | DEF 148/17 | | 1·640 | S1 S2 S3 (ROTOR) | 90 | 78 | 0·215 | 3·5 | 40 |
| | | | | | 972-6679 | — | 17A | | | | | | | |
| | | 1-B | * 15TDX4C | 15M5D1 | 014-9816 | 017 | 17D | 1·640 | | 90 | 78 | 0·215 | 3·5 | 40 |
| | TORQUE RECEIVERS | 1-A | 15TR4C | 15M4D1 | 972-0182 | DEF 148/19 | 19A | | R1 R2 (ROTOR) | 115 | 115 | 0·19 | 3·4 | 40 |
| | | 1-A | | 15M4D2 | 523-3862 | — | — | 1·640 | | 26 | 26 | 0·90 | 3·25 | 2·15 |

| | SYNCHRO FUNCTION | Drawing & Hardware Detail Ref· | DESCRIPTION: TYPE DESIGNATION Military | Muirhead | NATO NUMBER 5990-99- | MILITARY SPECIFICATION DEF STAN 59-27(2) | MIL-S 20708/ | LENGTH (Dim·L) in inches max· | PRIMARY: TERMINALS | RATED VOLTS | Volts | NO LOAD INPUT Amps max | Watts max | D.C. RESISTANCE Ohms nom |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 60 Hz | CONTROL TRANSMITTER | 1-A | 15CX6b | 15M1H1 | 972-7593 | — | 20A | 2·391 | R1 R2 (ROTOR) | 115 | 115 | 0·56 | 2·4 | 550 |
| | CONTROL DIFFERENTIAL TRANSMITTER | 1-A | 15CDX6b | 15M3G1 | | DEF 148/22 | | 2·391 | S1 S2 S3 (STATOR) | 90 | 78 | 0·038 | 0·63 | 500 |
| | † CONTROL TRANSFORMER | 1-A | 15CT6b | 15M2N1 | | DEF 148/21 | | 2·391 | S1 S2 S3 (STATOR) | 90 | 78 | 0·013 | 0·21 | 1300 |
| | TORQUE TRANSMITTERS | 1-A | See Note 1 | 15M9D1 | | See Note 1 | | 2·391 | R1 R2 (ROTOR) | See Note 2 | | | | |
| | | 1-A | See Note 1 | 15M9E1 ** | | | | | | 115 | 115 | 0·2 | 1·7 | 450 |
| | | 1-A | See Note 1 | 15M9F1 | | | | | | 115 | 115 | 0·2 | 1·7 | 450 |
| | TORQUE RECEIVER | 1-A | 15TR6a | 15M4H1 | 972-0183 | DEF 148/23 | 23A | 2·391 | R1 R2 (ROTOR) | 115 | 115 | 0·2 | 3·1 | 400 |

## STANDARD HARDWARE ITEMS NORMALLY SUPPLIED WITH EACH INSTRUMENT

| Item | Type No· | Detail Ref |
|---|---|---|
| Clamp Assembly | F500/1 | A-B |
| Shaft Nut | F500/11 | A-B |
| Drive Washer (Aluminium) | F500/10A | A |
| Drive Washer (Brass) | F500/10B | B |
| Terminal Lug | F3090 | A-B |

* Denotes that the Synchro is on the British Qualified products list to specification DEF STAN 59-27 (PART 2). It is also certified as conforming to NATO Electronics Parts Recommendations for Standardisation of Synchros (N.E.P.R. No. 22) which refers to USA Specification MIL-S-20708C. It is preferred for defence applications. Qualification is subject to renewal every four years.
† Voltage Gradient for Control Transformers is 1 volt/degree.

### SPECIAL NOTES

NOTE 1: 15M9C1, 15M9D1 and 15M9E1 are basically designed to MIL-S-20708A. 15M9D1 & E1 are suitable for atomic reactor use as control rod indicator transmitters in ambients up to 150°C and regions of limited radio activity. 15M9F1 is basically designed to MIL-S-20708A and is intended for use as a transmitter with 15TR6a.
NOTE 2: Details as for 15M9E1, but spiral ligaments limiting rotation to 450°.

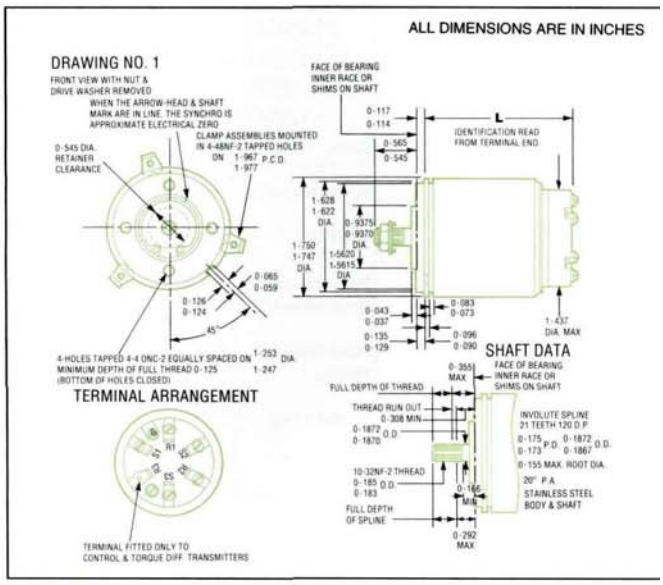
| TERMINALS | SECONDARY NO LOAD OUTPUT Volts | Phase lead | D.C. RESISTANCE Ohms nom | NOMINAL IMPEDANCE ohms Zro | Zrs | Zso | Zss | PERFORMANCE ERROR mins Stator | Rotor | Receiver | mV RESIDUAL Fund | Total | MINIMUM TORQUE GRADIENT Fund g cm | degree oz in | MAXIMUM CONTINUOUS Torque g cm | displace-ment deg | PULL-OUT TORQUE g cm | SYNCHRO-NISING TIME secs 30° - 175° | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S1 S2 S3 (STATOR) | 90 | 3·6 | 83 | 179+j1400 | 217+j125 | 100+j775 | 112+j63 | 6 | | | 40 | 90 | | | | | | | |
| | 90 | 3·6 | 83 | 179+j1400 | 217+j125 | 100+j775 | 112+j63 | 6 | | | 32 | 60 | | | | | | | |
| R1 R2 R3 (ROTOR) | 90 | 5·2 | 139 | 159+j1060 | 190+j125 | 129+j917 | 164+j111 | 6 | 6 | | 60 | 90 | | | | | | | |
| | 90 | 5·2 | 139 | 159+j1060 | 190+j125 | 129+j917 | 164+j111 | 6 | 6 | | 32 | 60 | | | | | | | |
| R1 R2 (ROTOR) | 57·3 | 4·2 | 530 | 837+j5170 | 943+j589 | 1020+j8330 | 1500+j982 | 6 | | | 40 | 60 | | | | | | | |
| | 57·3 | 4·2 | 530 | 837+j5170 | 943+j589 | 1020+j8330 | 1500+j982 | 6 | | | 32 | 60 | | | | | | | |
| | 57·3 | 4·2 | 530 | 837+j5170 | 943+j589 | 1020+j8330 | 1500+j982 | 6 | | | 32 | 60 | | | | | | | |
| S1 S2 S3 (STATOR) | 90 | 2·5 | 42 | 100+j955 | 96+j68 | 65+j493 | 48+j33 | 6 | | | 120 | 220 | 2·2 | 0·03 | 22 | 10 | 85 | | |
| R1 R2 R3 (ROTOR) | 90 | 4·0 | 94 | 100+j503 | 107+j62 | 50+j418 | 88+j60 | 8 | 8 | | — | — | 0·79 | | | | | | |
| | 90 | 4·0 | 94 | 100+j503 | 107+j62 | 50+j418 | 88+j60 | 8 | 8 | | — | — | 0·79 | 0·011 | | | | | |
| S1 S2 S3 (STATOR) | 90 | 5·0 | 42 | 100+j995 | 96+j68 | 65+j493 | 48+j33 | 6 | | 45 | — | — | 2·2 | 0·03 | 22 | 10 | 85 | 1 | 2 |
| | 11·8 | 4·0 | 0·83 | 5+j47 | — | 1·1+j8·3 | 0·9+j0·4 | 6 | | 45 | — | — | 1.70 | 0·23 | 22 | 10 | 85 | 1 | 2 |

| TERMINALS | SECONDARY NO LOAD OUTPUT Volts | Phase lead | D.C. RESISTANCE Ohms nom | NOMINAL IMPEDANCE ohms Zro | Zrs | Zso | Zss | PERFORMANCE ERROR mins Stator | Rotor | Receiver | mV RESIDUAL Fund | Total | MINIMUM TORQUE GRADIENT Fund g cm | degree oz in | MAXIMUM CONTINUOUS Torque g cm | displace-ment deg | PULL-OUT TORQUE g cm | SYNCHRO-NISING TIME secs 30° - 175° | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S1 S2 S3 (STATOR) | 90 | 15 | 470 | 628+j2210 | 1170+j299 | 367+j1190 | 630+j143 | 7 | | | 75 | 110 | | | | | | | |
| R1 R2 R3 (ROTOR) | 90 | 10 | 940 | 780+j2625 | 1114+j270 | 435+j2270 | 930+j830 | 8 | 8 | | 75 | 125 | | | | | | | |
| R1 R2 (ROTOR) | 57·3 | 9·0 | 900 | 970+j3800 | 1430+j409 | 1140+j6240 | 2280+j836 | 6 | | | 60 | 90 | | | | | | | |
| S1 S2 S3 (STATOR) | 90 | 14 | 390 | 500+j2000 | 800+j180 | 300+j1300 | 450+j100 | 10 | | | — | — | 2.2 | 0·03 | 70 | 33 | 95 | | |
| | 90 | 14 | 390 | 500+j2000 | 800+j180 | 300+j1300 | 450+j100 | 6 | | | — | — | 2·2 | 0·03 | 70 | 33 | 95 | | |
| S1 S2 S3 (STATOR) | 90 | 14 | 350 | 502+j2240 | 885+j194 | 301+j1400 | 509+j106 | 6 | | 45 | — | — | 2·2 | 0·03 | 70 | 33 | 95 | 1 | 2 |

115V
60Hz & 400 Hz
MIL-S-20708
DEF-STAN
59-27 (PART 2)

AMBIENT
TEMPERATURE RANGE:
-55°C to +125°C

Weight 400g (14 oz)
Rotor Inertia 29g cm² (0·16 oz in²)
Friction Torque 3·6g cm (0·05 oz in)
(Not applicable to Torque Receivers)




| SYNCHRO FUNCTION | Drawing & Hardware Detail Ref· | DESCRIPTION: TYPE DESIGNATION Military | Muirhead | NATO NUMBER 5990-99- | MILITARY SPECIFICATION DEF STAN 59-27(2) | MIL-S 20708/ | LENGTH (Dim·L) in inches max· | PRIMARY: TERMINALS | RATED VOLTS | Volts | NO LOAD INPUT Amps max | Watts max | D.C. RESISTANCE Ohms nom |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 400 Hz | | | | | | | | | | | | | |
| CONTROL TRANSMITTERS | 1-A | 18CX4b | 18M1B2 | 519-5614 | DEF 148/28 | | | R1 R1 (ROTOR) | 115 | 115 | 0·11 | 1·32 | 25 |
| | | | | 972-6687 | — | 28A | | | | | | | |
| | 1-B | * 18CX4d | 18M1C1 | | — | 28C | 2·388 | | 115 | 115 | 0·11 | 1·32 | 25 |
| | 1-B | * 18CX4D | 18M1D1 | 014-9822 | 028 | 28D | | | 115 | 115 | 0·11 | 1·32 | 25 |
| CONTROL DIFFERENTIAL TRANSMITTERS | 1-A | 18CDX4b | 18M3B1 | 519-5618 | DEF 148/30 | | | S1 S2 S3 (STATOR) | 90 | 78 | 0·128 | 1·21 | 50 |
| | | | | 972-6667 | — | 30A | 2·388 | | | | | | |
| | 1-B | * 18CDX4C | 18M3D1 | 014-9825 | 030 | 30D | | | 90 | 78 | 0·128 | 1·21 | 50 |
| † CONTROL TRANSFORMERS | 1-A | 18CT4b | 18M2B2 | 519-5616 | DEF 148/29 | | | S1 S2 S3 (STATOR) | 90 | 78 | 0·0065 | 0·07 | 850 |
| | | | | 972-6662 | — | 29A | | | | | | | |
| | 1-B | 18CT4e | 18M2C1 | | — | 29C | 2·388 | | 90 | 78 | 0·0070 | 0·07 | 850 |
| | 1-B | * 18CT4C | 18M2E1 | 014-9824 | 029 | 29D | | | 90 | 78 | 0·0070 | 0·07 | 850 |
| TORQUE DIFFERENTIAL TRANSMITTER | 1-B | * 18TDX4C | 18M5C1 | 014-9826 | 031 | 31D | 2·388 | S1 S2 S3 (STATOR) | 90 | 78 | 0·45 | 4·5 | 11 |
| TORQUE RECEIVERS TRANSMITTERS | 1-A | 18TR4b | 18M4F1 | 972-6677 | DEF 148/32 | 32A | | R1 R2 (ROTOR) | 115 | 115 | 0·43 | 4·0 | 9·5 |
| | 1-B | 18TRX4a | 18M4L1 | 547-0891 | — | 32E | 2·388 | | 115 | 115 | 0·40 | 4·0 | 9·5 |

| SYNCHRO FUNCTION | Drawing & Hardware Detail Ref· | DESCRIPTION: TYPE DESIGNATION Military | Muirhead | NATO NUMBER 5990-99- | MILITARY SPECIFICATION DEF STAN 59-27(2) | MIL-S 20708/ | LENGTH (Dim·L) in inches max· | PRIMARY: TERMINALS | RATED VOLTS | Volts | NO LOAD INPUT Amps max | Watts max | D.C. RESISTANCE Ohms nom |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 60 Hz | | | | | | | | | | | | | |
| CONTROL TRANSMITTERS | 1-A | 18CX6b | 18M1B1 | 519-5613 | DEF 148/33 | | | R1 R2 (ROTOR) | 115 | 115 | 0·040 | 1·11 | 520 |
| | | | | 972-6658 | — | 33A | | | | | | | |
| | 1-B | 18CX6c | 18M1C2 | | — | 33B | 2·388 | | 115 | 115 | 0·040 | 1·11 | 520 |
| | 1-B | * 18CX6C | 18M1D2 | 014-9828 | 033 | 33C | | | 115 | 115 | 0·040 | 1·11 | 520 |
| CONTROL DIFFERENTIAL TRANSMITTERS | 1-A | 18CDX6b | 18M3B2 | 519-5619 | DEF 148/36 | | | S1 S2 S3 (STATOR) | 90 | 78 | 0·052 | 1·45 | 572 |
| | | | | 972-6668 | — | 36A | 2·388 | | | | | | |
| | 1-B | * 18CDX6D | 18M3D2 | 014-9831 | 036 | 36C | | | 90 | 78 | 0·052 | 1·45 | 572 |
| † CONTROL TRANSFORMERS | 1-A | 18CT6b | 18M2B1 | 519-5617 | DEF 148/34 | | | S1 S2 S3 (STATOR) | 90 | 78 | 0·017 | 0·45 | 2160 |
| | | | | 972-6663 | — | 34A | 2·388 | | | | | | |
| | 1-B | * 18CT6D | 18M2E2 | 014-9829 | 034 | 34C | | | 90 | 78 | 0·017 | 0·45 | 2160 |
| TORQUE TRANSMITTER | 1-A | 18TX6a | 18M9B1 | 972-6672 | DEF 148/37 | 37A | 2·388 | R1 R2 (ROTOR) | 115 | 115 | 0·100 | 4 | 245 |
| TORQUE RECEIVERS TRANSMITTERS | 1-A | 18TRX6a | 18M4E1 | 972-6683 | — | 35A | 2·388 | R1 R2 (ROTOR) | 115 | 115 | 0·105 | 4 | 245 |
| | 1-B | 18TRX6b | 18M4N1 | | — | 35C | | | 115 | 115 | 0·105 | 4 | 245 |
| | 1-A | ‡ | 18M4E2 | | — | | | | 115 | 115 | 0·094 | 5 | 365 |

## STANDARD HARDWARE ITEMS NORMALLY SUPPLIED WITH EACH INSTRUMENT

| Item | Type No· | Detail Ref |
|---|---|---|
| Clamp Assembly | F500/1 | A-B |
| Shaft Nut | F500/11 | A-B |
| Drive Washer (Aluminium) | F500/10A | A |
| Drive Washer (Brass) | F500/10B | B |
| Terminal Lug | F3090 | A-B |

* Denotes that the Synchro is on the British Qualified products list to specification DEF STAN 59-27 (PART 2). It is also certified as conforming to NATO Electronics Parts Recommendations for Standardisation of Synchros (N.E.P.R. No. 22) which refers to USA Specification MIL-S-20708C. It is preferred for defence applications. Qualification is subject to renewal every four years.
† The voltage gradient for the Control Transformers is 1 volt/degree.
‡ Designed to operate at 50Hz.

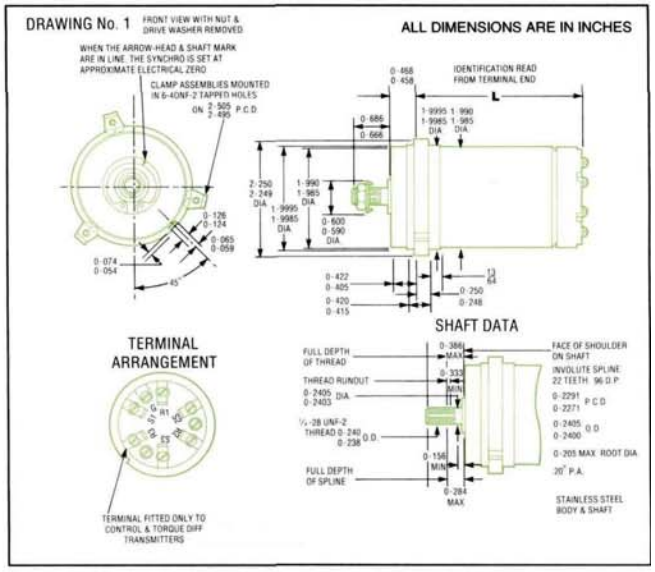
| SECONDARY | | | | NOMINAL IMPEDANCE ohms | | | | PERFORMANCE | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TERMINALS | NO LOAD OUTPUT Volts | Phase lead | D.C. RESISTANCE Ohms nom | Zro | Zrs | Zso | Zss | ERROR mins Stator | Rotor | Receiver | mV RESIDUAL Fund | Total | MINIMUM TORQUE GRADIENT Per degree g cm | oz in | MAXIMUM CONTINUOUS Torque g cm | displacement deg | PULL-OUT TORQUE g cm | SYNCHRONISING TIME secs 30° - 175° | |
| S1 S2 S3 (STATOR) | 90 | 1 | 38 | 78+j1210 | 78+j81 | 52+j598 | 40+j39 | 6 | | | 50 | 90 | | | | | | | |
| | 90 | 1 | 38 | 78+j1210 | 78+j81 | 52+j598 | 40+j39 | 6 | | | 40 | 60 | | | | | | | |
| | 90 | 1 | 38 | 78+j1210 | 78+j81 | 52+j598 | 40+j39 | 6 | | | 40 | 60 | | | | | | | |
| R1 R2 R3 (ROTOR) | 90 | 3 | 45 | 65+j669 | 72+j71 | 63+j623 | 65+j64 | 6 | 6 | | 40 | 75 | | | | | | | |
| | 90 | 3 | 45 | 65+j669 | 72+j71 | 63+j623 | 65+j64 | 6 | 6 | | 40 | 75 | | | | | | | |
| R1 R2 (ROTOR) | 57·3 | 2·5 | 390 | 800+j7770 | 745+j782 | 1360+j12600 | 1240+j1250 | 6 | | | 30 | 45 | | | | | | | |
| | 57·3 | 2·5 | 390 | 800+j7770 | 745+j782 | 1360+j12600 | 1240+j1250 | 6 | | | 20 | 30 | | | | | | | |
| | 57·3 | 2·5 | 390 | 800+j7770 | 745+j782 | 1360+j12600 | 1240+j1250 | 6 | | | 20 | 30 | | | | | | | |
| R1 R2 R3 (ROTOR) | 90 | 3 | 14 | 20·8+j206 | 21·1+j22·1 | 17+j183 | 18·3+j19·9 | 8 | 8 | | Not applicable | | 4·3 | 0·06 | | | | | |
| S1 S2 S3 (STATOR) | 90 | 1·5 | 10·5 | 25+j370 | 25+j25 | 16+j180 | 12+j12 | 5 | | 45 | Not applicable | | 7·2 | 0·1 | 104 | 12 | 455 | 1 | 2 |
| | 90 | 1·5 | 10·5 | 25+j370 | 25+j25 | 16+j180 | 12+j12 | 8 | | 45 | 50 | 100 | 7·2 | 0·1 | 104 | 12 | 455 | 1 | 2 |

| SECONDARY | | | | NOMINAL IMPEDANCE ohms | | | | PERFORMANCE | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TERMINALS | NO LOAD OUTPUT Volts | Phase lead | D.C. RESISTANCE Ohms nom | Zro | Zrs | Zso | Zss | ERROR mins Stator | Rotor | Receiver | mV RESIDUAL Fund | Total | MINIMUM TORQUE GRADIENT Per degree g cm | oz in | MAXIMUM CONTINUOUS Torque g cm | displacement deg | PULL-OUT TORQUE g cm | SYNCHRONISING TIME secs 30° - 175° | |
| S1 S2 S3 (STATOR) | 90 | 10 | 623 | 605+j3130 | 1380+j451 | 510+j1580 | 740+j150 | 8 | | | 65 | 115 | | | | | | | |
| | 90 | 10 | 623 | 605+j3130 | 1380+j451 | 510+j1580 | 740+j150 | 8 | | | 30 | 85 | | | | | | | |
| | 90 | 10 | 623 | 605+j3130 | 1380+j451 | 510+j1580 | 740+j150 | 8 | | | 30 | 85 | | | | | | | |
| R1 R2 R3 (ROTOR) | 90 | 17 | 867 | 717+j1850 | 1130+j315 | 465+j1490 | 885+j308 | 8 | 8 | | 80 | 100 | | | | | | | |
| | 90 | 17 | 865 | 717+j1850 | 1130+j315 | 465+j1490 | 885+j308 | 7 | 7 | | 60 | 100 | | | | | | | |
| R1 R2 (ROTOR) | 57·3 | 18 | 1050 | 1050+j3280 | 1880+j611 | 1690+j4800 | 2830+j848 | 6 | | | 30 | 60 | | | | | | | |
| | 57·3 | 18 | 1050 | 1050+j3280 | 1880+j611 | 1690+j4800 | 2830+j848 | 6 | | | 25 | 45 | | | | | | | |
| S1 S2 S3 (STATOR) | 90 | 14 | 300 | 335+j1270 | 686+j210 | 256+j916 | 379+j81 | 6 | | | Not applicable | | 3·6 | 0·05 | 134 | 37 | 172 | | |
| S1 S2 S3 (STATOR) | 90 | 14 | 300 | 335+j1270 | 686+j210 | 256+j916 | 379+j81 | 6 | | 45 | Not applicable | | 3·6 | 0·05 | 134 | 37 | 172 | 1 | 2 |
| | 90 | 14 | 300 | 335+j1270 | 686+j210 | 256+j916 | 379+j81 | 6 | | 45 | 50 | 300 | 3·6 | 0·05 | 134 | 37 | 172 | 1 | 2 |
| | 90 | 19 | 475 | 565+j1200 | | 405+j1120 | 594+j115 | 7 | | 60 | Not applicable | | 2·9 | 0·04 | | | | 1 | 2 |

## 115V, 60Hz & 400 Hz
## MIL-S-20708
## DEF 148
## DEF-STAN
## 59-27 (PART 2)

AMBIENT
TEMPERATURE RANGE:
-55°C to +125°C

Weight 850g (30 oz)
Rotor Inertia 130g cm² (0·71 oz in²)
Friction Torque 14g cm (0·2 oz in)
(Not applicable to Torque Receivers)




| | SYNCHRO FUNCTION | Drawing & Hardware Detail Ref· | DESCRIPTION: TYPE DESIGNATION Military | Muirhead | NATO NUMBER 5990-99- | MILITARY SPECIFICATION DEF STAN 59-27(2) | MIL-S 20708/ | LENGTH (Dim·L) in inches max· | TERMINALS | PRIMARY: RATED VOLTS | Volts | NO LOAD INPUT Amps max | Watts max | D.C. RESISTANCE Ohms nom |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 400 Hz | CONTROL TRANSMITTERS | 1-A | 23CX4b | 23M1C1 | 519-5633 971-7209 | DEF 148/45 — | 45A | 3·160 | R1 R2 (ROTOR) | 115 | 115 | 0·245 | 2·94 | 15·5 |
| | | 1-B | * 23CX4D | 23M1H1 | 014-9832 | 045 | 45D | | | 115 | 115 | 0·245 | 2·95 | 15·5 |
| | CONTROL DIFFERENTIAL TRANSMITTERS | 1-A | 23CDX4b | 23M3B1 | 519-5622 971-8487 | DEF 148/47 — | 47A | 3·410 | S1 S2 S3 (STATOR) | 90 | 78 | 0·284 | 2·9 | 18 |
| | | 1-B | * 23CDX4C | 23M3E1 | 014-9834 | 047 | 47C | | | 90 | 78 | 0·285 | 2·9 | 18 |
| | † CONTROL TRANSFORMERS | 1-A | 23CT4b | 23M2B1 | 519-5626 971-8488 | DEF 148/46 — | 46A | 3·160 | S1 S2 S3 (STATOR) | 90 | 78 | 0·0058 | 0·071 | 730 |
| | | 1-B | ** 23CT4C | 23M2E1 | 014-9833 | 046 | 46C | | | 90 | 78 | 0·0057 | 0·071 | 730 |
| | TORQUE TRANSMITTERS | 1-A | 23TX4b | 23M9C1 | 519-5634 | DEF 148/44 | | | R1 R2 (ROTOR) | 115 | 115 | 0·719 | 6·5 | 2·8 |
| | | 1-A | | ** 23M9C3 | | | | 3·160 | | 115 | 115 | 0·800 | 4·5 | 3·4 |
| | TORQUE DIFFERENTIAL TRANSMITTER | 1-A | | ‡ 23M5B1 | 972-6681 | — | — | 3·410 | S1 S2 S3 (STATOR) | 90 | 78 | 0·950 | 5·2 | 4·3 |
| | TORQUE RECEIVERS | 1-A | 23TR4b | 23M4D1 | 519-5624 | DEF 148/50 | | 3·160 | R1 R2 (ROTOR) | 115 | 115 | 0·719 | 6·5 | 2·8 |
| | | 1-B | * 23TRX4A | 23M4F2 | 014-9836 | 050 | 50C | | | 115 | 115 | 0·720 | 4·6 | 2·8 |

| | SYNCHRO FUNCTION | Drawing & Hardware Detail Ref· | DESCRIPTION: TYPE DESIGNATION Military | Muirhead | NATO NUMBER 5990-99- | MILITARY SPECIFICATION DEF STAN 59-27(2) | MIL-S 20708/ | LENGTH (Dim·L) in inches max· | TERMINALS | PRIMARY: RATED VOLTS | Volts | NO LOAD INPUT Amps max | Watts max | D.C. RESISTANCE Ohms nom |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 60 Hz | CONTROL TRANSMITTERS | 1-A | 23CX6c | 23M1C2 | 519-5632 972-6659 | DEF 148/52 — | 52A | 3·160 | R1 R2 (ROTOR) | 115 | 115 | 0·080 | 1·60 | 195 |
| | | 1-B | * 23CX6D | 23M1H2 | 014-9837 | 052 | 52C | | | 115 | 115 | 0·080 | 1·74 | 184 |
| | CONTROL DIFFERENTIAL TRANSMITTERS | 1-A | 23CDX6b | 23M3B2 | 519-5623 972-6669 | DEF 148/54 — | 54A | 3·410 | S1 S2 S3 (STATOR) | 90 | 78 | 0·090 | 1·60 | 255 |
| | | 1-B | * 23CDX6C | 23M3E2 | 014-9839 | 054 | 54C | | | 90 | 78 | 0·090 | 1·82 | 255 |
| | † CONTROL TRANSFORMERS | 1-A | 23CT6c | 23M2B2 | 519-5625 | DEF 148/53 — | 53A | 3·160 | S1 S2 S3 (STATOR) | 90 | 78 | 0·0185 | 0·45 | 1740 |
| | | 1-B | * 23CT6D | 23M2E2 | 014-9838 | 053 | 53C | | | 90 | 78 | 0·0185 | 0·50 | 1740 |
| | TORQUE TRANSMITTER | 1-A | 23TX6b | 23M9C2 | 972-6674 | DEF 148/51 | 51A | 3·160 | R1 R2 (ROTOR) | 115 | 115 | 0·23 | 6·0 | 74 |
| | TORQUE DIFFERENTIAL TRANSMITTER | 1-A | 23TDX6b | 25M5B2 | 972-6682 | — | 55A | 3·410 | S1 S2 S3 (STATOR) | 90 | 78 | 0·20 | 5·0 | 113 |
| | TORQUE RECEIVER TRANSMITTERS | 1-A | 23TRX6a | 23M4C1 | 519-5629 972-6684 | DEF 148/56 — | 56A | 3·160 | R1 R2 (ROTOR) | 115 | 115 | 0·23 | 6·0 | 74 |
| | | 1-B | * 23TRX6B | 23M4F1 | 014-9841 | 056 | 56C | | | 115 | 115 | 0·21 | 5·6 | 74 |

| STANDARD HARDWARE ITEMS NORMALLY SUPPLIED WITH EACH INSTRUMENT | | |
|---|---|---|
| Item | Type No· | Detail Ref |
| Shaft Nut | F500/53 | A-B |
| Drive Washer (Aluminium) | F500/32A | A |
| Drive Washer (Brass) | F500/32B | B |
| Terminal Lug | F3090 | A-B |

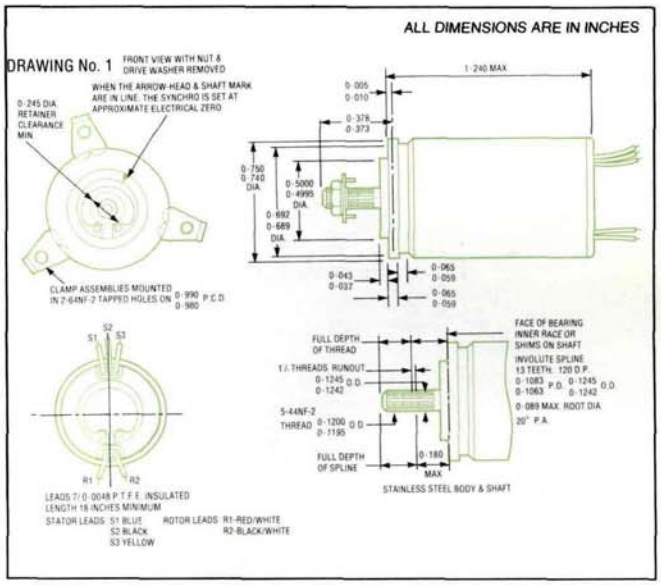
* Denotes that the Synchro is on the British Qualified products list to specification DEF STAN 59-27 (PART 2). It is also certified as conforming to NATO Electronics Parts Recommendations for Standardisation of Synchros (N.E.P.R. No. 22) which refers to USA Specification MIL-S-20708C. It is preferred for defence applications. Qualification is subject to renewal every four years.
† The voltage gradient for Control Transformers is 1 volt/degree.
** Basically designed to the requirements of MIL-S-20708A.
‡ Basically designed to the requirements of MIL-S-20708A and DEF 148.

| SECONDARY | | | | NOMINAL IMPEDANCE ohms | | | | PERFORMANCE | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TERMINALS | NO LOAD OUTPUT Volts | Phase lead | D.C. RESISTANCE Ohms nom | Zro | Zrs | Zso | Zss | ERROR mins Stator | Rotor | Receiver | mV RESIDUAL Fund | Total | MINIMUM TORQUE GRADIENT Fund g cm | degree oz in | MAXIMUM CONTINUOUS Torque g cm | displacement deg | PULL-OUT TORQUE g cm | SYNCHRONISING TIME secs 30° - 175° | |
| S1 S2 S3 (STATOR) | 90 | 1·8 | 11·8 | 31+j530 | 31+j36 | 15+j263 | 15·7+j17·7 | 8 | | | 40 | 60 | | | | | | | |
| | 90 | 1·8 | 11·8 | 31+j530 | 31+j36 | 15+j263 | 15·7+j17·7 | 6 | | | 32 | 48 | | | | | | | |
| R1 R2 R3 (ROTOR) | 90 | 3 | 19 | 26+j310 | 27+j30 | 24+j280 | 24·7+j27·2 | 7 | 7 | | 40 | 75 | | | | | | | |
| | 90 | 3 | 19 | 26+j310 | 27+j30 | 24+j280 | 24·7+j27·2 | 7 | 7 | | 30 | 60 | | | | | | | |
| R1 R2 (ROTOR) | 57·3 | 2 | 330 | 750+j8570 | 660+j812 | 1230+j14300 | 1100+j1360 | 6 | | | 30 | 60 | | | | | | | |
| | 57·3 | 2 | 330 | 750+j8750 | 660+j812 | 1230+j14300 | 1100+j1360 | 6 | | | 20 | 45 | | | | | | | |
| S1 S2 S3 (STATOR) | 90 | 1 | 3·7 | 14+j225 | 8·7+j11 | 8·5+j110 | 4·2+j5·3 | 6 | | | — | — | 18 | 0·25 | 290 | 16 | 1380 | | |
| | 90 | 1 | 3·0 | 18+j257 | 8·8+j12 | 10+j126 | 4·3+j5·8 | 6 | | | 75 | 100 | 17·3 | 0·24 | 275 | 16 | 1300 | | |
| R1 R2 R3 (ROTOR) | 90 | 2 | 6·0 | 10+j120 | 8·2+j11·7 | 7·8+j107 | 7·3+j10·6 | 8 | 8 | | | | 11 | 0·15 | | | | | |
| S1 S2 S3 (STATOR) | 90 | 1 | 3·7 | 14+j225 | 8·7+j11 | 8·5+j110 | 4·2+j5·3 | 6 | | 45 | — | — | 18 | 0·25 | 290 | 16 | 1380 | 1 | 2 |
| | 90 | 1 | 3·7 | 14+j225 | 8·7+j11 | 8·5+j110 | 4·2+j5·3 | 6 | | 45 | 30 | 150 | 18 | 0·25 | 275 | 16 | 1380 | 1 | 2 |

| SECONDARY | | | | NOMINAL IMPEDANCE ohms | | | | PERFORMANCE | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TERMINALS | NO LOAD OUTPUT Volts | Phase lead | D.C. RESISTANCE Ohms nom | Zro | Zrs | Zso | Zss | ERROR mins Stator | Rotor | Receiver | mV RESIDUAL Fund | Total | MINIMUM TORQUE GRADIENT Fund g cm | degree oz in | MAXIMUM CONTINUOUS Torque g cm | displacement deg | PULL-OUT TORQUE g cm | SYNCHRONISING TIME secs 30° - 175° | |
| S1 S2 S3 (STATOR) | 90 | 6 | 276 | 242+j1650 | 462+j150 | 211+j954 | 319+j62 | 8 | | | 40 | 75 | | | | | | | |
| | 90 | 6 | 221 | 242+j1650 | 462+j150 | 211+j954 | 319+j62 | 6 | | | 30 | 60 | | | | | | | |
| R1 R2 R3 (ROTOR) | 90 | 11 | 315 | | 453+j147 | 214+j947 | | 8 | 8 | | 65 | 80 | | | | | | | |
| | 90 | 11 | 315 | | 453+j147 | 214+j947 | | 8 | 8 | | 40 | 65 | | | | | | | |
| R1 R2 (ROTOR) | 57·3 | 14 | 800 | 883+j3080 | 1500+j512 | 1380+j4790 | 2370+j791 | 6 | | | 40 | 60 | | | | | | | |
| | 57·3 | 14 | 800 | 883+j3080 | 1500+j512 | 1380+j4790 | 2370+j791 | 6 | | | 30 | 45 | | | | | | | |
| S1 S2 S3 (STATOR) | 90 | 7 | 103 | 96+j738 | 210+j63 | 78+j445 | 106+j24 | 8 | | | | | 8·6 | 0·12 | 475 | 44 | 700 | | |
| R1 R2 R3 (ROTOR) | 90 | 11 | 129 | 105+j500 | 181+j62 | 85+j415 | 152+j54 | 6 | 6 | | | | 2·2 | 0·03 | | | | | |
| S1 S2 S3 (STATOR) | 90 | 7 | 103 | 96+j738 | 210+j63 | 78+j445 | 106+j24 | 8 | | 45 | | | 8·6 | 0·12 | 475 | 44 | 700 | 1 | 2 |
| | 90 | 5 | * 103 | 92+j980 | 218+j66 | 82+j480 | 108+j25 | 8 | | 45 | 60 | 160 | 8·6 | 0·12 | 475 | 44 | 700 | 1 | 2 |

26V 400Hz

| STANDARD HARDWARE SUPPLIED WITH EACH INSTRUMENT | |
|---|---|
| **Item** | **Type No.** |
| Clamp Assembly | F500/33 |
| Shaft Nut | F500/37 |
| Drive Washer (Aluminium) | F500/38A |




AMBIENT TEMPERATURE RANGE: -55°C to +125°C

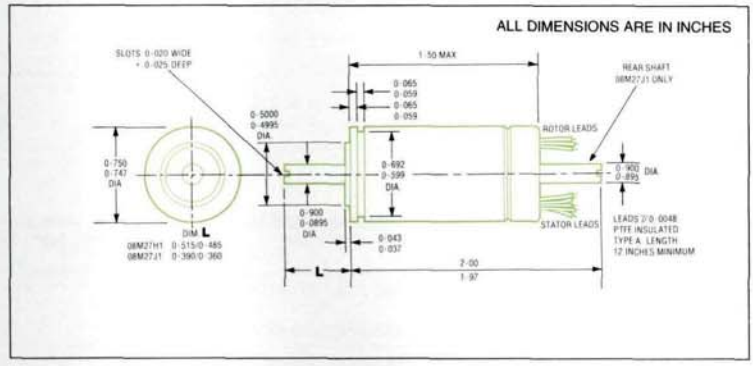
*Weight: 48g (1·7 oz)*
Friction Torque: 2·9 g cm (0·04 oz in)
Rotor Inertia: 1·0 g cm² (0·0055 oz in²)

| SYNCHRO FUNCTION | TYPE DESIGNATION Muirhead | PRIMARY TERMINALS | RATED VOLTS | Volts | NO LOAD INPUT Amps max | Watts max | D.C. RESISTANCE Ohms Nom. | SECONDARY TERMINALS | NO LOAD OUTPUT Volts | Phase lead | D.C. RESISTANCE Ohms nom. | NOMINAL IMPEDANCE Ohms Zro | Zrs | Zso | Zss | PERFORMANCE ERROR mins | mV RESIDUAL Fund | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CONTROL TRANSMITTER | 08M71A1 | R1 R2 (ROTOR) | 26 | 26 | 0·12 | 2·2 | 8·0 | S1 S2 S3 (STATOR) | 11·8 | 28 | 60 | 160+j215 | 220+j215 | 80+j80 | 92+j13 | 10 | 20 | 30 |
| CONTROL TRANSFORMER | 08M72A1 | S1 S2 S3 (STATOR) | 11·8 | 10·2 | 0·027 | 0·053 | 62 | R1 R2 (ROTOR) | 22·5 | 17 | 500 | 1100+j1640 | 1300+j470 | 75+j400 | | 14 | 30 | 40 |

# size 08 tandem synchros

400 Hz

| STANDARD HARDWARE SUPPLIED WITH EACH INSTRUMENT | |
|---|---|
| **Item** | **Type No.** |
| Clamp Assembly | F500/33 |




AMBIENT TEMPERATURE RANGE -55°C to 125°C

Weight: 50g 1·7 oz
Friction Torque: 1 g cm. (0·014 oz in)
Rotor Inertia: 1 g cm² (0·0055 oz in²)

| SYNCHRO FUNCTION | TYPE DESIGNATION Muirhead | PRIMARY TERMINALS | RATED VOLTS | Volts | NO LOAD INPUT Amps max | Watts max | D.C. RESISTANCE Ohms Nom. | SECONDARY TERMINALS | NO LOAD OUTPUT Volts | Phase lead | D.C. RESISTANCE Ohms nom. | NOMINAL IMPEDANCE Ohms Zro | Zrs | Zso | Zss | PERFORMANCE ERROR mins | mV RESIDUAL Fund | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CONTROL TRANSFORMER | 08M27H1 | (STATOR) | 11·8 | 10·2 | 0·032 | 0·070 | 60 | (ROTOR) | 22·5 | 6·5 | 260 | 410+j2040 | 470+j180 | 60+j370 | 90+j30 | 15 | 40 | 40 |
| PICK-OFF RESOLVER | 08M27J1 | (STATOR) | 15 | 15 | 0·053 | 0·73 | 277 | (ROTOR) | | 54 | 122 | 130+j130 | 180+j80 | 280+j200 | 370+j120 | 15* | | |

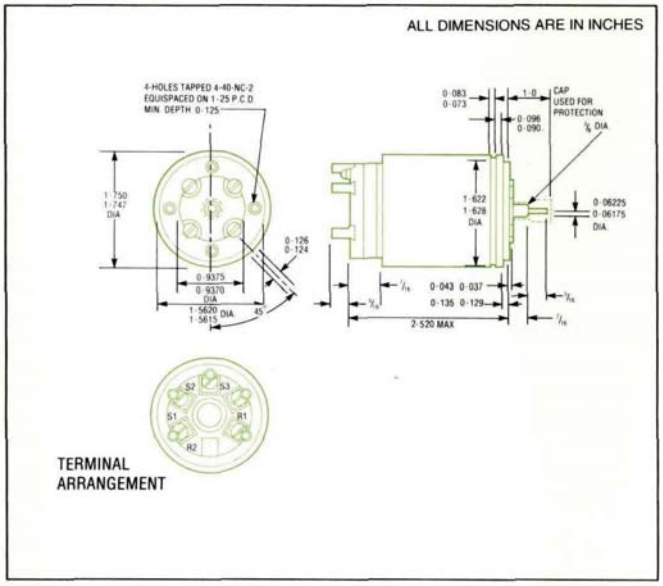
* Or 1½% of electrical angle, whichever is greater. Measured over limited angular range of ± 60°

115V
60Hz & 400 Hz

AMBIENT
TEMPERATURE
RANGE:
-55°C to +85°C

| STANDARD HARDWARE ITEMS NORMALLY SUPPLIED WITH EACH INSTRUMENT | |
|---|---|
| **Item** | **Type No.** |
| **3 Clamp Assemblies** | **F500/1** |

Weight 370g (13 oz)
Rotor Inertia 2·7g cm² (0·15 oz in²)




| TYPE DESIGNATION Muirhead | Military | NATO NUMBER 5990-99 | PRIMARY ELECTRICAL DATA FREQUENCY Hz | TERMINALS | VOLTAGE Volts | CURRENT Amps | IMPEDANCE Ohms | D.C. RESISTANCE Ohms Nom | SECONDARY ELECTRICAL DATA STATOR VOLTAGE Volts | CURRENT Amps | POWER Watts | IMPEDANCE Ohms | D.C. RESISTANCE Ohms Nom | FOLLOWING ACCURACY Degrees |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 18R16X | 18M23A2 | 372-7453 | 60 | R1 R2 (ROTOR) | 115 | 0·03 | 3000+j3800 | 2500 | 90 | 0·03 | 3·0 | 3300+j3000 | 2900 | 4(spread) |
| | 18M23A1 | 523-3887 | 400 | R1 R2 (ROTOR) | 115 | 0·03 | 1500+j3800 | 410 | 90 | 0·03 | 2·0 | 2200+j3000 | 2175 | 4 (spread) |

SPECIAL NOTE

These units are low torque receivers for use with size 18 or 23 control transmitters (see pages 10-13). They are designed for pointer indication only and impose little reaction on the transmitter so that, if a number of receivers are operated from one transmitter and one is restrained, the accuracy of the others is not impaired.

# Conversion Table

| Parameter | Metric Unit | Multiply by to convert to | Imperial Unit | Divide by to convert | Metric Unit |
|---|---|---|---|---|---|
| Length | | | | | |
| | mm | 0.03937 | Inches | 25.40 | mm |
| Weight | | | | | |
| | g | 0.035274 | oz | 28.3495 | g |
| Temperature | | | | | |
| | °C | (°Cx9÷5)+32 | °F | (°F-32x5)÷9 | °C |
| Speed | | | | | |
| | rad/s | 9.54930 | rpm | 0.10472 | rad/s |
| Force | | | | | |
| | N | 3.59572 | oz | 0.2781 | N |
| Torque | | | | | |
| | Nm | 0.73731 | lbft | 1.355628 | Nm |
| | Nm | 141.5636 | ozin | 0.00706 | Nm |
| | gcm | 0.01388 | ozin | 72.0461 | gcm |
| Torque Sensitivity | | | | | |
| | Nm/A | 0.73731 | lbft/A | 1.35628 | Nm |
| | Nm/A | 141.5636 | ozin/A | 0.00706 | Nm |
| | gcm/A | 0.01388 | ozin/A | 72.0461 | gcm/A |
| Motor Constant | | | | | |
| | Nm/√W | 0.73731 | lbft/√W | 1.35628 | Nm/√W |
| Damping Factor | | | | | |
| | Nm/rad/s | 0.73731 | lbft/rad/s | 1.35628 | Nm/rad/s |
| Voltage Sensitivity | | | | | |
| | V/rad/s | 1 | V/rad/s | 1 | V/rad/s |
| Rotor Inertia | | | | | |
| | kgm2 | 23.7303 | lbft2 | 0.04214 | Kgm2 |

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