



INVERTER FR-D700-SC-EC

Safety stop function instruction manual

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Compliance with the EU Machinery Directive – Functional Safety

WARNING

Any misuse of safety function could lead to personal injury or death, property damage, or economic loss. To ensure that the system complies fully with requirement of safety, make a system-level risk assessment. Mitsubishi Electric Co. cannot assume responsibility for any system to comply with safety directive.

CAUTION

The information of this manual is merely a guide for proper installation. Mitsubishi Electric Co. cannot assume responsibility for the compliance or the noncompliance to any code, national, local or otherwise for the proper installation of this equipment. A hazard of personal injury and/or equipment damage exists if codes are ignored during installation.

WARNING

To avoid an electric shock hazard, verify that the voltage on the bus capacitors has discharged before performing any work on the drive. Measure the DC bus voltage at the P(+) and N(-) terminals or test points (refer to your drive's *User Manual* for locations and discharging time). The voltage must be zero.

WARNING

The safety stop function do not isolate electrically between drive and motor. To avoid an electric shock hazard, disconnect/isolate power to the drive and verify to ensure that the voltage is zero before performing any work on the motor (refer to your drive's *User Manual* for discharging time).

CAUTION

This instruction manual is compatible with FR-D700-SC-EC source-logic safety terminal model. For FR-D700-EC sink-logic safety terminal model, refer to the FR-D700 safety stop function instruction manual (BCN-A211508-000).

1. General description

Features

Mitsubishi FR-D700-SC safety stop function prevents a drive from supplying rotational energy to motors. Dual safety channels 'S1' and 'S2' cut off the gate-drive power for IGBT to turn off.

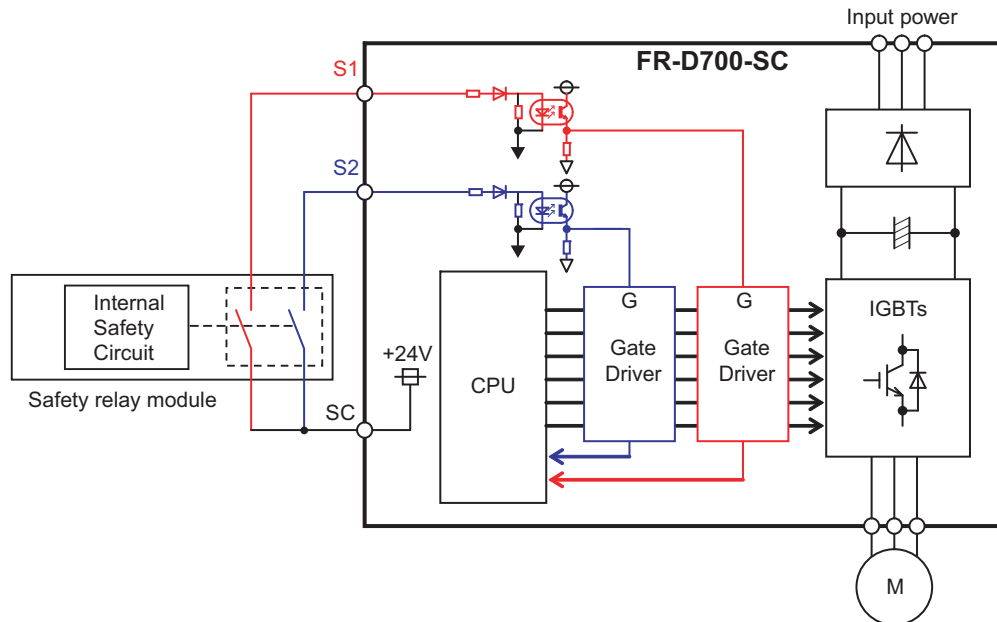


Fig.1 FR-D700-SC safety stop function diagram

WARNING

The safety stop function doesn't isolate electrically between drive and motor. To avoid an electric shock hazard, disconnect power to the drive and verify that the voltage is zero before performing any work on the motor (refer to your drive's *User Manual* for discharging time).

Directives

Mitsubishi FR-D700-SC safety stop function meets the following directives and categories.

ISO13849-1:2008 Category 3/PLd

IEC62061:2005 / IEC61800-5-2:2007 / IEC61508 SIL2

IEC60204-1:2006 / IEC61800-5-2:2007 Stop category 0

WARNING

The misuse of safety function leads to personal injury or death, property damage, or economic loss. To ensure that the system complies fully with requirement of safety, make a system-level risk assessment. Mitsubishi Electric Co. cannot assume responsibility for any system to comply with safety directive.

2. Installation and wiring

CAUTION

The following information is merely a guide for proper installation. Mitsubishi Electric Co. cannot assume responsibility for the compliance or the noncompliance to any code, national, local or otherwise for the proper installation of this equipment. A hazard of personal injury and/or equipment damage exists if codes are ignored during installation.

CAUTION

Ensure the safety relay unit and the FR-D700-SC unit is mounted closely in enclosure meeting IP54 and all interconnection wiring is short and protected against open and short circuit faults. Refer EN/ISO13849-2.

Installation

Mitsubishi FR-D700-SC safety stop function should be used under following condition and environment.

Table.1 The condition and environment for using safety stop function

Item		Condition
Temperature range	Operation	-10°C to +50°C (non-freezing)
	Storage	-20°C to +65°C
Ambient humidity		90%RH maximum (non-condensing)
Vibration		5.9m/s ² or less
Altitude		maximum 1000m above sea level
Atmosphere		Indoors (without corrosive gas, flammable gas, oil mist, dust and dirt etc.)
Over voltage category		II or less
Pollution degree		II or less
Mounting		wall mounting / vertical orientation

CAUTION

In order to meet safety stop, an approved safety relay unit to ISO13849-1/EN954-1 safety category 3 or better shall be used in conjunction with FR-D700-SC as shown in example1,2. In addition, all other components with in the safety stop loop shall be 'safety approved' types.

WARNING

To avoid an electric shock hazard, insert the magnetic contactor (MC) between power source and drive. Open the contact of MC and keep away from drive for discharging time (refer to your drive's *User Manual* for information) before performing any work on the drive. And verify that the voltage on the bus capacitors has discharged before Measure the DC bus voltage at the P(+) and N(-) terminals or test points (refer to your drive's *User Manual* for locations). The voltage must be zero.

CAUTION

To avoid systematic faults, a test even for faulty demands of the safety function has to be performed in order to check the correct function of the monitor signal. This test shall be carried out at system installation, any software changes, parameterization changes, and/or at least once per year. Refer to '4. Test and checking failure'.

Wiring

The safety related terminals are described in Table.2 and Table.3

Table.2 The safety related terminals

Terminal Symbol	Description	Rating
S1	For input of safety stop channel1. S1-SC is Open: In safety stop mode. Short: Non safety stop mode.	Input resistance:4.7kΩ Current : 4 to 6 mA (In case of shorted to SC) Voltage : 21 to 26 V (In case of open from SC)
S2	For input of safety stop channel2. S2-SC is Open: In safety stop mode. Short: Non safety stop mode.	
SC	Common terminal for S1, S2 terminals. *SC is connected terminal PC internally.	
SO (SAFE)	As output for safety stop condition. SO terminal type is 'Open collector output'. SO-SE is OFF(Open): Drive enabled, or drive shutoff (with internal circuit fault) ON(Close): Drive shutoff (no internal circuit fault) Important: SO terminal should be used for monitoring safety stop condition only. SO terminal cannot be used for safety function.	Load: 24VDC/0.1A max. Voltage drop: 3.4V max. (In case of 'ON' state)
RUN (SAFE2)	As output for failure detection and alarm. RUN terminal type is 'Open collector output'. RUN-SE is OFF(Open): Detect failure or Alarm. ON(Close): No failure detected. Attention: To use RUN terminal for monitor output of failure detection, <u>The parameter No.190 should be set 81 (Safety monitor 2).</u> Note: This terminal can be used for alarm or to prevent restart only, no other safety function.	
SE	Common terminal for safety RUN and SO terminal.	

Table.3 Truth table of Safety related signals

Input power	S1-SC	S2-SC	Internal safety circuit fault *1	SO (SAFE)	RUN (SAFE2) *2	Drive state
OFF	-	-	-	OFF(Open)	OFF(Open)	Drive shutoff (Safe state)
ON	Short	Short	No failure	OFF(Open)	ON(Close)	Drive enable
			Detected	OFF(Open)	OFF(Open)	Drive shutoff (Safe state)
	Open	Open	No failure	ON(Close)	ON(Close)	Drive shutoff (Safe state)
			Detected	OFF(Open)	OFF(Open)	Drive shutoff (Safe state)
	Short	Open	N/A	OFF(Open)	OFF(Open)	Drive shutoff (Safe state)
	Open	Short	N/A	OFF(Open)	OFF(Open)	Drive shutoff (Safe state)

" N/A " denotes a condition where circuit fault does not apply.

*1 At an internal safety circuit fault, one of E.SAF or E.CPU is displayed on the operation panel. SA is displayed on the operation panel while S1 and S2 signals are both open and the safety function operates (without internal safety circuit fault).

*2 To use RUN terminal for monitor output of failure detection, the parameter No.190 should be set 81 (Safety monitor 2).

Wire and ferrule specification

Table.4 wire and ferrule specification

Wire size (mm ²)	Ferrule with insulation collar *	Crimping tool *
0.3 / 0.5	AI 0,5-10WH	CRIMPFOX 6
0.75	AI 0,75-10GY	
1	AI 1-10RD	
1.25 / 1.5	AI1,5-10BK	
0.75 (combined 2 wire)	AI TWIN 2 X 0,75-10GY	

*Ferrules and tools are distributed by Phoenix Contact.

Jumper cable

The jumper cable between S1,S2 and SC terminal has been installed in the factory as shown in Fig.2.

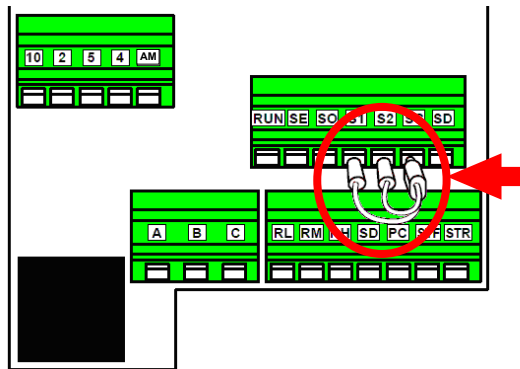


Fig.2. Short wire

Before connecting safety input wire to S1,S2 and SC terminal, remove this jumper cable.

3. Example of safety system configuration

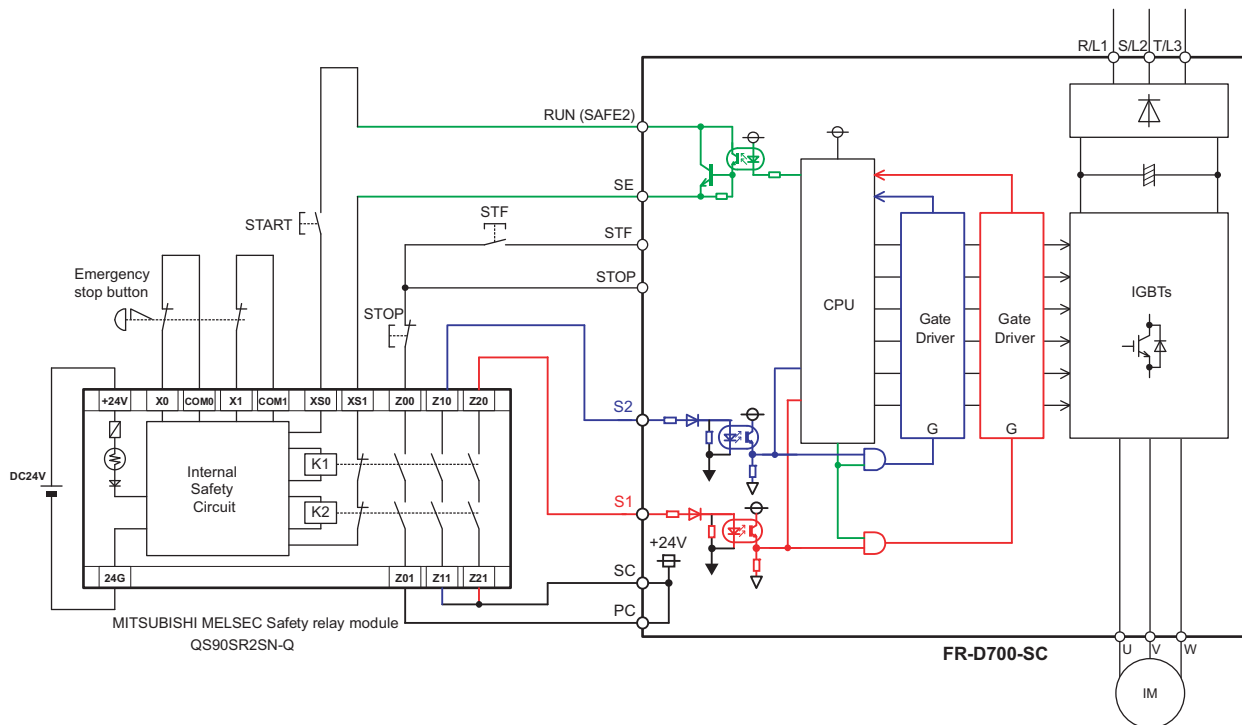


Fig.3 Safety system example – STOP synchronous with emergency stop button and fault detection through RUN output.

For safety stop, configure the wiring as shown in Fig.3 above.

Note: the above wiring is configured to prevent restart in case of a fault.

XS0 should be connected to RUN terminal and XS1 should be connected to SE, because polarity of XS0 is positive, XS1 is negative.

The parameter No.190 (RUN terminal function selection) must be set to '81'. This setting makes the RUN output to turn off in case of failure.

After the power-up, to reset the safety stop mode, press the START switch, and also press the STF switch, then start the motor rotation.

In the above Fig.3, wired example, in the event of reset of 'safe-condition' the motor rotation will not occur until STF is pressed.

(for normal 'non-safety' STF/STOP function, please refer to your drive's *User Manual*)

CAUTION

To prevent restart in case of recovering from input power loss of drive, 3-wired connection for STF/STOP control is recommended.

In case of 2-wire connection and using latching type switch to short between STF and PC for starting, ensure the compliance with safety requirement for the restarting when the drive recover from input power loss.

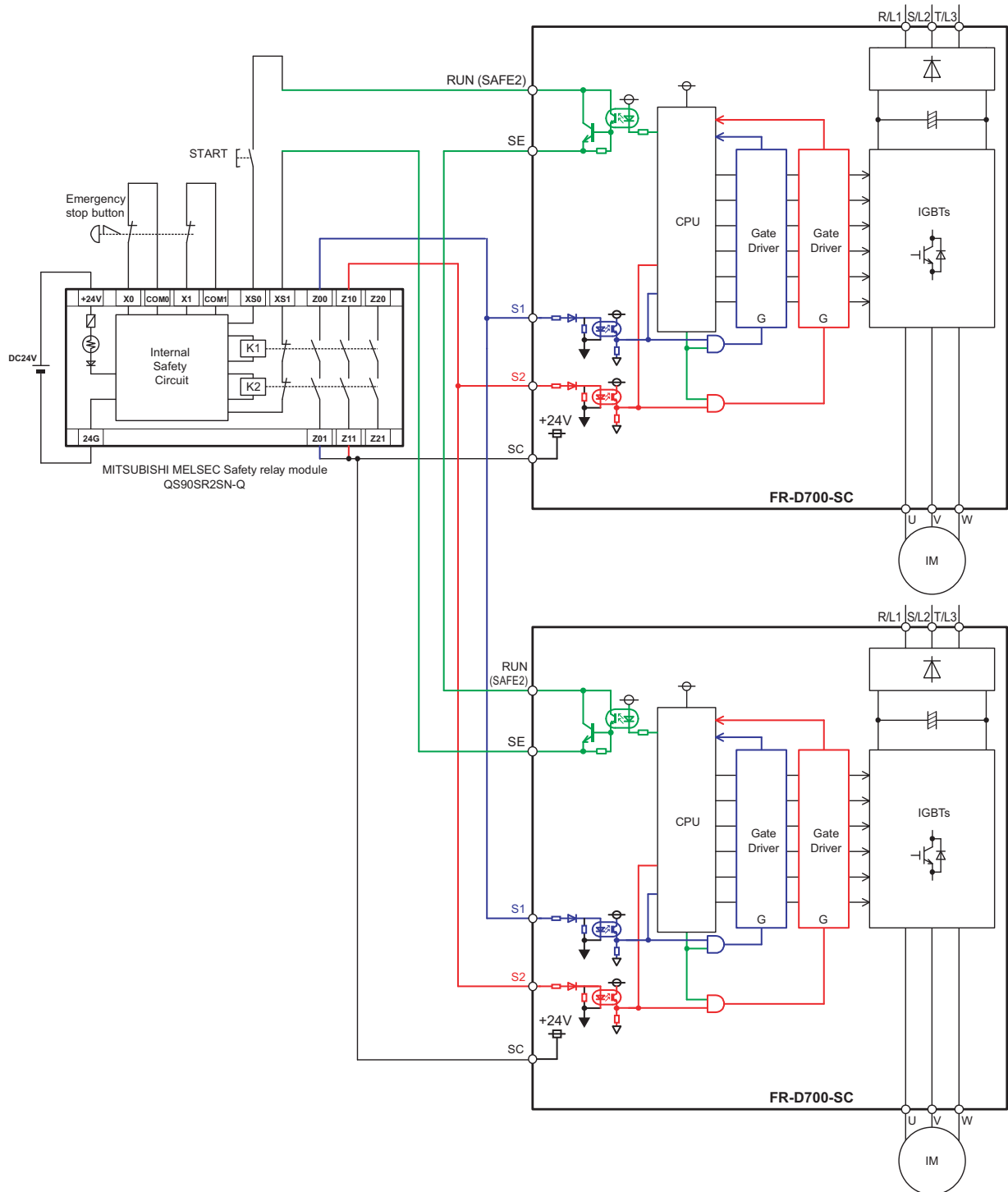


Fig.4 Example when using multiple FR-D740-SC inverters for the safety stop function

The parameter No.190 (RUN terminal function selection) must be set to '81'. This setting makes the RUN output to turn off in case of failure.



NOTE

Do not connect the FR-D700 sink-logic safety terminal model together with FR-D700-SC source-logic safety terminal model. If connected together, the safety stop function does not work properly.

4. Test and checking failure

CAUTION						
To avoid systematic faults, a test even for faulty demands of the safety function has to be performed in order to check the correct function of the monitor signal. This test shall be carried out at system installation, any software changes, parameterization changes, and/or at least once per year.						

I/O status and failure

FR-D700-SC safety related I/O status obeys the following truth table.

Table.5 Truth table of Safety related signals

Input power	S1-SC	S2-SC	Internal safety circuit fault *1	SO (SAFE)	RUN (SAFE2) *2	Drive state
OFF	-	-	-	OFF(Open)	OFF(Open)	Drive shutoff (Safe state)
ON	Short	Short	No failure	OFF(Open)	ON(Close)	Drive enable
			Detected	OFF(Open)	OFF(Open)	Drive shutoff (Safe state)
	Open	Open	No failure	ON(Close)	ON(Close)	Drive shutoff (Safe state)
			Detected	OFF(Open)	OFF(Open)	Drive shutoff (Safe state)
	Short	Open	N/A	OFF(Open)	OFF(Open)	Drive shutoff (Safe state)
	Open	Short	N/A	OFF(Open)	OFF(Open)	Drive shutoff (Safe state)

" N/A " denotes a condition where circuit fault does not apply.

*1 At an internal safety circuit fault, one of E.SAF or E.CPU is displayed on the operation panel. SA is displayed on the operation panel while S1 and S2 signals are both open and the safety function operates (without internal safety circuit fault).

*2 To use RUN terminal for monitor output of failure detection, the parameter No.190 should be set 81 (Safety monitor 2).

In case of diagnostic or functionality test, check the I/O state whether it is same or not as Table.5.

Diagnostic

If the failure detected, FR-D700-SC output alarm signal and indicate 'E.SAF' at the display.

In case of FR-D700-SC output the alarm, please take following action.

- (1) Check the S1-SC and S2-SC input signal logic is the same. If these are different logic, correct the input signal and reset the FR-D700-SC.
- (2) Disconnect the wire from S1, S2, SC terminal, then reset or power-off and on, If the 'SA' letter is flashed up at display, there is failure in system except FR-D700-SC. But, still 'E.SAF' is displayed and alarm output, there is malfunction on FR-D700-SC.

Self diagnostic test

FR-D700-SC does the self-diagnostic test on the power-ON.

If FR-D700-SC output alarm at power-ON, please take the action described in 'Diagnostic' at above.

Test procedure for functionality

As depicted 'ATTENTION' in above, the test for the functionality is important.

Please do the test following procedure.

- (1) Please make each state of S1-SC and S2-SC depicted at Table.5.
- (2) If there is any different state from Table.5, FR-D700-SC has some malfunction.
- (3) If there is no different state from Table.5, check the systematic performance, such as, press the Emergency switch, press the start/restart button at the failure detected (RUN-SE opened), and so on.
- (4) Finally clear the error record of the FR-D700-SC (see the user manual how to clear the error record).

5. Safety parameters of FR-D700-SC

FR-D700-SC safety related I/O status obeys the following truth table.

Table.6 Safety parameters of FR-D700-SC

Parameter	Value
PFD _{AVG}	2.06×10^{-4}
PFH _D	2.35×10^{-9}
PL	d
MTTF _D	725 years
DC _{AVG}	60%

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HEADQUARTERS

MITSUBISHI ELECTRIC EUROPE B.V. **EUROPE**
 German Branch
 Gothaer Straße 8
D-40880 Ratingen
 Phone: +49 (0)2102 / 486-0
 Fax: +49 (0)2102 / 486-1120

MITSUBISHI ELECTRIC EUROPE B.V.-org.sl. **CZECH REP.**
 Czech Branch
 Avenir Business Park, Radlická 714/113a
CZ-158 00 Praha 5
 Phone: +420 - 251 551 470
 Fax: +420 - 251-551-471

MITSUBISHI ELECTRIC EUROPE B.V. **FRANCE**
 French Branch
 25, Boulevard des Bouvets
F-92741 Nanterre Cedex
 Phone: +33 (0)1 / 55 68 55 68
 Fax: +33 (0)1 / 55 68 57 57

MITSUBISHI ELECTRIC EUROPE B.V. **IRELAND**
 Irish Branch
 Westgate Business Park, Ballymount
IRL-Dublin 24
 Phone: +353 (0)1 4198800
 Fax: +353 (0)1 4198890

MITSUBISHI ELECTRIC EUROPE B.V. **ITALY**
 Italian Branch
 Viale Colleoni 7
I-20041 Agrate Brianza (MB)
 Phone: +39 039 / 60 53 1
 Fax: +39 039 / 60 53 312

MITSUBISHI ELECTRIC EUROPE B.V. **POLAND**
 Poland Branch
 Krakowska 50
PL-32-083 Balice
 Phone: +48 (0)12 / 630 47 00
 Fax: +48 (0)12 / 630 47 01

MITSUBISHI ELECTRIC EUROPE B.V. **RUSSIA**
 52, bid. 3 Kosmodamienskaya nab 8 floor
RU-115054 Moscow
 Phone: +7 495 721-2070
 Fax: +7 495 721-2071

MITSUBISHI ELECTRIC EUROPE B.V. **SPAIN**
 Spanish Branch
 Carretera de Rubí 76-80
E-08190 Sant Cugat del Vallés (Barcelona)
 Phone: 902 131121 // +34 935653131
 Fax: +34 935891579

MITSUBISHI ELECTRIC EUROPE B.V. **UK**
 UK Branch
 Travellers Lane
UK-Hatfield, Herts. AL10 8XB
 Phone: +44 (0)1707 / 27 61 00
 Fax: +44 (0)1707 / 27 86 95

MITSUBISHI ELECTRIC CORPORATION **JAPAN**
 Office Tower "Z" 14 F
 8-12,1 chome, Harumi Chuo-Ku
Tokyo 104-6212
 Phone: +81 3 622 160 60
 Fax: +81 3 622 160 75

MITSUBISHI ELECTRIC AUTOMATION, Inc. **USA**
 500 Corporate Woods Parkway
Vernon Hills, IL 60061
 Phone: +1 847 478 21 00
 Fax: +1 847 478 22 53

EUROPEAN REPRESENTATIVES

GEVA **AUSTRIA**
 Wiener Straße 89
AT-2500 Baden
 Phone: +43 (0)2252 / 85 55 20
 Fax: +43 (0)2252 / 488 60

TECHNIKON **BELARUS**
 Oktyabrskaya 19, Off. 705
BY-220030 Minsk
 Phone: +375 (0)17 / 210 46 26
 Fax: +375 (0)17 / 210 46 26

ESCO DRIVES & AUTOMATION **BELGIUM**
 Culliganlaan 3
BE-1831 Diegem
 Phone: +32 (0)2 / 717 64 30
 Fax: +32 (0)2 / 717 64 31

Koning & Hartman b.v. **BELGIUM**
 Woluwelaan 31
BE-1800 Vilvoorde
 Phone: +32 (0)2 / 257 02 40
 Fax: +32 (0)2 / 257 02 49

INEA RBT d.o.o. **BOSNIA AND HERZEGOVINA**
 Aleja Lipa 56
BA-71000 Sarajevo
 Phone: +387 (0)33 / 921 164
 Fax: +387 (0)33 / 524 539

AKHNATON **BULGARIA**
 4, Andrei Ljapchev Blvd., PO Box 21
BG-1756 Sofia
 Phone: +359 (0)2 / 817 6000
 Fax: +359 (0)2 / 97 44 06 1

INEA RBT d.o.o. **CROATIA**
 Losinjska 4 a
HR-10000 Zagreb
 Phone: +385 (0)1 / 36 940 - 01 / -02 / -03
 Fax: +385 (0)1 / 36 940 - 03

AutoCont C.S. s.r.o. **CZECH REPUBLIC**
 Technologická 374/6
CZ-708 00 Ostrava-Pustkovce
 Phone: +420 595 691 150
 Fax: +420 595 691 199

Beijer Electronics A/S **DENMARK**
 Lykkegårdsvej 17
DK-4000 Roskilde
 Phone: +45 (0)46 / 75 76 66
 Fax: +45 (0)46 / 75 56 26

Beijer Electronics Eesti OÜ **ESTONIA**
 Pärnu mnt.160i
EE-11317 Tallinn
 Phone: +372 (0)6 / 51 81 40
 Fax: +372 (0)6 / 51 81 49

Beijer Electronics OY **FINLAND**
 Peltoie 37
FIN-28400 Ulvila
 Phone: +358 (0)207 / 463 540
 Fax: +358 (0)207 / 463 541

UTEKO **GREECE**
 5, Mavrogenou Str.
GR-18542 Piraeus
 Phone: +30 211 / 1206 900
 Fax: +30 211 / 1206 999

MELTRADE Kft. **HUNGARY**
 Fertő utca 14.
HU-1107 Budapest
 Phone: +36 (0)1 / 431-9726
 Fax: +36 (0)1 / 431-9727

Beijer Electronics SIA **LATVIA**
 Rītausmas iela 23
LV-1058 Rīga
 Phone: +371 (0)784 / 2280
 Fax: +371 (0)784 / 2281

Beijer Electronics UAB **LITHUANIA**
 Savanoriu Pr. 187
LT-02300 Vilnius
 Phone: +370 (0)5 / 232 3101
 Fax: +370 (0)5 / 232 2980

EUROPEAN REPRESENTATIVES

ALFATRADE Ltd. **MALTA**
 99, Paola Hill
Malta- Paola PLA 1702
 Phone: +356 (0)21 / 697 816
 Fax: +356 (0)21 / 697 817

INTEHSIS srl **MOLDOVA**
 bld. Traian 23/1
MD-2060 Kishinev
 Phone: +373 (0)22 / 66 4242
 Fax: +373 (0)22 / 66 4280

HIFLEX AUTOM.TECHNIEK B.V. **NETHERLANDS**
 Wolveverstraat 22
NL-2984 CD Ridderkerk
 Phone: +31 (0)180 - 46 60 04
 Fax: +31 (0)180 - 44 23 55

Koning & Hartman b.v. **NETHERLANDS**
 Haarlbergweg 21-23
NL-1101 CH Amsterdam
 Phone: +31 (0)20 / 587 76 00
 Fax: +31 (0)20 / 587 76 05

Beijer Electronics AS **NORWAY**
 Postboks 487
NO-3002 Drammen
 Phone: +47 (0)32 / 24 30 00
 Fax: +47 (0)32 / 84 85 77

Fonseca S.A. **PORTUGAL**
 R. João Francisco do Casal 87/89
PT - 3801-997 Aveiro, Esgueira
 Phone: +351 (0)234 / 303 900
 Fax: +351 (0)234 / 303 910

Sirius Trading & Services srl **ROMANIA**
 Aleea Lacul Morii Nr. 3
RO-060841 Bucuresti, Sector 6
 Phone: +40 (0)21 / 430 40 06
 Fax: +40 (0)21 / 430 40 02

INEA RBT d.o.o. **SERBIA**
 Izletnicka 10
SER-113000 Smederevo
 Phone: +381 (0)26 / 615 401
 Fax: +381 (0)26 / 615 401

SIMAP s.r.o. **SLOVAKIA**
 Jána Derku 1671
SK-911 01 Trenčín
 Phone: +421 (0)32 743 04 72
 Fax: +421 (0)32 743 75 20

PROCONT, spol. s r.o. Prešov **SLOVAKIA**
 Kúpeľná 1/A
SK-080 01 Prešov
 Phone: +421 (0)51 7580 611
 Fax: +421 (0)51 7580 650

INEA RBT d.o.o. **SLOVENIA**
 Stegne 11
SI-1000 Ljubljana
 Phone: +386 (0)1 / 513 8116
 Fax: +386 (0)1 / 513 8170

Beijer Electronics AB **SWEDEN**
 Box 426
SE-20124 Malmö
 Phone: +46 (0)40 / 35 86 00
 Fax: +46 (0)40 / 93 23 01

Omni Ray AG **SWITZERLAND**
 Im Schörl 5
CH-8600 Dübendorf
 Phone: +41 (0)44 / 802 28 80
 Fax: +41 (0)44 / 802 28 28

GTS **TURKEY**
 Bayraktar Bulvarı Nutuk Sok. No:5
TR-34775 Yukarı Dudullu-Ümraniye-İSTANBUL
 Phone: +90 (0)216 526 39 90
 Fax: +90 (0)216 526 3995

CSC Automation Ltd. **UKRAINE**
 4-B, M. Raskovoyi St.
UA-02660 Kiev
 Phone: +380 (0)44 / 494 33 55
 Fax: +380 (0)44 / 494-33-66

Systemgroup **UKRAINE**
 2 M. Krivonosy St.
UA-03680 Kiev
 Phone: +380 (0)44 / 490 92 29
 Fax: +380 (0)44 / 248 88 68

EURASIAN REPRESENTATIVES

TOO Kazpromavtomatika **KAZAKHSTAN**
 Ul. Zhambyla 28
KAZ-100017 Karaganda
 Phone: +7 7212 / 50 10 00
 Fax: +7 7212 / 50 11 50

MIDDLE EAST REPRESENTATIVE

SHERF Motion Techn. Ltd. **ISRAEL**
 Rehov Hamerkava 19
IL-58851 Holon
 Phone: +972 (0)3 / 559 54 62
 Fax: +972 (0)3 / 556 01 82

CEG INTERNATIONAL **LEBANON**
 Cebaco Center/Block A Autostrade DORA
Lebanon - Beirut
 Phone: +961 (0)1 / 240 430
 Fax: +961 (0)1 / 240 438

AFRICAN REPRESENTATIVE

CBI Ltd. **SOUTH AFRICA**
 Private Bag 2016
ZA-1600 Isando
 Phone: +27 (0)11 / 977 0770
 Fax: +27 (0)11 / 977 0761