TOSHIBA

Leading Innovation

Toshiba Multi Function Book-type inverter

Variable Speed Drive

TOSVERT VF-MB1

Concept

3 advanced features.

SLIM SHAPE BODY

Side-by-side installation, Flat Mounting Installation

ADVANCED MOTOR DRIVE

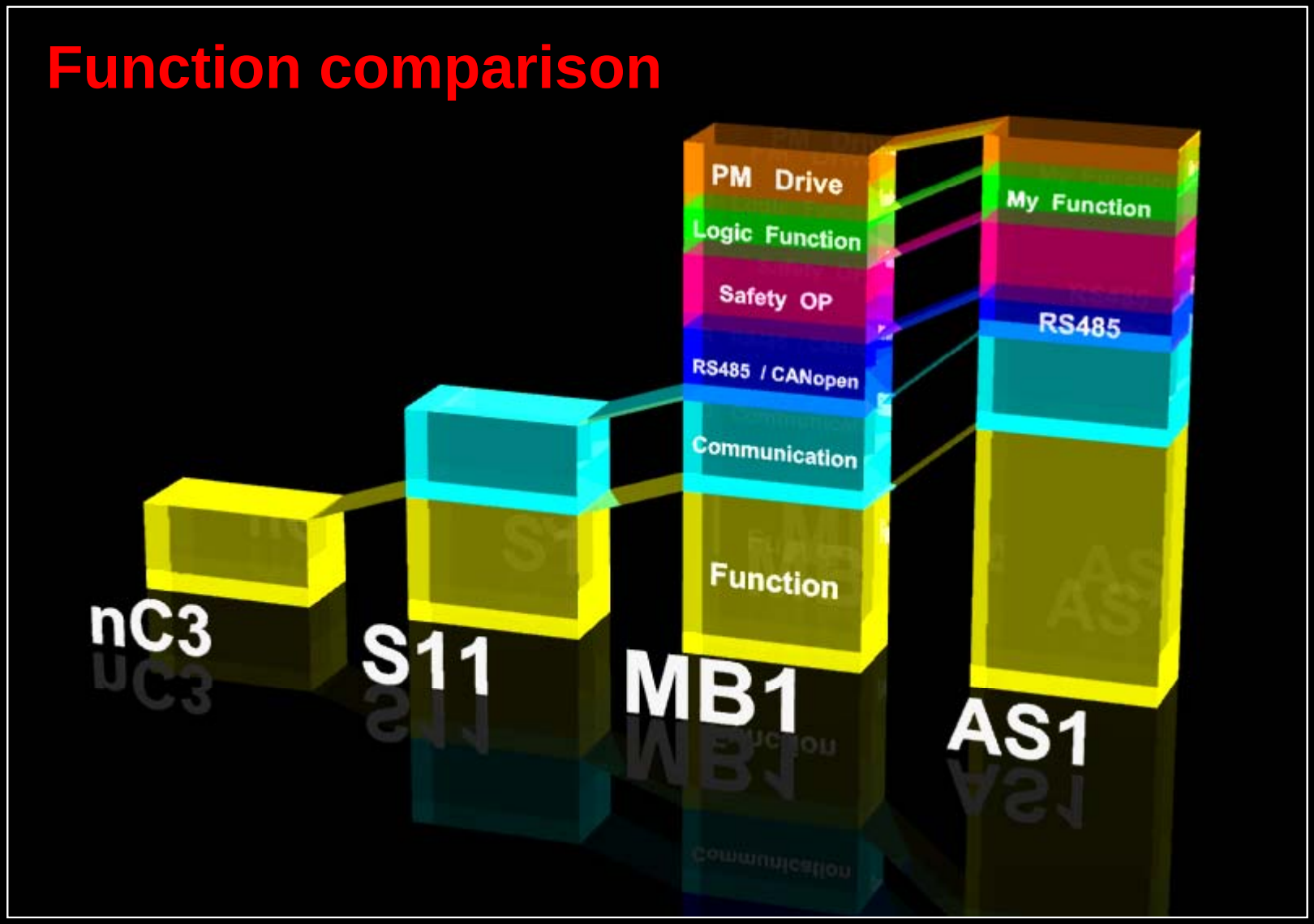
Sensor-less Permanent Magnetic motor, SPM/IPM, and Induction Motor drive capability
Toshiba unique magnetic pole position detection

FLEXIBLE OPERATION

- Simple Panel “Turn and Push” setting dial RUN and STOP keys
- Communication <Built-in> RS485 and CANopen®
- <Add-on option> EtherNet/IP™ -Modbus® TCP, PROFIBUS® DP, DeviceNet™, EtherCAT®
- Dual rating, two types of rating can drive variable torque and constant torque applications with minimal drive size.

The VF-MB1 can drive elevator, lifting, conveyor, food & beverage processing, material handling, machine tool and various applications.

Function comparison



Concept

Side-by-side installation

The VF-MB1 has been minimized width size in comparison with conventional model.
In addition, side-by-side installation can save space in control cabinet (*1).

DC bus terminals are located in top side for the model of 4.0kW or less, and bottom side for the model of 5.5kW to 15kW.

These DC bus terminals are useful for Textile machinery in case of connecting multi-drive to the common DC bus supply.

SLIM SHAPE BODY

<45mm width>
1 ph-240V: 0.2kW to 0.75kW
3ph-500V: 0.4kW to 1.5kW

<60mm width>

1 ph-240V: 1.5kW and 2.2kW
3ph-500V: 2.2kW and 4.0kW

Slim design

For 240V-0.2kW to 0.75kW and 500V-0.4kW to 1.5kW models are À tted to 45mm slim design. And also, 240V-1.5kW to 2.2kW and 500V-2.2kW to 4.0kW models can be fitted to 60mm.

Features

Product line *VF-MB1*

+ Removable Motor connector
+ Safety (STO)
+ Slim body for space savings
+ Fast response time
+ Extended communication options (Profibus / EthernetIP / ModbusTCP)
+ External control power supply
+ Graphic key pad connection
+ Multi-loader option
+ PM motor control

Multifunction

- Logic sequence function Similar to AS1's function
- Traverse function for textile application
- Brake sequence function
- Hit and stop function
- Long lifetime design

Features

- **Slim shape body:** 45mm (up to 200V-0.75kW, 400V-1.5kW)
- **Easy installation**
  - Side-by-side installation, Flat mounting
  - Removable power terminal (up to 4kW), Flurle terminals
- **Easy operation and panel**
  - Jog dial, 4 keys, and 4 small LEDs with Green 7 segments LEDs
- **Safety function:** Power removal
- **EMC noise filter inside:** C2 class EMC filter inside
- **PM motor drive**
- **Flexible I/O terminals**
  - 2 or 3 functions assigned, +/-10V input, Pulse train input, PTC input, etc.
- **Communication**
  - RS485 and CANopen embedded
  - Cassette type option: Ethernet IP/Modbus TCP, Profibus DP, DeviceNet
- **Multifunction**
  - Logic sequence function, Traverse function, Brake sequence function
- **Options**
  - Parameter writer, Remote keypad, EMC plate, LCD keypad

Features

- **Safety function**
  - STO: Safe Torque Off
    - Freewheel stop by eliminating the torque on the motor shaft.
    - IEC 61508 edition 1
- **EMC noise filter inside**
  - C2 class EMC filter inside
- **PM motor drive**
  - IPM / SPM drive w/o sensor
    - Need to tuning by combination test with motor

Features

Title		VF-MB1	VF-S11
Range	1ph-240V	0.2 to 2.2kW	0.2 to 2.2kW
	3ph-240V	-	0.2 to 15kW
	3ph-500V	0.4 to 15kW	0.4 to 15kW
Power cable connection		Top/bottom (up to 4kW) Bottom/bottom (5.5 to 15kW)	Bottom/bottom
Power terminal		Detachable (up to 4kW)	No
Braking transistor		Built-in	Built-in
Sensorless vector control		Yes	Yes
PM motor control		Yes (IPM / SPM)	Yes (IPM)
Operation		Jog + 4 keys (with EASY key)	Potentiometer + 6 keys
Long life design		10 years	10 years
Communication (Enbedded)		RS485 (38.4kbps) CANopen	TTL
Communication option		Eternet IP/Modbus TCP Profibus DP DeviceNet	RS485 19.2kbps) CC-Link DeviceNet Lonworks
Control power supply input		Yes (DC24V)	No
Sink / source switching		Slide switch	Slide switch
Logic input		6 x LI 2 x AI as LI function switching	6 x LI 2 x AI as LI function switching
Analog input		3 x AI (0-10V, 0-20mA, +/-10V)	2x AI (0-10V, 0-20mA)
Analog output		1 x AO (0-10V/0-20mA/Meter)	1 x AO (0-10V/0-20mA)
Logic output		1 x LO (100mA/Pulse)	1 x LO (50mA/Pulse)
Relay		1 x NO, 1 x NO/NC	1 x NO, 1 x NO/NC
Safety functions		Power removal	No
Password protection		Yes	No
Parameter writer (Power off)		Yes	No

Mounting

Flat Mounting

NEW

Image: VFMB1S-2002PL

Slim shape ability

The model of VFMB1S-2002PL ~ 2022PL and VFMB1-4004PL ~ 4037PL can have 90 degree front block.

Also various installation is available by side flat mounting.

90 degree attachment

The front block of VF-MB1 can be attached 90 degree by using additional mount bracket.

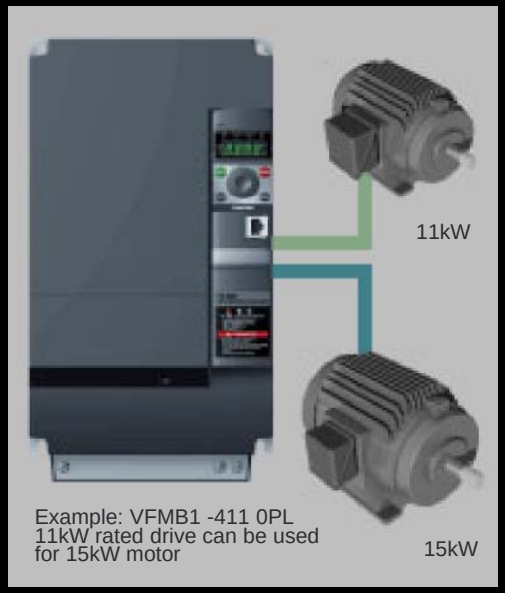
Flat mount

The VF-MB1 can be mounted by Flat mounting.

The VF-MB1 can be attached with side panel by side screw without any attachment.

Side flat mounting

Three screws can fix side mounting for narrow space.



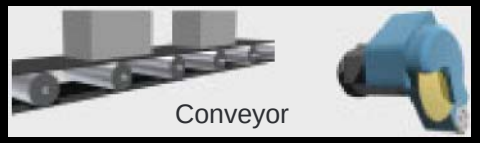
Dual rating (CT/VT)

The VF-MB1 can be used for the constant torque and variable torque applications by dual rating operation. (5.5kW or larger type)

For example, if variable torque application (fan and pump) require 15kW drives, it can be operated by 11 kW rated of VF-MB1.

Constant torque application

The torque value of constant torque application require the high torque level of different motor speed for Conveyors,



Conveyor

Machine tool

Crane Hoist

Machine tool, Food machine and Elevator.

Variable torque application

The torque value of variable torque application such as Fan, Pump and HVAC require low torque until starts to operating speed. (Compressor is excluded)

Fan / Blower

Pump

Dual rating

Single Phase

1ph – 200V

Type form	Applied Motor (kW)	Rated Current (A) *1
VFMB1S-2002PL	0.2	1.5
VFMB1S-2004PL	0.4	3.3
VFMB1S-2007PL	0.75	4.8
VFMB1S-2015PL	1.5	8.0
VFMB1S-2022PL	2.2	11.0

Three Phase

3ph – 400V

Type form	Applied Motor (kW)	Rated Current (A) *1
VFMB1-4004PL	0.4	1.5
VFMB1-4007PL	0.75	2.3
VFMB1-4015PL	1.5	4.1
VFMB1-4022PL	2.2	5.5
VFMB1-4037PL	4.0	9.5
VFMB1-4055PL	5.5	14.3
	(7.5)	(17.0)
VFMB1-4075PL	7.5	17.0
	(11)	(23.0)
VFMB1-4110PL	11	27.7
	(15)	(33.0)
VFMB1-4150PL	15	33.0
	(18,5)	(40.0)

Dual rating

*1: At 4kHz of carrier frequency

FLEXIBLE OPERATION

■ Easy operation and panel

Charge LED

Communication connector for RS485 & CANopen (RJ45)

Panel keypad

4 x small LED

Green 7 segments LED

Common Jog dial as VF-nC3

4 x Keys

FLEXIBLE OPERATION

NEW

Communication (Built-in / Optional)

Image: VFMB1S-2002PL

Built-in (RS485 / CANopen)

RS485 (Modbus RTU)
Baud rate: 38.4 kbps maximum

CANopen®: Baud rate: 1.0Mbps maximum

Optional

Ethernet/IP / Modbus TCP / EtherCAT / DeviceNet / Profibus DP

D-Sub 9pin type

D-SUB 9 pin is standard connection of Profibus DP communication

PROFIBUS DP

RJ45 (2 connector)

RJ45 type can connect daisy chain easily.

EtherNet/IP™
Modbus TCP
EtherCAT®

Wiring terminal

Terminal connection is standard of DeviceNet communication

CANopen®
DeviceNet™

• Product Line-up

1ph – 200V		
Type form	Applied Motor (kW)	Rated Current (A) *1
VFMB1S-2002PL	0.2	1.5
VFMB1S-2004PL	0.4	3.3
VFMB1S-2007PL	0.75	4.8
VFMB1S-2015PL	1.5	8.0
VFMB1S-2022PL	2.2	11.0

Single Phase

3ph – 400V		
Type form	Applied Motor (kW)	Rated Current (A) *1
VFMB1-4004PL	0.4	1.5
VFMB1-4007PL	0.75	2.3
VFMB1-4015PL	1.5	4.1
VFMB1-4022PL	2.2	5.5
VFMB1-4037PL	4.0	9.5
VFMB1-4055PL	5.5	14.3
VFMB1-4075PL	7.5	17.0
VFMB1-4110PL	11	27.7
VFMB1-4150PL	15	33.0

Three Phase

*1: At 4kHz of carrier frequency

Dimensions

Input Voltage Class	Applied Motor Capacity (kW)	Outline Dimension (mm)		
		Width	Height	Depth
1ph-240V	0.2	45	250	232
	0.4	45	250	232
	0.75	45	250	232
	1.5	60	250	232
	2.2	60	250	232
3ph-500V	0.4	45	250	232
	0.75	45	250	232
	1.5	45	250	232
	2.2	60	250	232
	4.0	60	250	232
	5.5	150	220	232
	7.5	150	220	232
	11	180	310	232
	15	180	310	232

Outline

Same depth dimension: 232mm

EMC noise suppression

Size	Power rating	Built-in EMC filter
		IEC61800-3
S1B2	240V-1ph-0.2kW	Category C2
	240V-1ph-0.4kW	
	240V-1ph-0.75kW	
S2B2	240V-1ph-1.5kW	Category C2
	240V-1ph-2.2kW	Category C2
S1B4	500V-3ph-0.4kW	Category C2
	500V-3ph-0.75kW	
	500V-3ph-1.5kW	
S2B4	500V-3ph-2.2kW	Category C2
	500V-3ph-4kW	
S4B4	500V-3ph-5.5kW	Category C3
	500V-3ph-7.5kW	
S5B4	500V-3ph-11kW	Category C3
	500V-3ph-15kW	

Comparison of Rated Current for 1ph – 240V

Single phase 240V Class 1ph with EMC							
		VF-MB1			VF-S11		
Size	Rating	Rated Current		Max Current 60s(rms)	Rated Current		Max Current 60s(rms)
		(rms) (4kHz)	(rms) (12kHz)		(rms) (4kHz)	(rms) (12kHz)	
1B2	0.2kW	1.5	1.5	2.3	1.5	1.5	2.3
	0.4kW	3.3	3.3	5.0	3.3	3.3	5.0
	0.75kW	4.8	4.4	7.2	4.8	4.4	7.2
2B2	1.5kW	8.0	7.9	12.0	8.0	7.9	12.0
	2.2kW	11.0	10.0	16.5	11.0	10.0	16.5

Outline

Comparison of Rated Current for 3ph – 500V

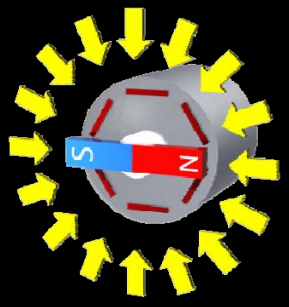
3 phase 500V Class 1ph with EMC							
		VF-MB1			VF-S11		
Size	Rating	Rated Current		Max Current 60s(rms)	Rated Current		Max Current 60s(rms)
		(rms) (4kHz)	(rms) (12kHz)		(rms) (4kHz)	(rms) (12kHz)	
1B4	0.4kW	1.5	1.5	2.3	1.5	1.5	2.3
	0.75kW	2.3	2.2	3.5	2.3	2.1	3.5
	1.5kW	4.1	3.7	6.2	4.1	3.7	6.2
2B4	2.2kW	5.5	5.1	8.3	5.5	5.0	8.3
	4kW	9.5	8.6	14.3	9.5	8.6	14.3
4B4	5.5kW	14.3	13.0	21.5	14.3	13.0	21.5
	7.5kW	17.0	17.0	25.5	17.0	17.0	25.5
5B4	11kW	27.7	25.0	41.6	27.7	25.0	41.6
	15kW	33.0	30.0	49.5	33.0	30.0	49.5

PM motor drive energy saving

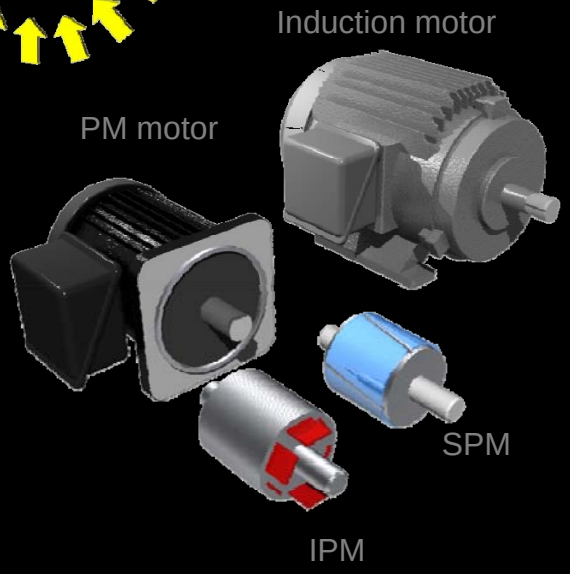
<Standard feature of Permanent Magnetic (PM) motor drive>

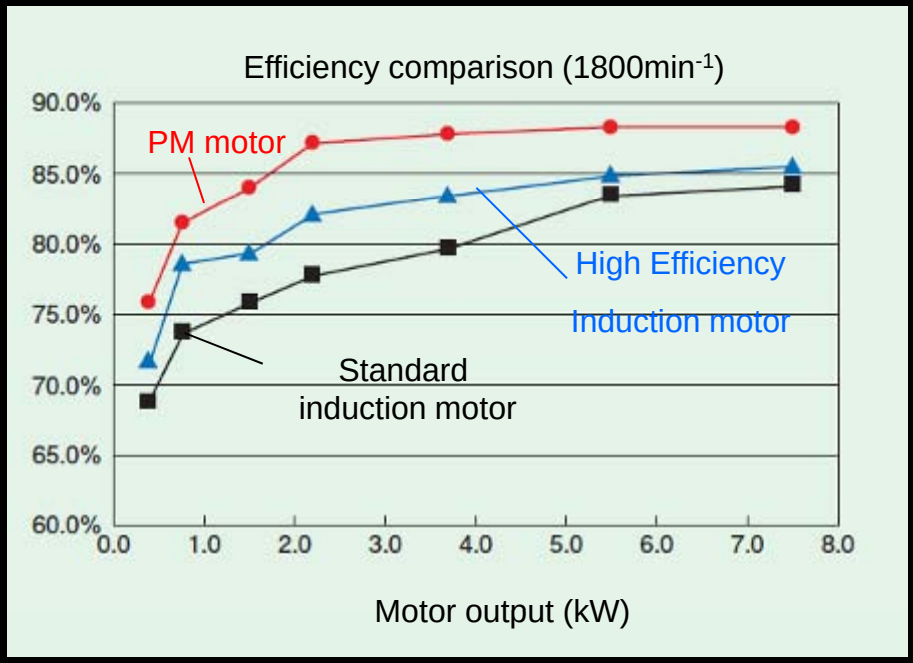
The VF-MB1 controls not only 3-phase induction motors (Standard, High efficiency motor) but also Interior Permanent Magnetic Motor (PM) and Surface Permanent Magnetic motor (SPM) for high efficiency, high torque, energy saving, downsizing and lightening.

Power-ON sensor less initial magnetic pole detection



- Initial magnetic pole position can be detected quickly without magnetic pole sensor
- High starting torque





Motor efficiency comparison

PM drive technology

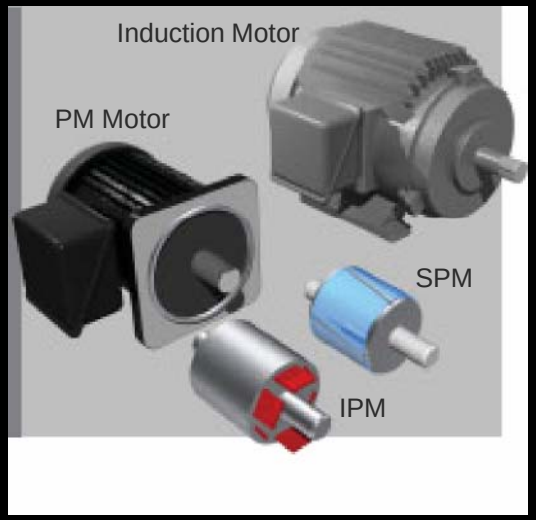
Induction Motor, and Sensor-less Permanent Magnetic motor, SPM / IPM drive capability

Toshiba unique magnetic pole position detection

The VF-MB1 controls not only 3-phase induction motors (Standard, High eficiency motor) but also Interior Permanent Magnetic Motor (IPM) and Surface Permanent Magnetic Motor (SPM) for high eficiency, high torque, energy saving, downsizing and lightening.

IPM motor
(Interior Permanent Magnet)

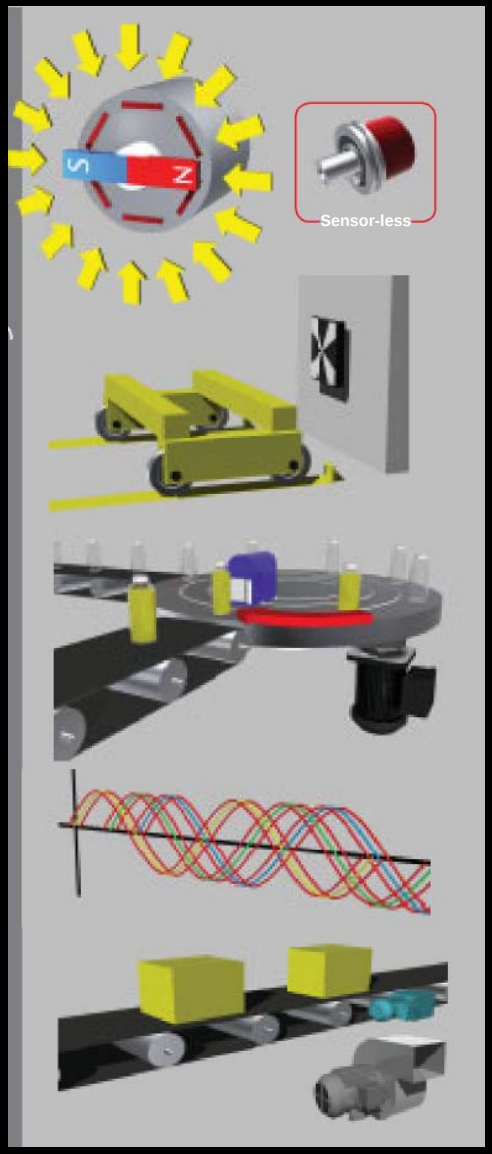
IPM motor explains work of reluctance torque and the expansion effect of the control range.



SPM motor
(Surface Permanent Magnet)

The SPM motor explained the winding technology for realizing high efficiency, and the technology of reducing a torque ripple.

ADVANCED MOTOR DRIVE



PM drive technology

Power-ON sensor less initial magnetic pole detection

- Initial magnetic pole position can be detected quickly without magnetic pole sensor.
- Motor has high starting torque
- It can minimize motor space, wiring and suitable with system requirements.

(If the auto-tuning performed with motor rated parameter settings, high torque control operation can be achieved.) (*1)

Hit and stop function (Torque limit function)

Extra limit switch can be eliminated for conveyor, machine tool or other mechanical application by using Hit and stop function with torque limit function which can be adjusted torque value of motor torque, and motor rotation can be stopped by torque detection.

Servo lock function

The VF-MB1 and PM motor combined, servo lock function can be used for automated system. It can control easily for stop and go applications by smooth speed reduction control for shock-less mechanical braking.

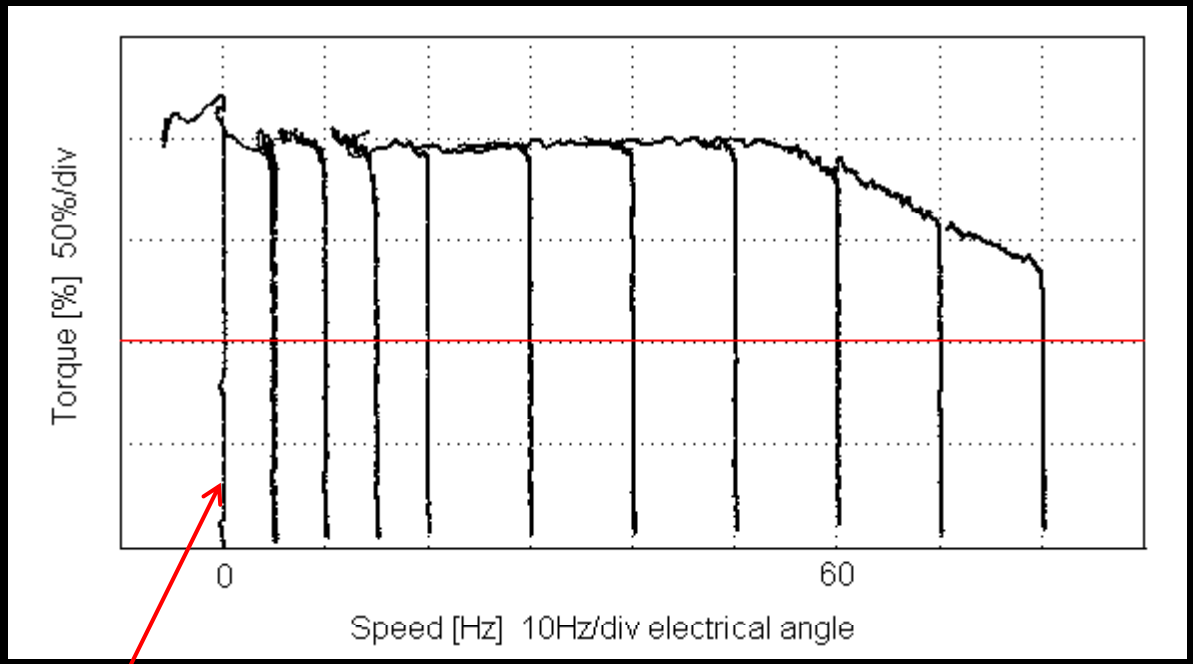
Sensor less step-out detection

The VF-MB1 will keep detecting the pole position during PM motor is rotating. This function can prevent the step-out even if motor has impact and variable load torque.

Constant and Variable torque control

The VF-MB1 can drive PM motor with not only variable torque but also constant torque which is required large torque when motor start to rotate.

Torque-Speed Characteristic (Testing)



Motor spec

N customer 1800min-1 0.4kW 4Pole
PMType: **IPMSM**

Rs:8.5ohm / phase

Ld:43mH /phase

Lq:70mH /phase

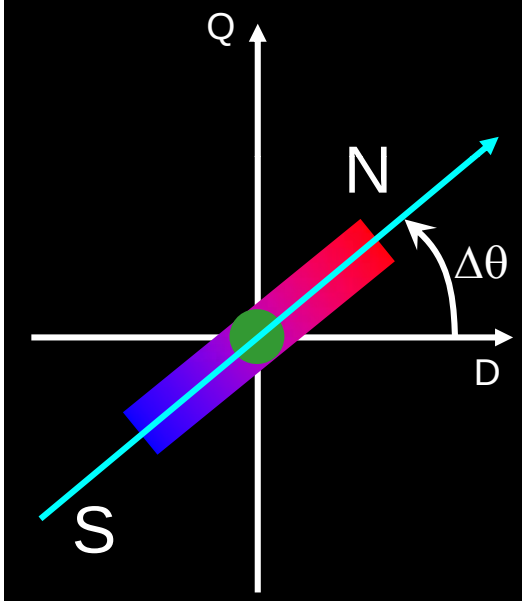
(Lq-Ld)/Lq=0.39

this value is expected more than 0.25 at least for stable control .

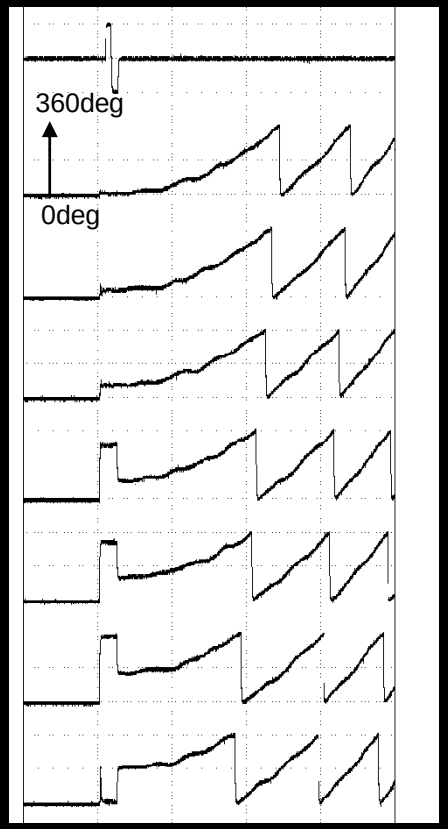
Zero Speed can be controlled by servo lock function

Detecting the Initial Pole Position

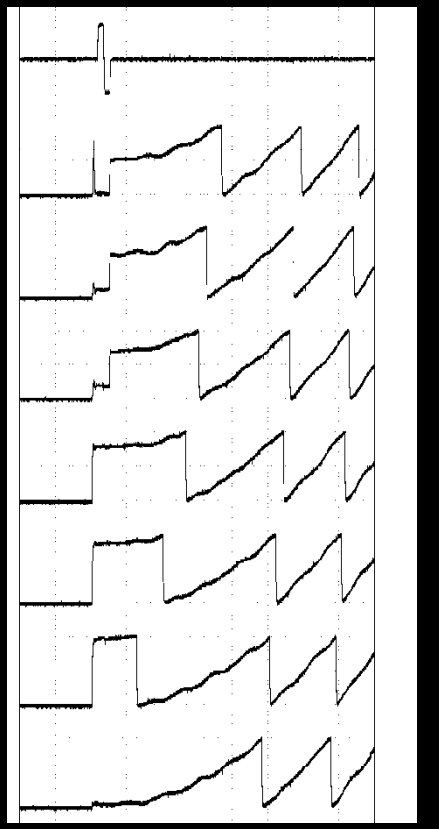
Drive can start smoothly from any initial rotor positions.



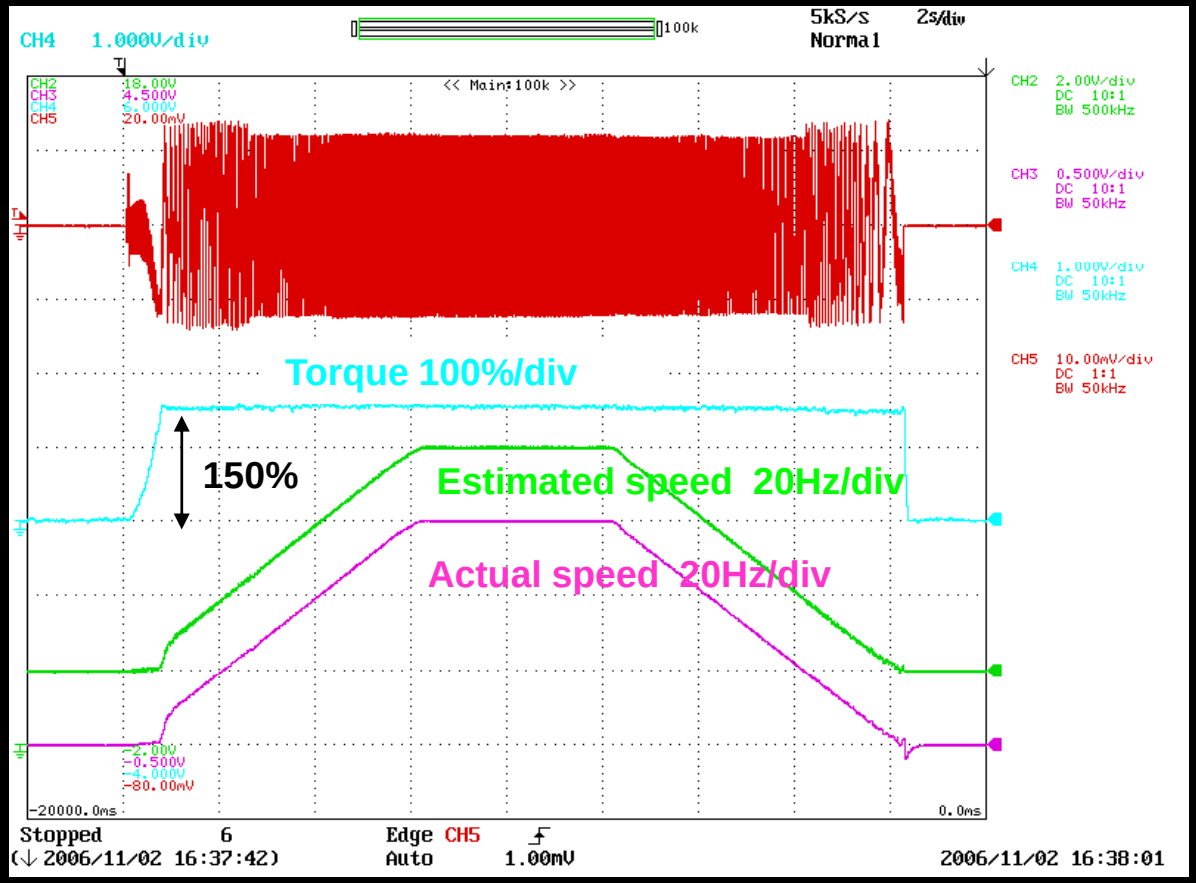
Δθ=0deg
Δθ=30deg
Δθ=60deg
Δθ=90deg
Δθ=120deg
Δθ=150deg
Δθ=180deg



Δθ=180deg
Δθ=210deg
Δθ=240deg
Δθ=270deg
Δθ=300deg
Δθ=330deg
Δθ=360deg



Acceleration with 150% torque (Testing)

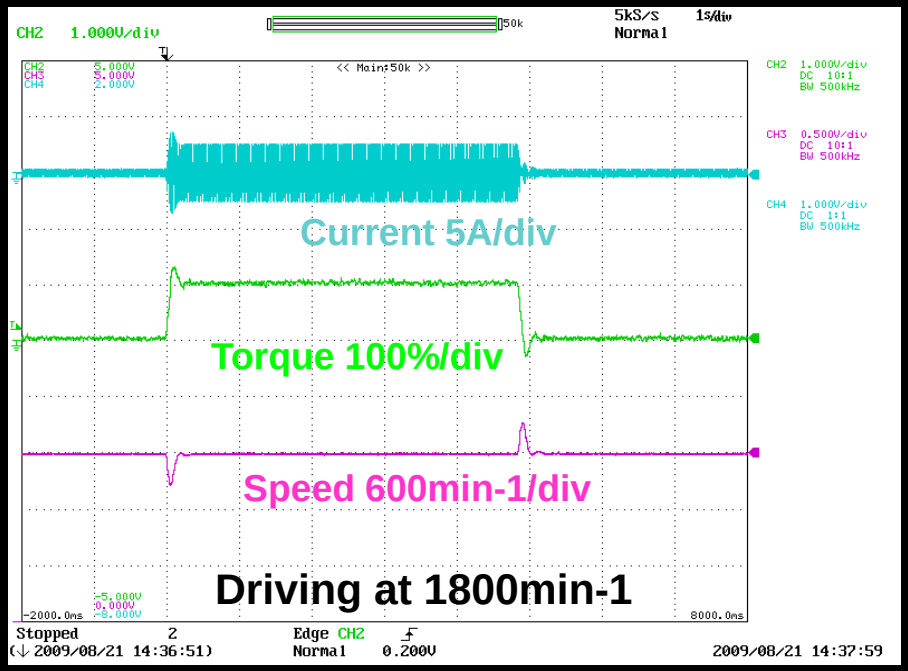


Motor spec
TOSHIBA 1800min-1 3.7kW 6Pole
PMType: IPMSM
Rs:0.5ohm / phase
Ld:4.74mH /phase
Lq:8.42mH /phase

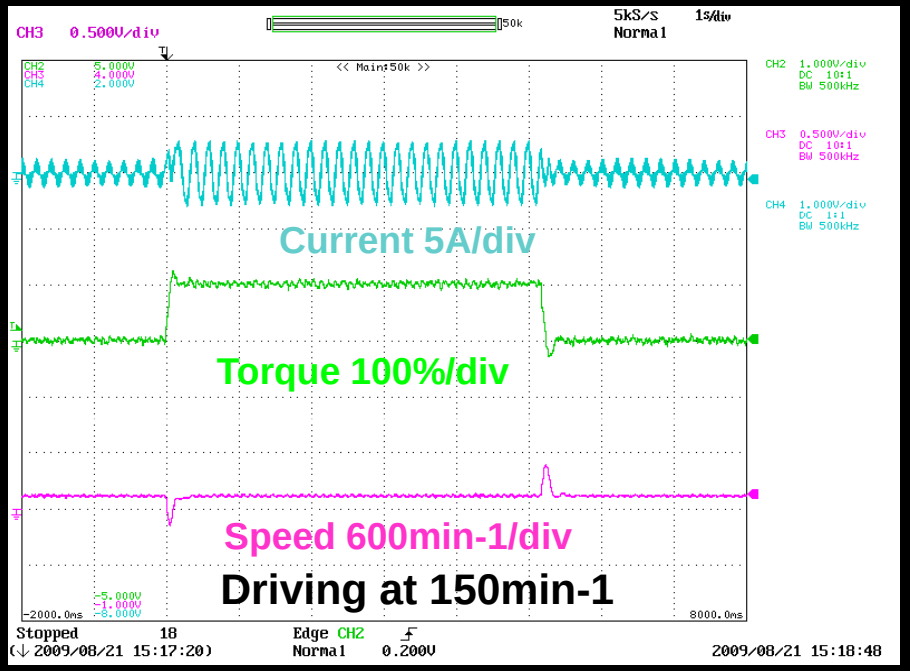
(Lq-Ld)/Lq=0.44
this value is expected more than 0.25 at least for stable control .

Scale
Time: 2s/div
Current:20A/div
Speed: 20Hz/div
ACC setting 120Hz/10s

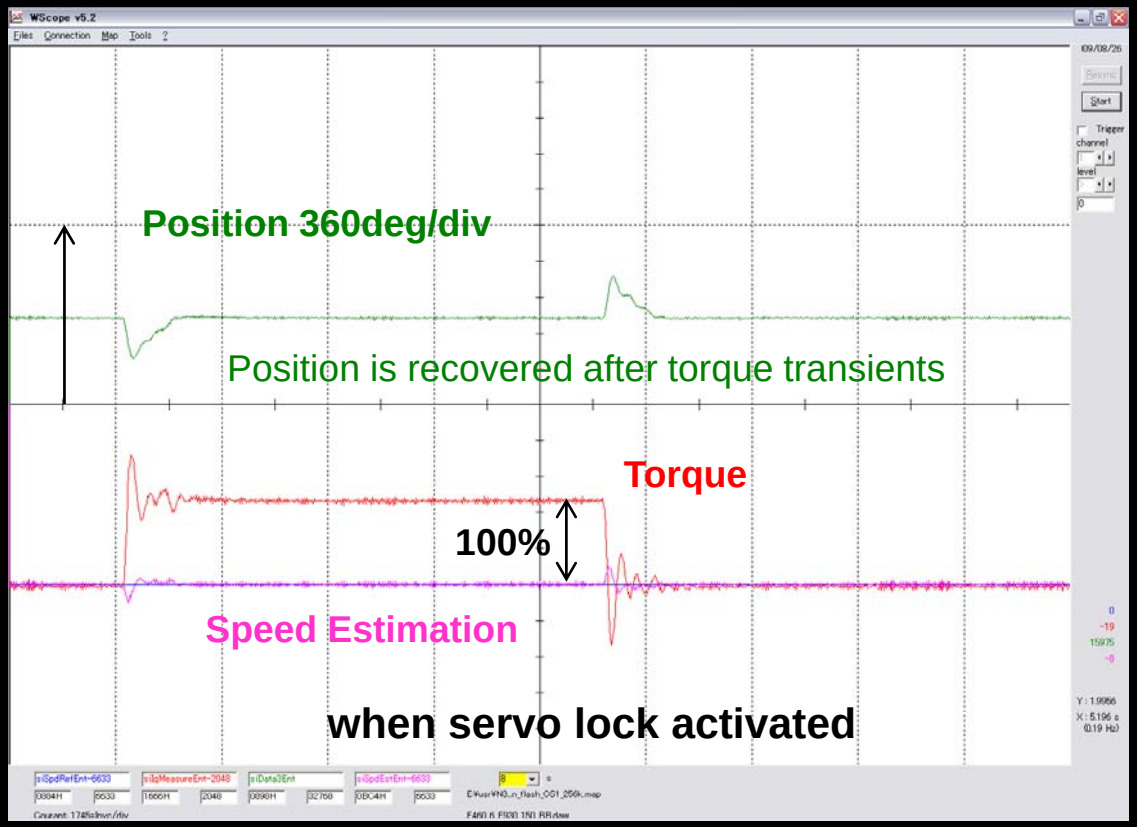
Disturbance Torque Response when speed control



Motor spec
N customer 1800min-1, 0.4kW
4Pole PM Type: **IPMSM**
Rs: 8.5ohm / phase
Ld: 43mH /phase
Lq: 70mH /phase

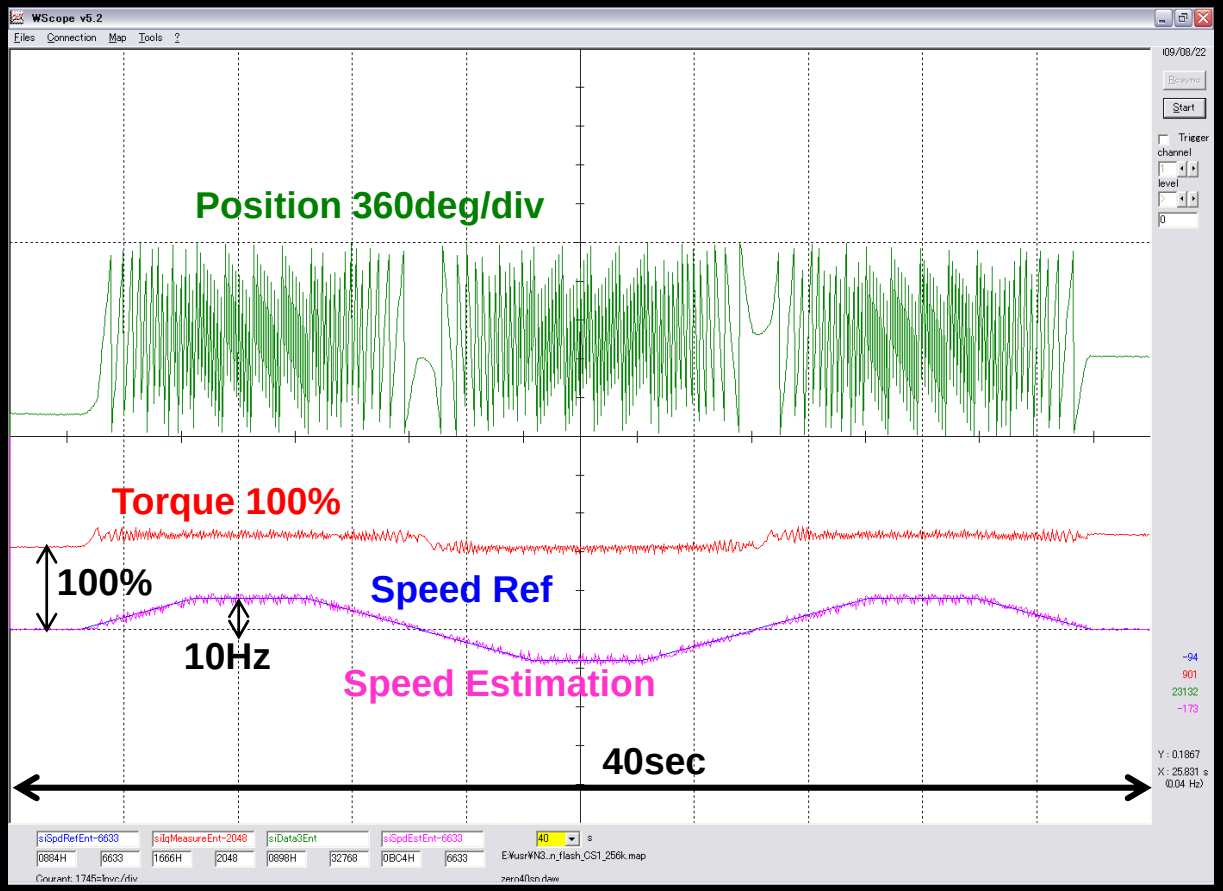


Disturbance Torque Response when servo lock activated



Motor spec
N customer 1800min-1 0.4kW
4Pole PMType: **IPMSM**
Rs:8.5ohm / phase
Ld:43mH /phase
Lq:70mH /phase

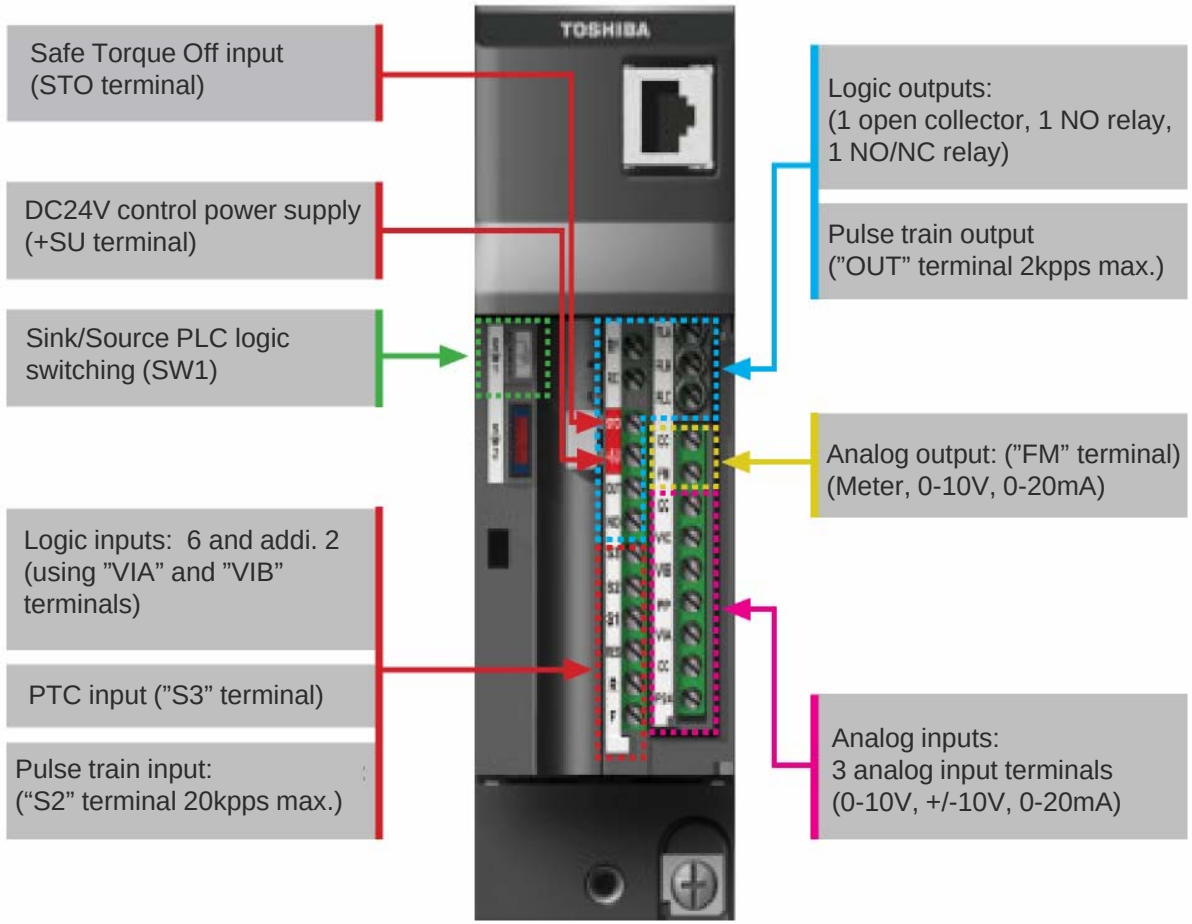
Stable Drive around 0 Hz with nominal load



Motor spec
N customer 1800min-1 0.4kW
4Pole PMType: **IPMSM**
Rs:8.5ohm / phase
Ld:43mH /phase
Lq:70mH /phase

FLEXIBLE TERMINALS

Control terminal layout



Combination I/O

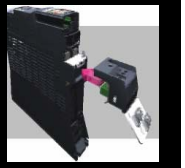
Multiple input terminal functions can be assigned with single input terminal, also output terminal can be assigned by "AND" and "OR" logics. This variety of functions allows for flexible system design.

Covered input terminals

Easy connection of front side input terminals with safety quick open cover.

Removable output terminal block

Easy install and maintenance by quick detachable output terminal block.(up to 4.0kW)



FLEXIBLE TERMINALS

■ Flexible I/O terminals

- ➢ Logic input: 6 terminals + 2 terminals (Using VIA & VIB)
  - 2 or 3 functions can be assigned.
  - Number of function menu: About 110 functions
  - Sink/source logic switching: Slide switch SW1
- ➢ Logic output: 1 open collector, 1 NO relay, 1 NO/NC relay
  - 2 functions can be assigned and and/or logic can be set.
  - Open collector terminal is isolated. (OUT-NO terminal)
  - Number of function menu: About 150 functions
- ➢ Analog input: 3 terminals (0-10V, +/-10V, 0-20mA)
  - Not only Frequency reference, but also special functions (ACC, vLv, etc…)
- ➢ Analog output: 1 terminals (Meter option/0-10V/0-20mA)
  - Function switching: Parameter
- ➢ Pulse train output: Using OUT terminal (5kHz max.)
- ➢ Pulse train input: Using S2 terminal (30 kHz max.)
- ➢ PTC input: Using S3 terminal

FLEXIBLE TERMINALS

Title	Marking	Function
Control power supply	**+SU**	- Between +SU & CC, DC24V input for control power supply. - Between +SU & CC, DC24V output by automatically switching.
DC24V output	**P24**	- Internal DC24V power supplly is used for LI. - External DC24V power supply input by automatically switching
Power removal	**PWR**	- Between PWR & +SU is closed, inverter can be operated. - Between PWR & +SU is opened, inverter is no operated. (Free run)
Power supply	**PP**	DC10V output for frequency reference
Common	**CC x 2**	Common
Logic input 1	**F**	Logic input 1
Logic input 2	**R**	Logic input 2
Logic input 3	**RES**	Logic input 3
Logic input 4	**S1**	Logic input 4
Logic input 5	**S2**	- Logic input 5 - Pulse train input by parameter switching
Logic input 6	**S3**	- Logic input 6 - PTC input by slide switch (SW2)
Analog input 1	**VIA**	- 0-10V input - Logic input 8 by parameter switching
Analog input 2	**VIB**	- +/-10V input - Logic input 7 by parameter switching
Analog input 3	**VIC**	- 0-20mA input
Analog output	**FM**	- Meter option - 0-10V output by parameter switching - 0-20mA output by parameter switching
Logic output 1	**OUT / NO**	- Logic output - Pulse train output by parameter switching
Ry output 1	**RY / RC**	NO relay output
Ry output 2	**FLA/FLB/FLC**	NO/NC relay output

Application list

Category	Applications
Food processing Machinery	Mixer, Slicer, Bread making machine
Material handling	Conveyor, Feeder, Elevator, Lifting machine, Parking system, Lapping machine
Textile machinery	Flat knitting machine, Circular knitting machine, dyeing machine
Chemical machinery	Soap machine, Mixer, Sand mill, Grinding mill, Centrifugal separator
Machine tool	Turning machine, Grinding machine, Milling center, Press machine, Boring mills
Fan/Pump	HVAC, Chiller, Air handler, Water supply, Heat pump, centrifugal fan, Clean room
Paper industries	Winder, Printing
Healthcare	Lifter, Fitness machine, X-ray
Amusement	Park ride, Stage equipment machine
Home appearance	Washing machine, Home elevator, Dust collector

- The general purpose variable frequency inverter drive can be used for the equipment for factory automation, air conditioner, pump and lifting applications.

Optional Devices

Multifunction

- Logic sequence function: Similar to AS1's function
- Traverse function for textile application
- Brake sequence function
- Hit and stop function
- Long lifetime design

Options

- Remote keypad : RKP007Z
- Parameter writer (power on) : RKP002Z
- Parameter writer (power off) : PWU003Z
- LCD keypad : RKP004Z

Optional Devices

Multi-Loader PWU003Z

NEW

Customize

The Handy writer (Multi-loader) can customize the VF-MB1 for application demand.

The PWU003Z has own power (standard AAA battery) and VF-MB1 is not necessary to plug the input power source.

Once parameter is pre-programmed, operator may not necessary to set the parameter after install.

Multi-Loader set
(PWU003Z)

(1) Parameter writer

(2) SD card

(3) Standard USB type A to Mini-B cable

(4) RJ45 (RJ45/RJ45) cable(Length: 1m)

(5) Carry case

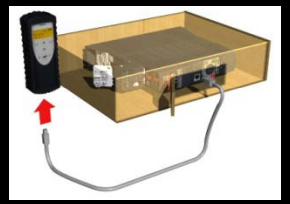
(6) User's manual (Japanese and English)

(7) Impact resistant cover

(8) Wrist strap

Data transfer
(PWU003Z – VF-MB1)

The PWU003Z can transfer the data (Parameter, Software) without power supply for VF-MB1.



This function is used for the OEM customer.

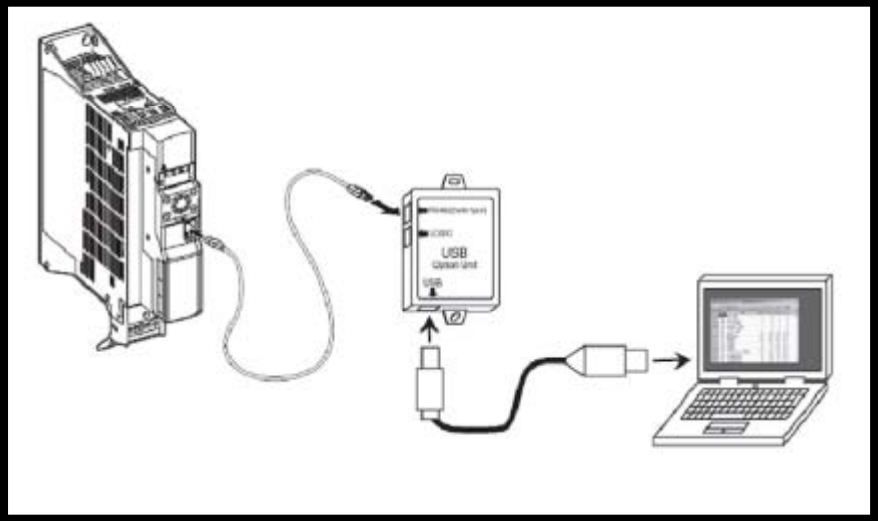
(VF-MB1: RJ45 port)

Data transfer
(PWU003Z – PC)

The transferred data of Parameter and Software can download to PWU003Z by using the USB cable or SD memory card.

Multi USB communication

Image: USB002Z



Data Editing

USB001Z

Your PC and the VF-MB1 can be connected. Data monitoring and parameter setting can be transferred from PC directory.

Software

The Sequence programming software and The Communication software (PCM001Z) are free software for customization.

Sequence programming software

The Sequence programming software can programmed the MY-FUNCTION (logic sequence program) by using PC.

It can eliminate the setting on he panel of VF-MB1

Communication software (PCM001Z)

The PCM001Z is communication software for PC.

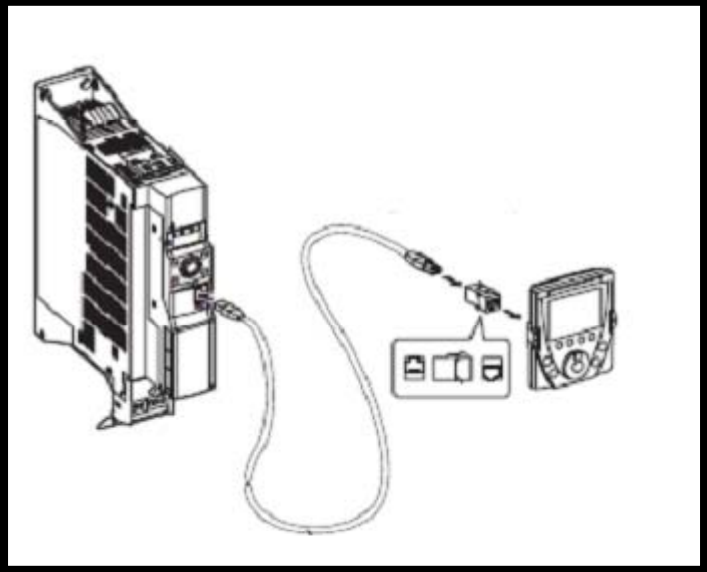
Each parameter can set by offline and online with VF-MB1.

Also, data monitoring can be linked with VF-MB1.

The condition of Voltage, Amperage, Torque, Consumption power can be monitored on the graphical screen.

Multi

External control panel



Monitoring and Control

USB001Z

Your PC and the VF-MB1 can be connected.
Data monitoring and parameter setting can be transferred from PC directory.

Software

The Sequence programming software and The Communication software (PCM001Z) are free software for customization.

LCD Extension Panel

The 23-character x 8 line display can be used for simple setup and monitoring by selection of parameters using jog dial.

The display language can be switched.

W x H x D: 92mm x 107mm x 26mm

LED extension panel (RKP002Z)

The RKP002Z is using 20mm LEDs.

Parameter copy function is available.

W x H x D: 115mm x 80mm x 17mm

LED extension panel (RKP007Z)

The RKP007Z is compact size extension panel.

Parameter copy function (read/write) is available.

W x H x D: 50mm x 70mm x 15mm


TOSHIBA
Leading Innovation