V7 Custom Software
Kinetic Energy Back-up
(KEB)

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Yaskawa Electric America, Inc.

Software Numbers: VSP015166 (0.4 - 3.7kW)
VSP015292 (5.5 - 7.5kW)

Drive Part Number: CIMR-V7AM*-091

Please note that the high horsepower version VSP015292 contains both the KEB function as well as the Traverse function. The low horsepower traverse function is available in software VSP018031 (CIMR-V7AM*-029). Refer to the manual TM.V7SW.029 for Traverse function details.

1. Basic Specification

The basic specifications of KEB (Kinetic Energy Back-up) function are in conformance with the description of the V7 Technical Manual (TM.V7.01). The following outlines the exclusive specifications.

In order to prevent the drive from tripping at low voltage because of a momentary power loss or power failure during operation or the motor from coasting for a long time period, the drive detects a momentary power loss or power failure immediately when it occurs, and continues control using the regenerative energy from the motor or decelerates to a stop. (The KEB function and the standard software function momentary power loss ride through cannot be used simultaneously.)

The power supply is monitored according to the status of the multi-function digital input terminals; the motor re-accelerates to the former speed at recovery from the power loss   (Power loss detecting relay must be mounted externally and the run command must be kept during momentary power loss).

Automatic power loss detection function is available in order to make the motor switch to the regenerated status promptly without tripping even at a momentary power loss or power failure during high-load operation (However, perfect prevention from tripping depends on the load ratio, load inertia, motor characteristics or capacitor size in the drive).

Note: This software does not support the energy-saving control.

2. Details of KEB Specification

2.1 Basic Circuit

The KEB function becomes active when parameter n081 (Operation after Recovery from Momentary Power Loss) is set to 3 (KEB Continuous Operation) or when a multi-function digital input terminal is set to the KEB command. To restore the motor to the former operation status upon recovery from a power loss, program one of the multi-function digital input terminals S1 to S7 (n050 to 056) to the KEB command (set values: 28 or 29) as shown in the following table. The run command must also be maintained during the momentary power loss. When the run command is removed during the momentary power loss, the drive continues decelerating to a stop even if power returns.
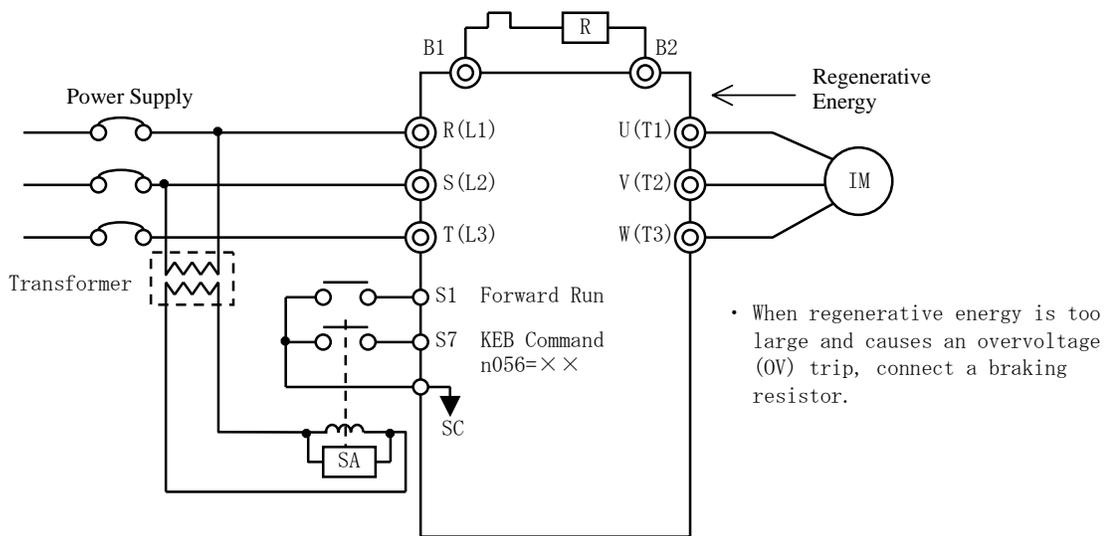
2.2 Added / Modified Parameters

No.	5.5/7.5kW standard VSP010104	5.5/7.5kW KEB software VSP01529x
n045	Reserved	KEB deceleration time 1
n046	Reserved	KEB deceleration time 2
n047	Reserved	KEB deceleration Ratio changeover time
n048	Reserved	KEB starting voltage
n049	Reserved	Stall prevention during deceleration (braking transistor operational) voltage
n139	Energy saving control selection	AVR time constant
n140	Energy saving coefficient K2	Undervoltage detection level
n141	Energy saving control voltage lower limit (@ 60Hz)	Operation selection at power ON
n142	Energy saving control voltage lower limit (@ 6Hz)	Selection of braking transistor operation during stop
n143	Power average time	KEB compensation time
n144	Search operation voltage limit	Power loss detection relay delay time
n145	Search operation voltage step (@100%)	KEB re-acceptance prohibition time
n146	Search operation voltage step (@5%)	Reserved
n159	Upper voltage limit for energy saving control (@60Hz)	Disturb waveform amplitude
n160	Upper voltage limit for energy saving control (@6Hz)	Disturb waveform Jump
n161	Search operation power detection hold width	Negative slope time
n162	Time constant of power detection filter	Positive slope time
n170	Reserved	Disturb waveform selection
n171	Reserved	Stall prevention during acceleration selection
n172	Reserved	Stall prevention voltage during acceleration

Note: Reference manual TM.V7SW.029 for details on the Traverse function.

2.3 Setting Range Changes

No.	Parameter name	Settings
n050 - n056	Multi-function input selection 1-7	*Additional selections:* 28: KEB command (NO) 29: KEB command (NC) 30: Disturb disable (opened = enabled) 31: Simple synchronized Accel/Decel
n057 - n059	Multi-function output selection 1-3	*Additional selections:* 22: During KEB operation 23: High-speed operation 24: During disturb up 25: During disturb
n081	Operation selection after momentary power loss	*Additional selection:* 3: KEB operation

2.4 KEB Function Related Parameters

No.	Modbus Register	Name	Description	Setting Range	Initial Value	Remarks
n050 to n056	0132H to 0138H	Multi-function Digital Input Selection 1 - 7	Programming the KEB command (settings NO contact: 28 or NC contact: 29) to a multi-function digital input enables the KEB function, resulting in re-acceleration at recovery from the power loss. If a KEB command is not programmed, operation follows the setting of parameter n081.	-	-	KEB command cannot be set to more than two terminals and settings 28 and 29 cannot be set at the same time.
n057 to n059	0139H to 013BH	Multi-function Digital Output Selection 1 - 3	22: During KEB Operation KEB signal is output during KEB deceleration or re-acceleration. This function is not active if the KEB function is not programmed. 23: High-Speed Operation <This output closes during speed agree the high-speed (main) frequency selection (when none of the multi-function digital input functions Multi-step Speed 1-4 or Jog are closed.). The output cycles close/open every 0.5 seconds during speed agree (except for the main speed reference). The output cycles close/open every 1 second during acceleration or deceleration regardless of the frequency reference. The output opens while stopping. This function is active even if the KEB function is not programmed. 15: Undervoltage Detection In addition to the standard software conditions of Undervoltage, the output will also close during deceleration due to the KEB function. 30: Disturb waveform disable Signal disables the disturb waveform. **Note: Function available in large HP version only (VSP01529X).** 31: Simple synchronized Accel/Decel When the signal is input, the Accel/Decel times are modified as follows: Time = Accel/Decel time x (Fmax / Fref) **Note: Function available in large HP version only (VSP01529X).**	-	-	All multi-function digital outputs have a 100msec minimum state length.
n081	0151H	Selection of Operation after Momentary Power Loss	0: Operation not continued. 1: Ride Through. Operation continued at recovery from power loss within 0.5 second 2: CPU Ride Through. Operation continued at recovery from power loss (no fault output). 3: KEB Operation.	0 to 3	3	
n045	012DH	KEB Deceleration Time 1	When KEB operation starts, the motor decelerates in KEB Deceleration Time 1. After KEB Deceleration Ratio Changeover Time, the motor decelerates in KEB Deceleration Time 2. The setting unit of KEB Deceleration Times 1 and 2 depends on the setting of parameter n018: Accel/Decel Time Setting Unit.	0.00 to 6000 sec	10.0sec	Parameters can be set during running.
n046	012EH	KEB Deceleration Time 2		0.00 to 6000sec	10.0sec	
n047	012FH	KEB Deceleration Ratio Changeover Time		0.00 to 2.55sec	0.10sec	
n048	0130H	KEB Starting Voltage	The drive starts KEB operation when main circuit DC bus voltage becomes less than the KEB detection voltage value or when the multi-function digital input function "KEB Command" is closed. Note: Parameter n081: Momentary Power Loss must be set to 3.	135 to 300Vdc	225Vdc	The setting range and the initial value are doubled for 460V units.

No.	Modbus Register	Name	Description	Setting Range	Initial Value	Remarks
n049	0131H	Stall Prevention during Deceleration (and Braking Transistor Operational Voltage)	Sets the Stall Prevention during Decel operational voltage and the braking transistor turn-on voltage when a braking resistor is provided. Note: This function is active regardless of the KEB function status or programming.	300 to 400Vdc	400Vdc	
n139	018BH	AVR Time Parameter	Sets the time constant of the output voltage AVR (stabilization) function. AVR function is disabled when the set value is 0.00sec.	0.00 to 2.55sec	1.00sec	
n140	018CH	Undervoltage Detection Level	Sets the Undervoltage (UV1) trip level of the DC bus. Normally, this setting does not have to be changed. Note: This function is active regardless of the KEB function status or programming.	135 to 210Vdc	150Vdc	The setting range and the initial value are doubled for 460V units.
n141	018DH	Operation Selection at Power ON	Operation can be prohibited if the run command (forward or reverse) is present when the power supply is turned on. This can prevent accidental machine operation. 0: Run Permitted 1: Run Prohibited Note: This function is active regardless of the KEB function status or programming.	0 to 1	0	
n142	018EH	Selection of Transistor Operation during Stop	Selects whether the braking transistor circuit is active when the drive stops. 0: Disabled 1: Enabled Note: This function is active regardless of the KEB function status or programming.	0 to 1	0	
n143	018FH	KEB Compensation Time	An Undervoltage (UV1) trip will occur regardless of the DC bus voltage when a momentary power loss lasts more than the KEB Compensation Time. Note: This function is disabled when the set value is 0.00 seconds.	0.0 to 25.5sec	0.0sec	
n144	0190H	Power Loss Detection Relay Delay Time	Prevents power loss recovery errors caused by a delay in the opening of the power loss detection relay by determining when the re-acceleration sequence is needed. The drive monitors the status of the KEB Command and the DC bus voltage. Re-acceleration is made when the multi-function input terminal and the main circuit DC bus bar voltage are restored after the power loss detection relay delay time elapses. Note: A setting of 50msec will be used when the set value is 0.0sec.	0.0 to 25.5sec	0.1sec	
n145	0191	KEB Re-acceptance Prohibition Time	Re-acceptance of KEB operation can be prohibited only for the specified time after re-acceleration starts after a momentary power loss. Note: This function is disabled when the set value is 0.00 seconds.	0.0 to 25.5sec	0.0sec	
n146 <2>	0192H	KEB Re-acceleration Time selection	Selects the KEB re-acceleration time after the KEB Command is removed. 0: Selected acceleration time (n019, n021, n041 or n043) 1: KEB re-acceleration time (n148)	0 to 1	0	
n148 <2>	0194H	KEB Re-acceleration Time	Sets the KEB re-acceleration time when KEB re-acceleration time selection (n146) is 1. Note: This parameter is not effective when n146 is set to 0.	0.00 to 6000sec	10.0sec	

2.5 Description of Operation

Basic Operation

Setting parameter n081 (Selection of Operation after Recovery from Momentary Power Loss) to 3 (KEB Operation Continued) or setting a multi-function digital input terminal to the KEB command (NO contact: 28, NC contact: 29) enables the KEB function. The drive detects a power loss due to the DC bus voltage or the multi-function digital input KEB command, decelerates immediately and maintains its own DC bus voltage using the regenerative energy from the motor (load) to continue control of the motor during deceleration.

If the KEB command is not programmed to a multi-function digital input and Selection of Operation after Momentary Power Loss (parameter n081) is set to 3, KEB monitors the main circuit DC bus voltage.

・KEB Start Voltage: DC bus voltage $\leqq$ n048

・KEB Release Voltage: DC bus voltage $\geqq$ n048＋15VDC (30VDC for 460V units)

When the KEB command is set to the multi-function input and the run command is maintained during the power loss, the drive monitors the status of the KEB command. After the Power Loss Detection Relay Delay Time (n144) elapses, the drive will recovery from the power loss when the KEB command turns OFF and DC bus voltage exceeds the KEB releasing voltage by re-accelerating up to the speed obtained when KEB operation started. The motor decelerates to a stop without re-acceleration if the run command turns OFF during a momentary power loss or a long-term power loss occurs. (Unless the KEB command is set to the multi-function input, the drive specifies the recovery from the power loss according to the status of DC bus bar voltage after the Power Loss Detection Relay Delay Time (n144) elapses, and re-accelerates)

When the KEB operation starts, the motor decelerates in KEB Deceleration Time 1 (n045), and then in KEB Deceleration Time 2 (n046) after KEB Deceleration Ratio Changeover Time (n047) elapses. Therefore, set a fast deceleration ratio only when the KEB operation starts so that the drive DC bus bar voltage can be maintained immediately.

Multi-function Digital Outputs (Parameters n057 to n059)

When the KEB function is programmed, the Undervoltage detection signal (set value: 15) turns ON with DC bus voltage less than the KEB Starting Voltage (n048) or during KEB deceleration while the KEB running signal (set value: 22) turns ON during KEB deceleration or re-acceleration.

The high-speed running signal (set value: 23) is also available.   This signal turns ON during speed agreed of the high (main) speed reference. The high-speed frequency is defined as the reference when digital input functions Multi-step Speeds 1-3 are OFF (open). The output turns ON/OFF in the period of 1 second during acceleration or deceleration and in the period of 0.5 second during speed agreed operation at any frequency reference other than high speed frequency reference, and OFF during stop.

Mode	High Speed (Main Speed Frequency Reference Selected)	Low Speed (Any Frequency Reference Other than Main Speed Frequency Reference)
During Stop	OFF	OFF
During Acceleration or Deceleration	ON/OFF in period of 1 second	ON/OFF in period of 1 second
During Speed Agreed	ON	ON/OFF in period of 0.5 second

Stall Prevention Deceleration and Braking Transistor Operational Voltage (n049)

If an Overvoltage trip occurs when KEB starts (no braking resistor and stall prevention during deceleration enabled: n092 = 0), the stall prevention deceleration operational voltage can be reduced to avoid an OV trip. When several drives are connected on a common DC bus, connect a braking resistor to the largest drive and refer to monitor display U-05 (DC bus voltage) to adjust this parameter in order to avoid OV caused by uneven voltage detection.

・Braking transistor operational voltage: DC bus voltage ≧ n049

・Braking transistor releasing voltage: DC bus voltage ≦ n049 -10Vdc (20Vdc for 460V units)

AVR Time Constant (Parameter n139)

The time constant of the output voltage AVR (stabilization) function can be adjusted when the output current or DC bus voltage oscillates during KEB operation. Adjust this parameter in small steps. When the set value is 0.00sec, the AVR function is disabled.

Undervoltage Detection Level (Parameter n140)

UV1 trip voltage is set when the KEB function is used. Even if KEB operation is active and the DC bus voltage is reduced, when voltage becomes lower than this level, an Undervoltage (UV1) trip occurs and the motor coasts.

・Undervoltage detection level: DC bus voltage≦n140
・Undervoltage release level: DC bus voltage≧n140＋15Vdc (30Vdc for 460V units)

Selection of Operation at Power ON (Parameter n141)

Setting parameter n141 to 1 can prohibit operation, at power up, when the run command from the inputs terminals is already present. The digital operator displays EF blinking during prohibition of operation. In this condition, cycle the run command to begin normal operation.

Selection of Transistor Operation during Stop (Parameter n142)

When Selection of Transistor Operation during Stop is set to a 1 (enabled), the braking transistor turns ON when DC bus voltage exceeds the braking transistor operational voltage n049. In common DC bus applications, set the main drive with the braking transistor to a 1 (enabled) and all others to 0 (disabled).

KEB Compensation Time (Parameter n143)

When the set value of KEB Compensation Time is other than 0.0sec, the drive measures the duration of the KEB deceleration. If the time is greater than the KEB Compensation Time, an Undervoltage (UV1) trip occurs and the motor coasts, regardless of the DC bus voltage.

Power Loss Relay Delay Time (Parameter n144)

Sets the time in order to avoid improper detection caused by delayed operation of the power loss detection relay or frequent KEB operation when KEB operation is performed by DC bus voltage detection. The drive will continue KEB deceleration after KEB start until the power loss detection relay delay time elapses. Then it monitors the status of the multi-function digital input KEB Command and the DC bus voltage and determines whether re-acceleration is required.

KEB Re-acceptance Prohibition Time (Parameter n145)

Used when you do not want to repeat KEB operation when a long-term voltage reduction occurs at the level where the power loss detection relay does not operate or when a momentary power loss occurs frequently.   If the set value is other than 0.0sec, re-acceptance of the KEB Command is prohibited from the time when re-acceleration starts at recovery from the power loss to when the set time elapses. The drive will not perform KEB operation even if a momentary power loss occurs during prohibition of re-acceptance.   A DC bus voltage less than the Undervoltage Detection Level (n140) result in an Undervoltage trip.

Precautions on Application

1.The multi-function digital input function Acceleration/deceleration Prohibition (set value: 16) is not supported.

2. If the multi-function digital input function External Baseblock (set value: 12 or 13) is ON during KEB or the run command is turned OFF when the stopping method is set to "coasting to a stop" (n005 = 1), the drive enters the baseblock status, resulting in an Undervoltage (UV1) trip because the drive cannot use regenerative energy from the motor (load). Consideration must be taken so that the drive will not enter the baseblock status during KEB.

3. Increasing the S-curve time delays the start of KEB operation and can cause Undervoltage trips. Do not change the initial value (No S-curve, n023 = 0).

2.6 Timing Charts
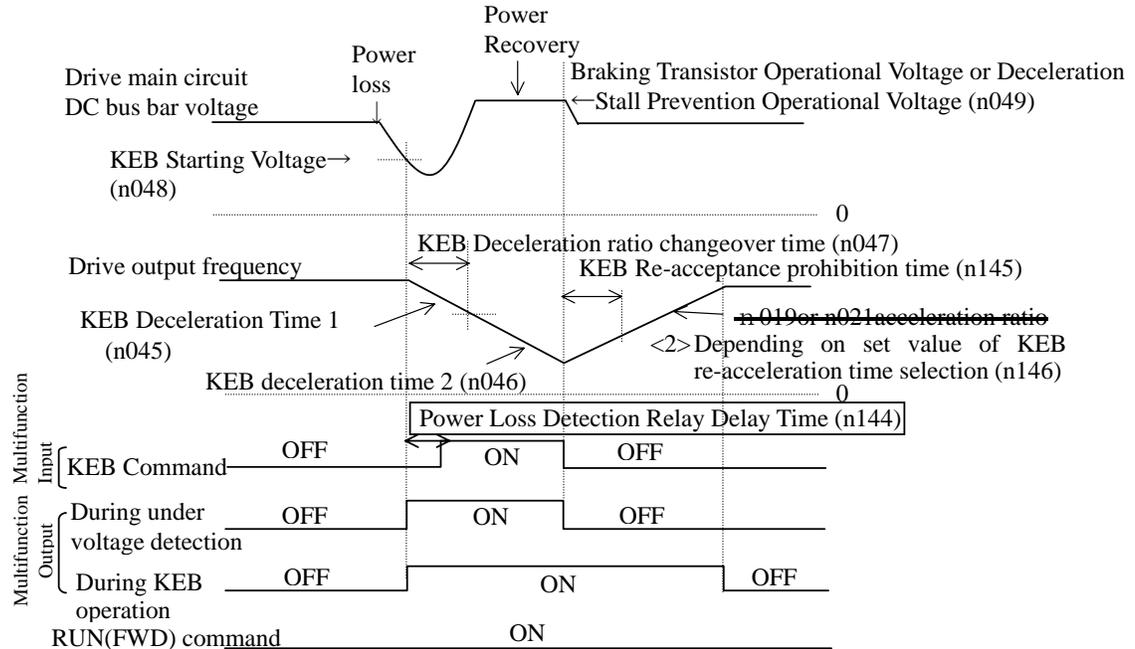
KEB Using DC Bus Voltage Detection

When a KEB command is not set to the multi-function input, KEB starts according to the drive's DC bus voltage.   The drive specifies the recovery from power loss when this voltage is restored after the Power Loss Detection Relay Delay Time elapses, and re-accelerates up to the former speed. Turn OFF the run command at a momentary power loss or when a power failure occurs if re-acceleration is not to be made at recovery from the power loss. The following shows the chart diagram when the run command is turned OFF.
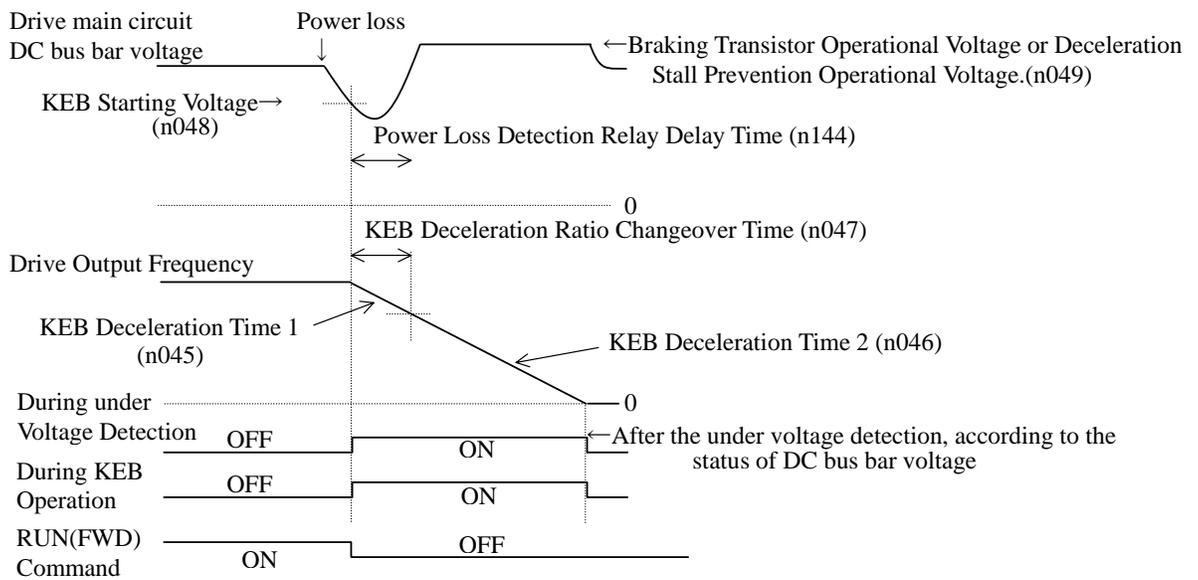
Note: To execute re-acceleration at recovery from the power loss, maintain the run command ON during power loss.   If recovery is sometimes detected improperly, set the Power Loss Detection Relay Delay Time (n144) to a greater value than the possible maximum momentary power loss time.
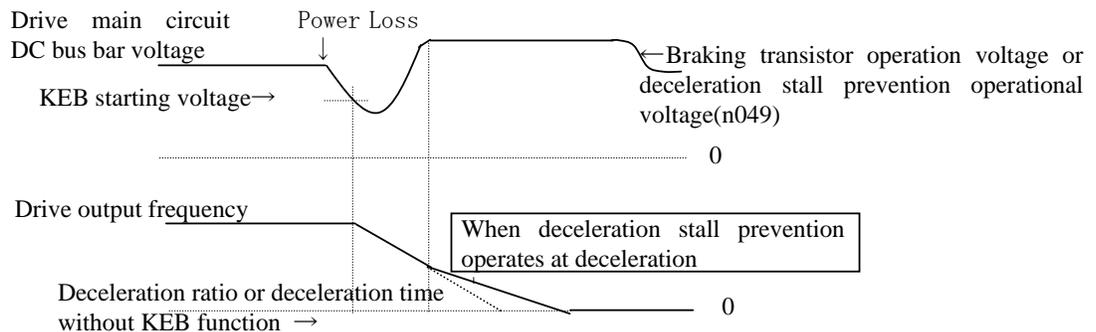
KEB Command Using Multi-function Digital Input

Programming the KEB command to a multi-function digital input, KEB starts with the KEB Command OR the drive's DC bus voltage.   The drive specifies the recovery from the power loss when these signals are restored after the Power Loss Detection Relay Delay Time elapses, and re-accelerates up to the former speed.
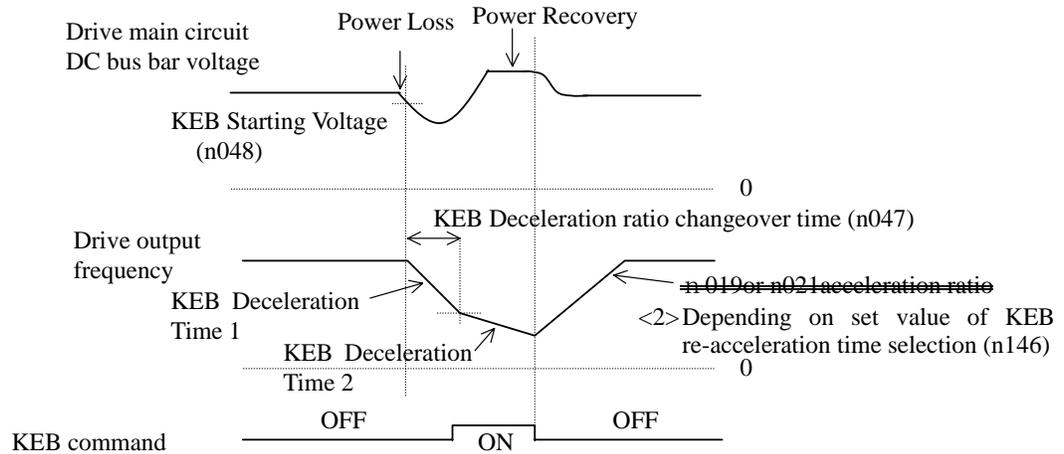

Note: Set KEB Starting Voltage (n048) to a lower value when using the multi-function digital input KEB command. This will prevent the DC bus voltage detection circuit from activating KEB.

KEB Without a Braking Resistor

Behavior when deceleration stall prevention operates at deceleration (Stall Prevention during Deceleration Enabled: n092 = 0)
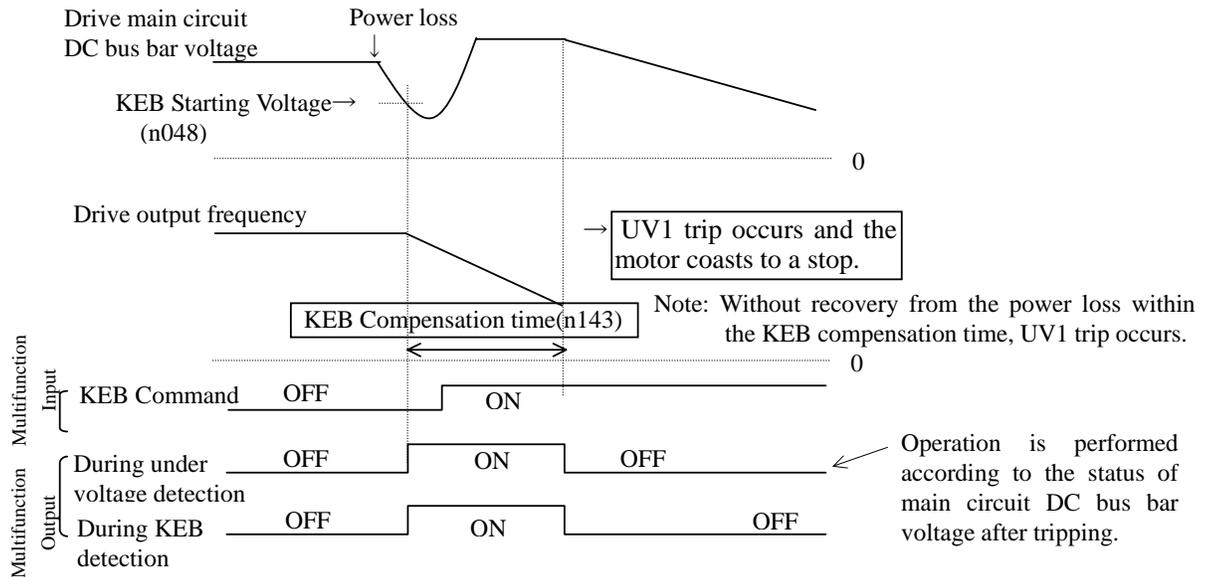
In Case of Rapid Deceleration Only When KEB Starts

Drive main circuit
DC bus bar voltage

Power Loss Power Recovery

KEB Starting Voltage
(n048)

0

KEB Deceleration ratio changeover time (n047)

Drive output
frequency

KEB Deceleration
Time 1

~~n 019or n021acceleration ratio~~

<2>Depending on set value of KEB
re-acceleration time selection (n146)

KEB Deceleration
Time 2

0

OFF   OFF

KEB command   ON

In case of power loss exceeding KEB compensation time

Operation when the multi-function input KEB command is used and the KEB compensation time is other than 0.0sec.

Drive main circuit
DC bus bar voltage

Power loss

KEB Starting Voltage→
(n048)

0

Drive output frequency

→ UV1 trip occurs and the motor coasts to a stop.

KEB Compensation time(n143)

Note: Without recovery from the power loss within the KEB compensation time, UV1 trip occurs.

0

Multifunction Input / Multifunction

KEB Command   OFF   ON

Multifunction Output / Multifunction

During under voltage detection   OFF   ON   OFF

During KEB detection   OFF   ON   OFF

Operation is performed according to the status of main circuit DC bus bar voltage after tripping.

2.7 How to Adjust

Cycle the power supply during constant speed operation or acceleration/deceleration to verify that the drive decelerates or re-accelerates without tripping. If the drive trips during KEB, adjust the following points.

（1） Undervoltage (UV1) trip occurs when KEB starts.
   ・Increase the KEB Starting Voltage (n048).   However, increasing it excessively makes the KEB operation perform even if the power supply is normal.   Do not set it higher than power supply voltage value$\times \sqrt{2} \times$0.9.
   ・Reduce the KEB Deceleration Time 1 (n045) and increase the KEB Deceleration Ratio Changeover Time (n047). Excessively rapid deceleration may make the motor stall.

（2） Undervoltage UV1 trip occurs during KEB deceleration.
   ・Reduce the KEB Deceleration Time 2 (n046).

（3） Undervoltage UV1 trip occurs at power loss during acceleration.
   ・Increase the acceleration time.

（4） Overvoltage OV trip occurs when KEB starts or during deceleration.
   ・Increase KEB Deceleration Time 1 or 2 (n045, n046).
   ・When a braking resistor is not provided, reduce the Deceleration Stall Prevention Operational Voltage (n049).   Reducing it excessively disables the drive to decelerate at normal deceleration.   Do not make it lower than power supply voltage$\times \sqrt{2} \times$1.2.
   ・Add a braking resistor if the above does not help.

（5） Output current or DC bus bar voltage oscillates during KEB operation.
   Adjust the AVR Time Parameter (n139).   However, reducing it excessively may cause oscillation during normal operation.

2.6 Guidelines of Selection and Adjustment

Regenerative power required to continue operation.(Pm)

$$Pm \ (kW) \ \geqq \ Load \ Power \ (kW) \ \diagup \ (Drive \ Efficiency \times Motor \ Efficiency)$$

Required deceleration torque (Tm)

$$Tm \ (Nm) \ \geqq \ (60 \times Pm) \ \times 10^3 \diagup [2\pi \times Motor \ RPM]$$

Note: Tm must be within the range of motor (drive) stalling torque and overload capacity

Deceleration time (td)

$$td \ (sec) \ \leqq \ [2\pi \ x \ (Reflected \ Load \ Inertia + Motor \ Inertia) \times (Motor \ RPM) \diagup (60 \times Tm) \ ]$$

Note: In the above equation, Inertia is expressed in kgm^2

Undervoltage (UV1)Trip time at power loss with no KEB (tuv)

$$tuv \ (msec) = [Drive \ Capacity \ (kW) \diagup Load \ Power \ (kW)] \times 15msec$$

Required backup capacitor capacity to be added for given backup time (Cb)

$$Cb \ (\mu F) \ \geqq \ [(2 \times P1 \times 10^3 \times tb) \ \diagup (Vn^2 - Vf^2) \times 0.9] \times 10^6$$

Note: In the above equation;

PI: Load power (kW)

tb: Backup time (sec)

Vn: Main circuit DC bus bar voltage (Vdc)

Vf: Undervoltage (UV1) trip voltage (Vdc)