



**SANYO Semiconductors**

# DATA SHEET

An ON Semiconductor Company

## LB8503V — Monolithic Digital IC DC Fan Motor Speed Control IC

### Overview

The LB8503V is an improved functionality version of the LB8500 and LB8502 products that features the added functions listed below. The LB8503V supports both single-phase and three-phase applications.

### Added Functions

- Supports origin shifting in the speed control function
- Adds a dedicated pin for setting the soft start time  
This allows a longer start time to be set without reducing the response time when changing speed.
- FG output pin added

### Functions and Features

- Achieves linear speed control  
Applications can set the slope of the change in motor speed with change in the input duty.
- Minimized speed fluctuations in the presence of line or load variations
- Allows a minimum speed to be set
- Soft start function
- Settings using external capacitors and resistors (to support easier mass production of end products)
- Supports both PWM duty and analog voltage control inputs

■ Any and all SANYO Semiconductor Co.,Ltd. products described or contained herein are, with regard to "standard application", intended for the use as general electronics equipment (home appliances, AV equipment, communication device, office equipment, industrial equipment etc.). The products mentioned herein shall not be intended for use for any "special application" (medical equipment whose purpose is to sustain life, aerospace instrument, nuclear control device, burning appliances, transportation machine, traffic signal system, safety equipment etc.) that shall require extremely high level of reliability and can directly threaten human lives in case of failure or malfunction of the product or may cause harm to human bodies, nor shall they grant any guarantee thereof. If you should intend to use our products for applications outside the standard applications of our customer who is considering such use and/or outside the scope of our intended standard applications, please consult with us prior to the intended use. If there is no consultation or inquiry before the intended use, our customer shall be solely responsible for the use.

■ Specifications of any and all SANYO Semiconductor Co.,Ltd. products described or contained herein stipulate the performance, characteristics, and functions of the described products in the independent state, and are not guarantees of the performance, characteristics, and functions of the described products as mounted in the customer's products or equipment. To verify symptoms and states that cannot be evaluated in an independent device, the customer should always evaluate and test devices mounted in the customer's products or equipment.

# LB8503V

## Specifications

### Absolute Maximum Ratings at $T_a = 25^\circ\text{C}$

Parameter	Symbol	Conditions	Ratings	Unit
Supply voltage	$V_{CC\text{ max}}$	$V_{CC}$ pin	18	V
Output current	$I_O\text{ max}$	E0 pin	3	mA
FG output pin output voltage	$V_{FG\text{ max}}$	FGOUT pin	18	V
FG output pin output current	$I_{FG\text{ max}}$	FGOUT pin	10	mA
Allowable power dissipation	$P_d\text{ max}$	When mounted on a circuit board *1	0.8	W
Operating temperature	$T_{opr}$		-30 to +95	$^\circ\text{C}$
Storage temperature	$T_{stg}$		-55 to +150	$^\circ\text{C}$

\*1 Specified circuit board :  $114.3 \times 76.1 \times 1.6\text{mm}^3$ , glass epoxy.

### Allowable Operating Range at $T_a = 25^\circ\text{C}$

Parameter	Symbol	Conditions	Ratings	Unit
Supply voltage range 1	$V_{CC1}$	$V_{CC}$ pin	7.5 to 17	V
Supply voltage range 2	$V_{CC2}$	$V_{CC}$ pin, with $V_{CC}$ shorted to 6VREG	5.5 to 6.5	V
Output current	$I_O$	E0 pin	2.5	mA
6V constant voltage output current	$I_{REG}$		-5	mA
CTL pin voltage	$V_{CTL}$		0 to 6VREG	V
LIM pin voltage	$V_{LIM}$		0 to 6VREG	V
VC1 pin voltage	$V_{CI}$		0 to 6VREG	V

### Electrical Characteristics at $T_a = 25^\circ\text{C}$ , $V_{CC} = 12\text{V}$

Parameter	Symbol	Conditions	Ratings			Unit
			min	typ	max	
Supply current	$I_{CC}$			5.5	6.5	mA
<b>6V constant voltage output (VREG pin)</b>						
Output voltage	VREG		5.8	6.0	6.2	V
Line regulation	$\Delta V_{REG1}$	$V_{CC} = 8$ to $17\text{V}$		40	100	mV
Load regulation	$\Delta V_{REG2}$	$I_O = -5$ to $5\text{mA}$		10	100	mV
Temperature coefficient	$\Delta V_{REG3}$	Design target*		0		mV/ $^\circ\text{C}$
<b>Integrating Amplifier Block (E01)</b>						
Common-mode input voltage range	$V_{ICM}$		2.0		VREG	V
High-level output voltage	$V_{OH}(E01)$	$I_{EO1} = -0.2\text{mA}$	VREG - 1.2	VREG - 0.8		V
Low-level output voltage	$V_{OL}(E01)$	$I_{EO1} = 0.2\text{mA}$		0.8	1.0	V
<b>Integrating Amplifier Block (E03)</b>						
High-level output voltage	$V_{OH}(E03)$	$I_{EO1} = -0.2\text{mA}$	VREG - 1.2	VREG - 0.8		V
Low-level output voltage	$V_{OL}(E03)$	$I_{EO1} = 0.2\text{mA}$		0.8	1.0	V
<b>FGIN pin</b>						
High-level input voltage	VFGH		3.0		VREG	V
Low-level input voltage	VFGL		0		1.5	V
Input open voltage	VFGO		VREG - 0.5		VREG	V
Hysteresis	VFGS		0.2	0.3	0.4	V
High-level input current	IFGH	$V_{FGIN} = 6\text{VREG}$	-10	0	10	$\mu\text{A}$
Low-level input current	IFGL	$V_{FGIN} = 0\text{V}$	-140	-110		$\mu\text{A}$
<b>FGOUT pin</b>						
Output low saturation voltage	VFG			0.2	0.3	V
Output leakage current	IFGL				10	$\mu\text{A}$

Continued on next page.

# LB8503V

Continued from preceding page.

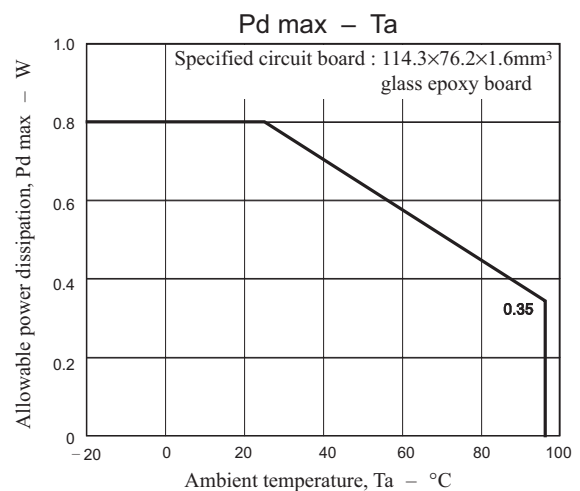
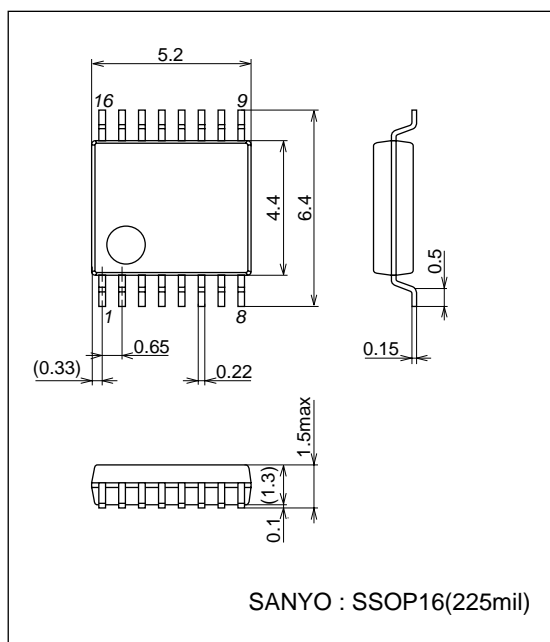
Parameter	Symbol	Conditions	Ratings			Unit
			min	typ	max	
<b>RC pin</b>						
High-level output voltage	$V_{OH}(RC)$		3.2	3.45	3.7	V
Low-level output voltage	$V_{OL}(RC)$		0.8	0.95	1.05	V
Clamp voltage	$V_{CLP}(RC)$		1.5	1.65	1.8	V
<b>CTL pin</b>						
High-level input voltage	$V_{CTH}$		2.0		VREG	V
Low-level input voltage	$V_{CTL}$		0		1.0	V
Input open voltage	$V_{CTO}$		VREG - 0.5		VREG	V
High-level input current	$I_{CTH}$	VFGIN = 6VREG	-10	0	10	$\mu A$
Low-level input current	$I_{CTL}$	VFGIN = 0V	-140	-110		$\mu A$
<b>C pin</b>						
High-level input voltage	$V_{OH}(C)$		VREG - 0.3	VREG - 0.1		V
Low-level input voltage	$V_{OL}(C)$		1.8	2.0	2.2	V
<b>LIM pin</b>						
Input bias current	$I_{B}(LIM)$		-1		1	$\mu A$
Common-mode input voltage range	VILIM		2.0		VREG	V
<b>SOFT pin</b>						
Charge current	$I_{C}(SOFT)$			1.4		$\mu A$
Operation voltage range	VISOFT		2.0		VREG	V
<b>VCI pin</b>						
Input bias current	$I_{B}(VCI)$		-1		1	$\mu A$
Common-mode input voltage range	VIVCI		2.0		VREG	V
<b>VCO pin</b>						
High-level output voltage	$V_{OH}(VCO)$			VREG - 0.2		V
Low-level output voltage	$V_{OL}(VCO)$			2.0		V

\* The design specification items are design guarantees and are not measured.

## Package Dimensions

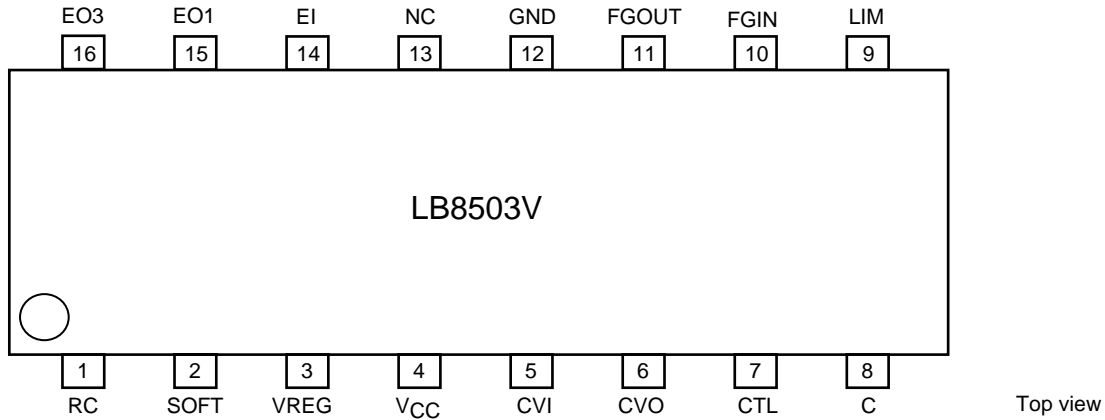
unit : mm (typ)

3178B



# LB8503V

## Pin Assignment



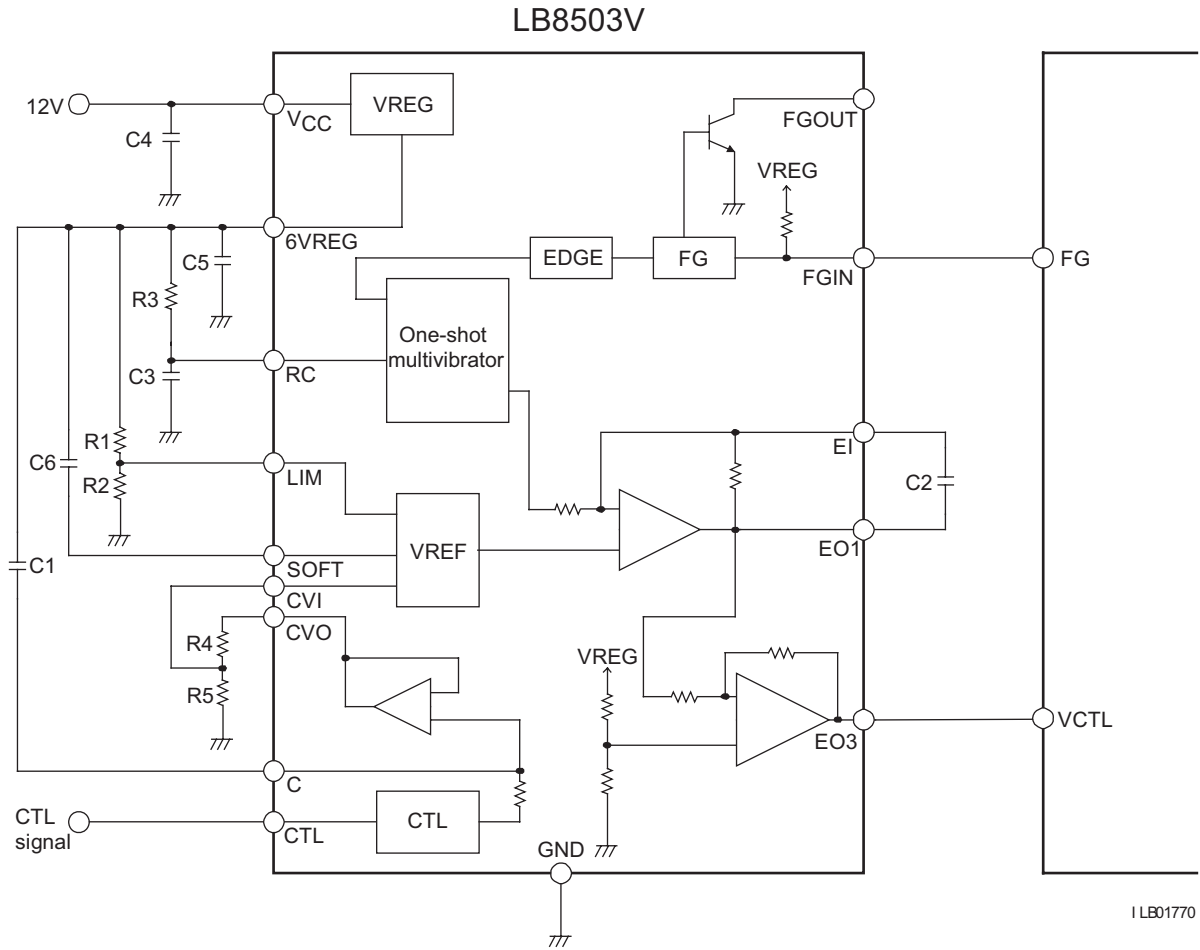
## Pin Functions

Pin No.	Pin	Description
RC	1	One-shot multivibrator pulse width setting. Connect a resistor between this pin and VREG, and a capacitor between this pin and ground.
SOFT	2	Soft start time setting. Connect a capacitor between this pin and VREG.
VREG	3	6V regulator output. Connect a capacitor between this pin and ground for stabilization.
V <sub>CC</sub>	4	Power supply. Connect a capacitor between this pin and ground for stabilization.
CVI	5	Control voltage input
CVO	6	Duty pulse signal smoothed voltage output
CTL	7	Duty pulse signal input. The speed is controlled by the duty of this pulse signal.
C	8	Duty pulse signal smoothing. Connect a capacitor between this pin and VREG.
LIM	9	Minimum speed setting. Normally, the 6V regulator level is resistor divided to set this pin's input level.
FGIN	10	FG pulse input
FGOUT	11	FG pulse output
GND	12	Grand pin
NC	13	NC pin
EI	14	One-shot multivibrator output and integrating amplifier input. A capacitor must be connected between this pin and EO for this integration.
EO1	15	Integrating amplifier output. (For use with an accelerating driver IC if the command voltage becomes low (single-phase systems).)
EO3	16	Integrating amplifier inverting output. (For use with an accelerating driver IC if the command voltage becomes high (three-phase systems).)



# LB8503V

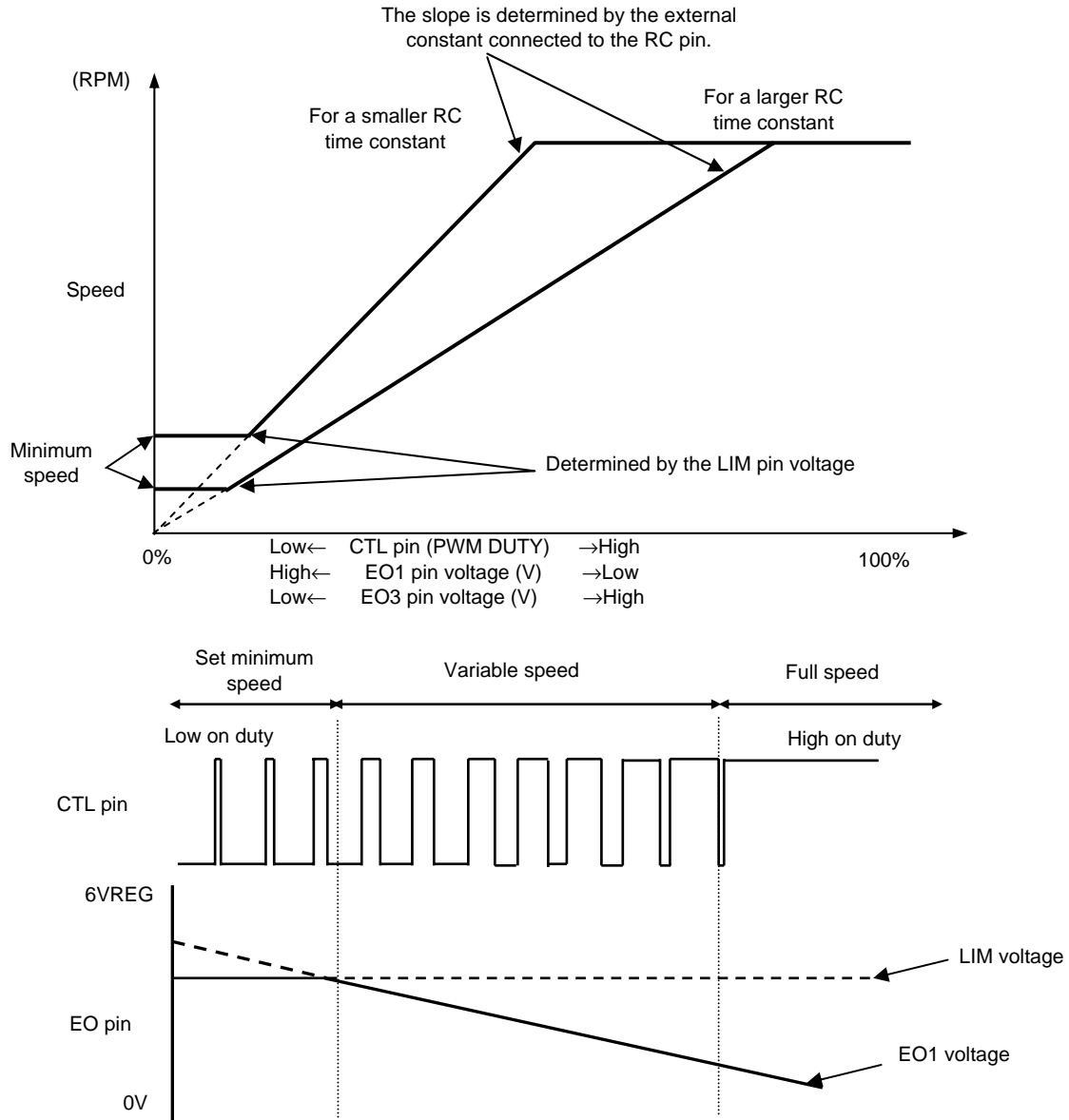
Combination with an accelerating driver IC when the command voltage goes high (three-phase systems)



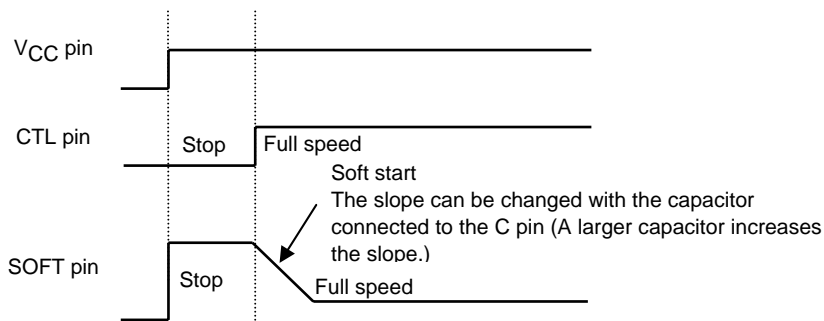
I LB01770

# LB8503V

## Speed Control Diagrams



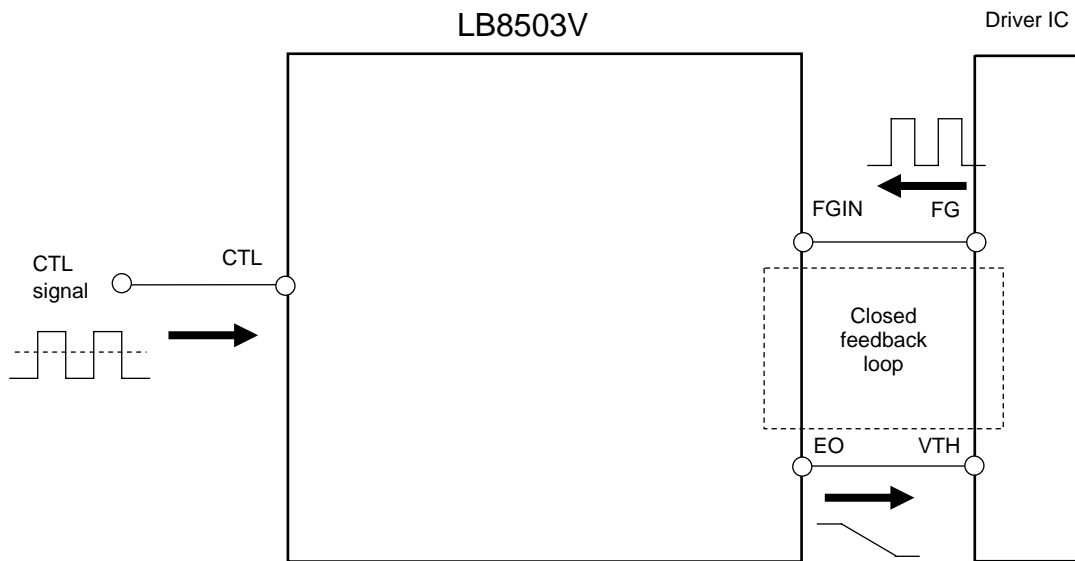
## Startup Timing (soft start)



# LB8503V

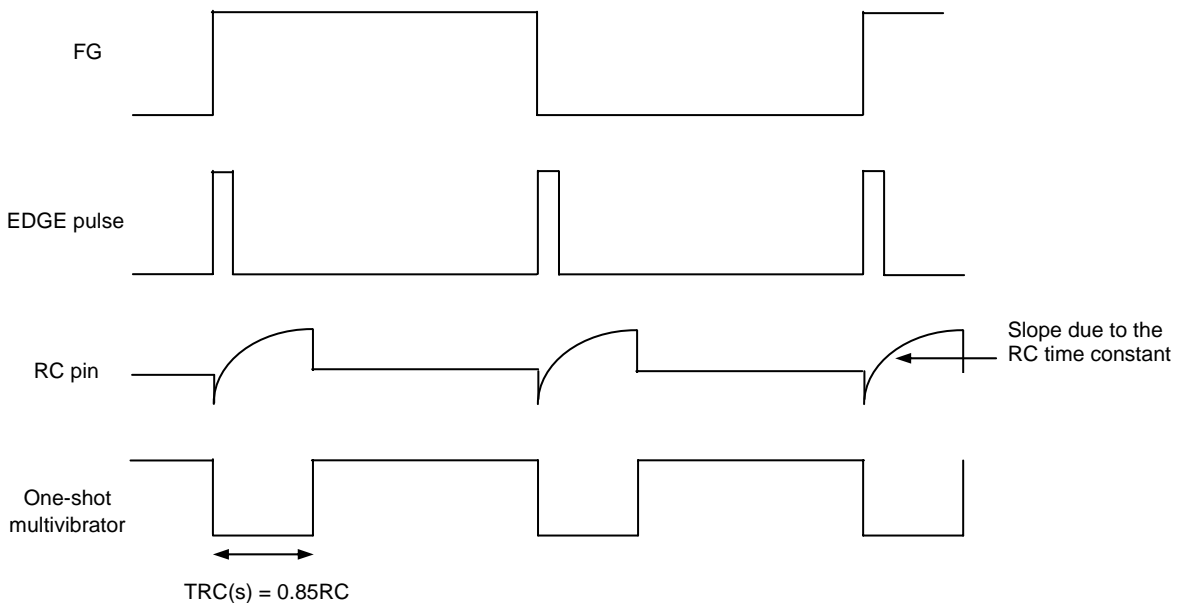
## Supplementary Operational Descriptions

The LB8503V accepts a duty pulse input and an FG signal from the driver IC, and generates the driver IC control voltage so that the FG period (motor speed) becomes proportional to the control voltage.



As shown in the figure below, the LB8503V generates a pulse signal from edges on the FG signal and then generates a pulse width waveform determined by the RC time constant in a one-shot multivibrator.

The LB8503V then integrates that pulse waveform to create the output driver IC control voltage (a DC voltage).



It is also possible to change the slope of the VCTL/speed relationship as shown in the speed control diagram in the previous section by changing the pulse width with the RC time constant.

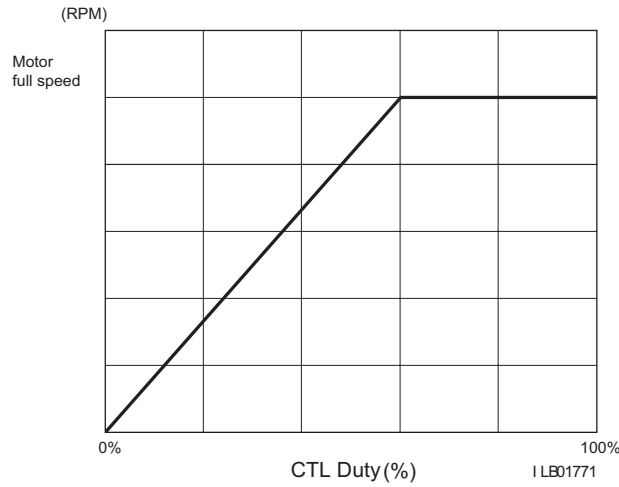
Note, however, that since pulses determined by this RC time constant are used, variation in the RC components will appear as speed control errors.



## Pin Setting Procedures (Provided for reference purposes)

### [RC pin]

The slope in the speed control diagram is determined by the RC pin time constant.



1. Determine the FG signal frequency ( $f_{FG}$  (Hz)) at the motor's highest speed.  
 (When 2 FG pulses are created on each motor revolution.)  
 $f_{FG}(\text{Hz}) = 2\text{rpm}/60 \dots\dots\dots(1)$
  
2. Determine the time constant for the RC pin.  
 (Let DUTY be the control duty at the highest motor speed. For example, 100% = 1.0, 60% = 0.6)  
 $R \times C = \text{DUTY} / (3 \times 0.85 \times f_{FG}) \dots\dots\dots(2)$
  
3. Determine the resistor and capacitor values  
 The range of capacitors that can be used is from 0.01 to 0.015  $\mu\text{F}$  due to the charge capabilities of the RC pin circuit. Therefore, an appropriate resistor value can be determined from either (3) or (4) below from the result obtained in step 2 above.  
 $R = (R \times C) / 0.01 \mu\text{F} \dots\dots\dots(3)$   
 $R = (R \times C) / 0.015 \mu\text{F} \dots\dots\dots(4)$

Note that the temperature characteristics of the curve are determined by the temperature characteristics of the capacitor connected to the RC pin.

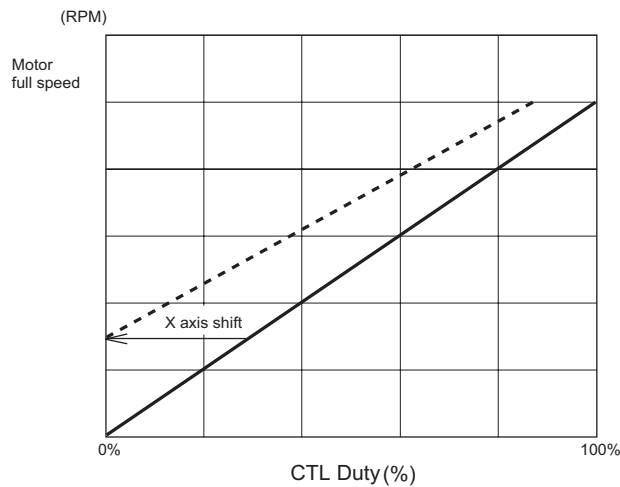
A capacitor with excellent temperature characteristics must be used to minimize motor speed variation with temperature.

# LB8503V

## [CVO and CVI Pins]

These pins determine the origin of the slope. (To set the origin to 0% at 0 rpm, short CVO to CVI.)

### 1. X axis shift (Resistor dividing the CVO to ground potential)



To shift the characteristics from a 0% = 0 rpm origin to a situation where the speed at a duty of 30% is shifted to 0%: First, determine the required CVI pin input voltage at 0%.

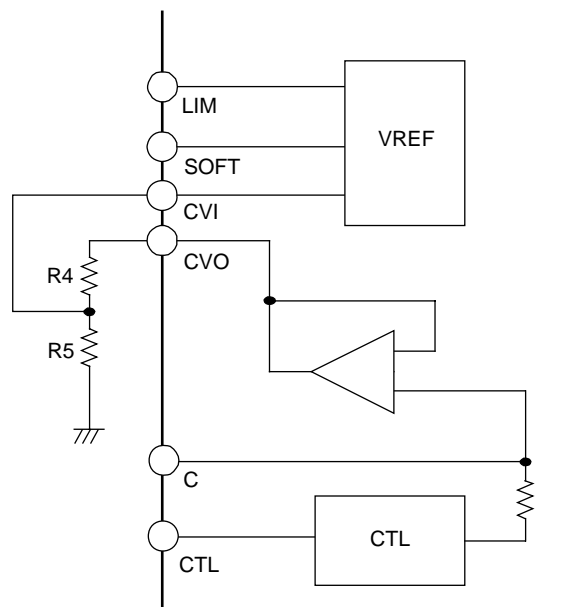
$$CVI = 6 - (4 \times DUTY) = 6 - (4 \times 0.3) = 6 - 1.2 = 4.8V$$

Next, when CVO is 6V, determine the resistor values for the resistor divider between CVO and ground such that the midpoint becomes 4.8V.

$$CVO - CVI : CVI - \text{ground} = 1.2V : 4.8V = \text{a ratio of } 1 : 4.$$

From the above, the desired resistor values will be 20kΩ between CVO and CVI and 80kΩ between CVI and ground. Note that the slope will change. (In this case, since the resistor ratio is 1:4, the result will be 4/5 of (or 0.8 times) the original slope.)

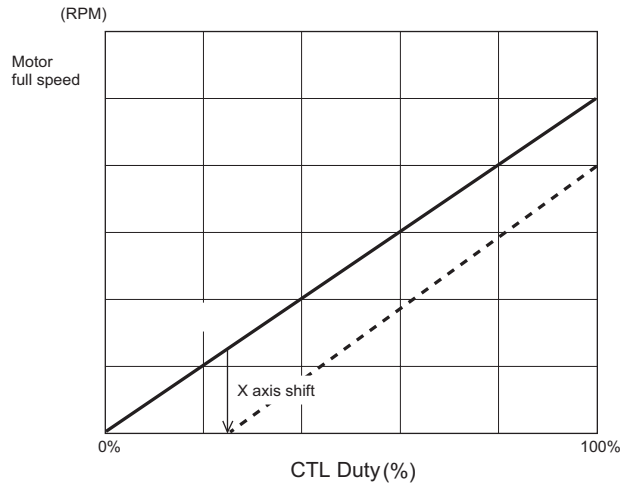
If required, the RC pin resistor value must be changed to correct the slope.



ILB01773

# LB8503V

## 2. Y axis shift (Resistor dividing the CVO to V<sub>CC</sub> potential)



To shift the characteristics from a 0% = 0 rpm origin to a situation where the speed is 0 rpm at a duty of 30%:

First, determine the required CVO pin input voltage at 0%.

$$CVO = 6 - (4 \times DUTY) = 6 - (4 \times 0.25) = 6 - 1 = 5V$$

Determine the resistor values such that at CVO = 5 V, CVI becomes 6V.

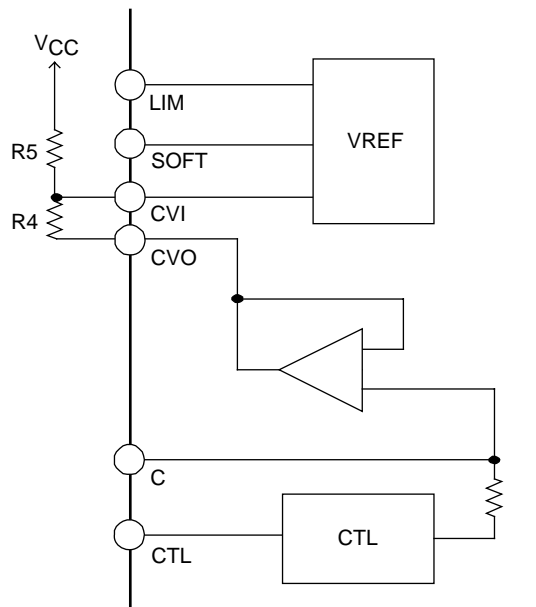
$$CVO - CVI : CVI - V_{CC} = 1 V : 6V = \text{a ratio of } 1:6.$$

From the above, the desired resistor values will be 20kΩ between CVO and CVI and 80kΩ between CVI and ground.

(Due to the current capability of the CVO pin, the total resistor value must exceed 100kΩ.)

Note that the slope will change. (In this case, since the resistor ratio is 1:6, the result will be 6/7 of (or 0.86 times) the original slope.)

If required, the RC pin resistor value must be changed to correct the slope.

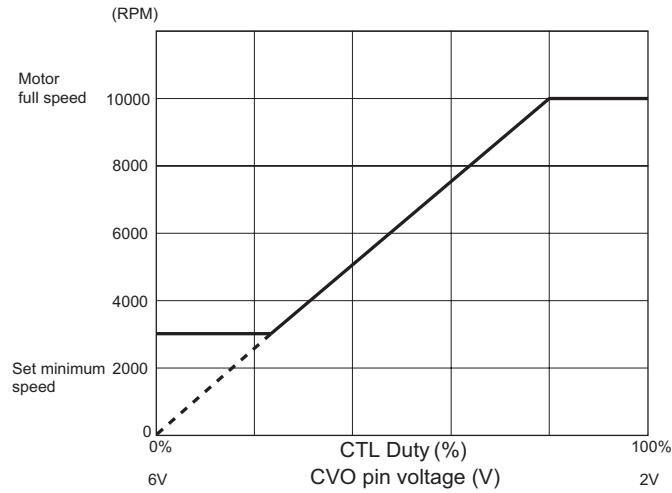


ILB01775

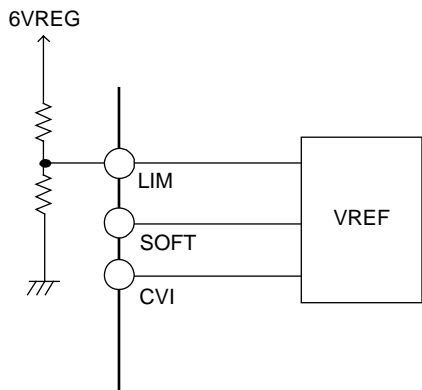
# LB8503V

**[LIM Pin]**

The minimum speed is determined by the LIM pin voltage.



1. Determine the ratio of the required minimum speed and the maximum speed.  
 $R_a = \text{minimum speed}/\text{maximum speed} \dots\dots\dots (1)$   
 In the example in the figure above,  $R_a = \text{minimum speed}/\text{maximum speed} = 3000/10000 = 0.3$
  
2. Determine the product of the duty that produces the maximum speed and the value from equation 1.  
 $C_a = \text{maximum speed duty} \times R_a \dots\dots\dots (2)$   
 For example,  $C_a = \text{maximum speed duty} \times R_a = 0.8 \times 0.3 = 0.24$
  
3. Determine the required LIM pin voltage  
 $LIM = 6 - (4 \times C_a) \dots\dots\dots (3)$   
 For example,  $LIM = 6 - (4 \times C_a) = 6 - (4 \times 0.24) \approx 5V$
  
4. Generate the LIM voltage by resistor dividing the 6 V regulator voltage.  
 For example, the resistor ratio to create a 5V level will be 1:5.  
 Thus the resistor values will be 10kΩ between 6VREG and LIM and 51kΩ between LIM and ground.



ILB01777

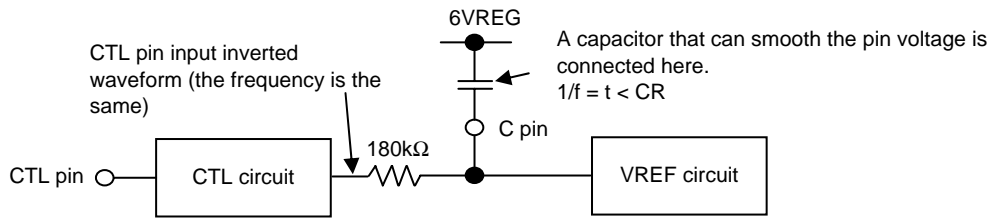
## LB8503V

### [C Pin]

Since a capacitor that can smooth the pin voltage is connected to the C pin, if the CTL pin input signal frequency is  $f$  (Hz), then the capacitor must meet the following condition. (Here,  $R$  is the IC internal resistance of  $180\Omega$  (typical).)

$$1/f = t < RC$$

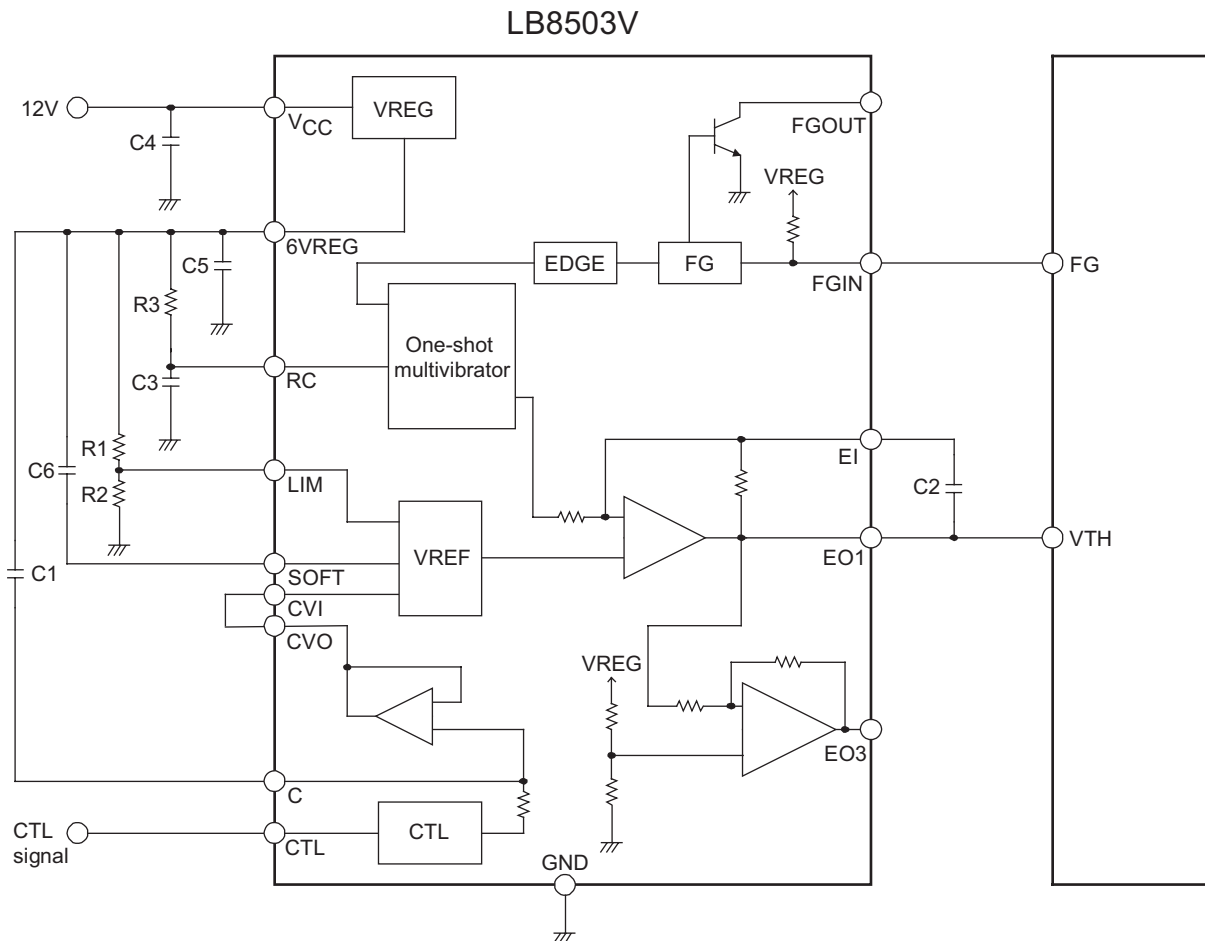
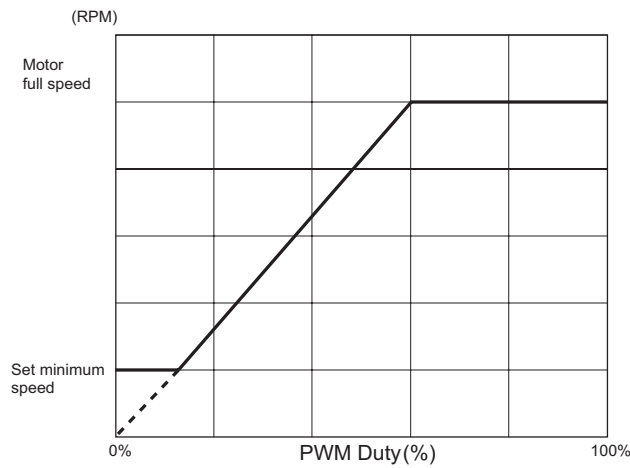
Note that the larger the capacitor, the slower its response to changes in the input signal will be.



# LB8503V

## Application Example 2

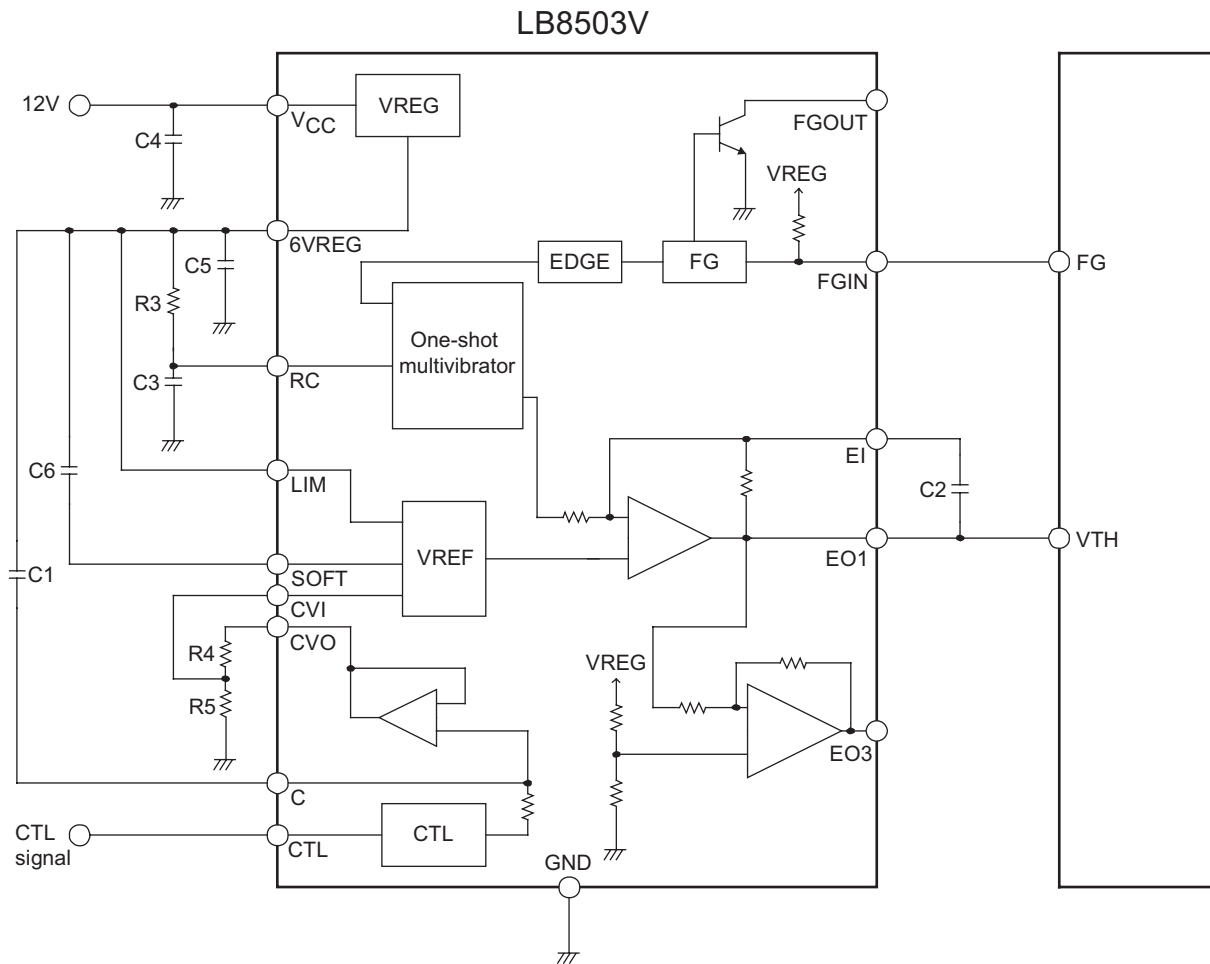
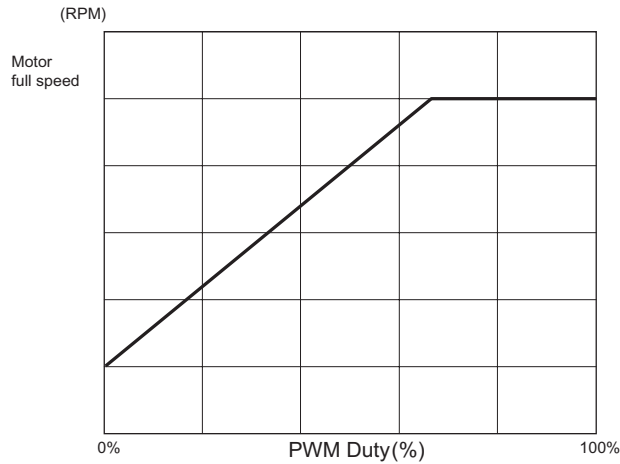
[Setting the minimum speed for an origin of 0% = 0 rpm]



When the speed control diagram origin is 0% = 0 rpm, the CVO pin is connected to the CVI pin.  
 If the minimum speed is not set, connect the LIM pin to the 6VREG pin.

Application Example 3

[Origin shift in the Y direction (the motor turns at 0%)]

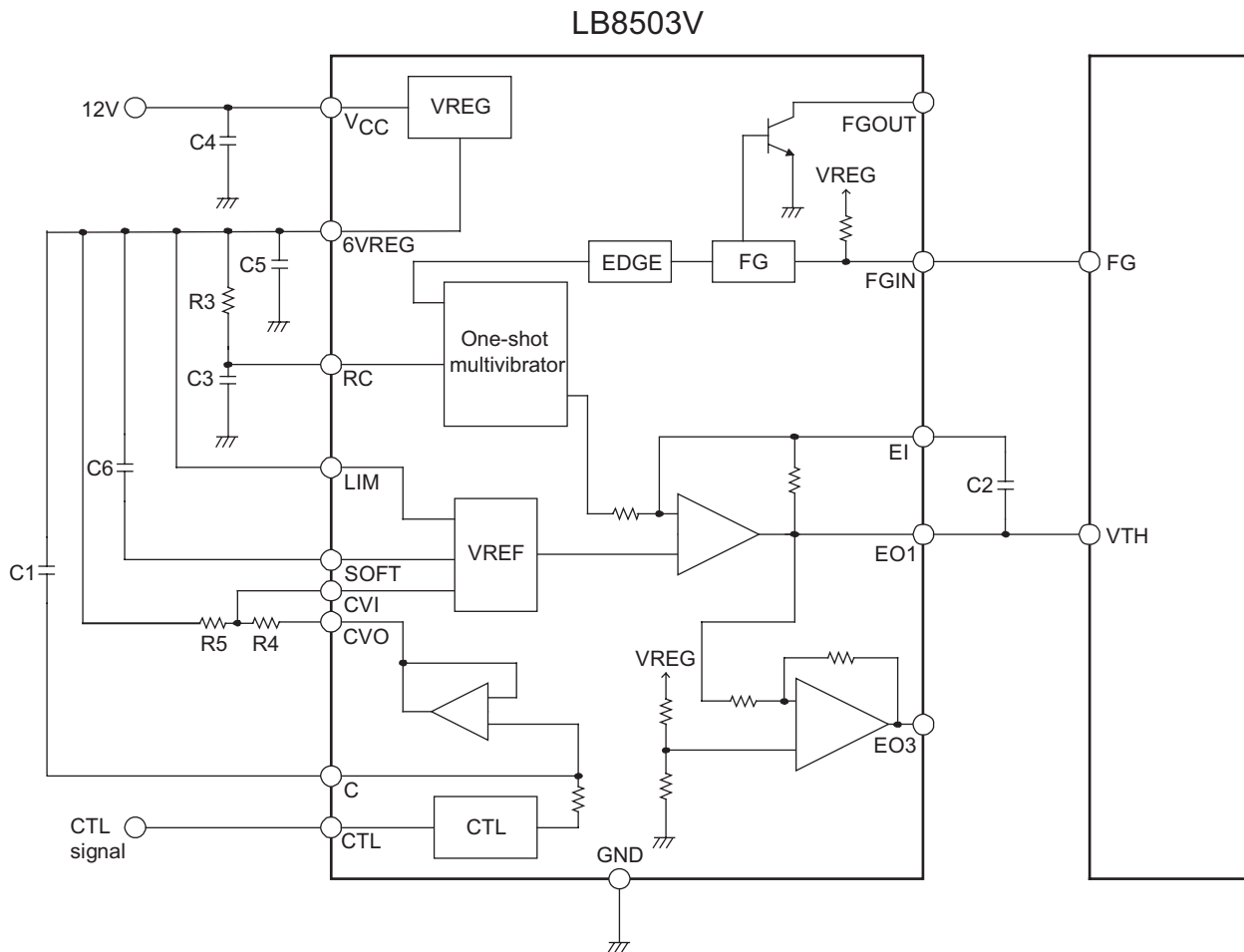
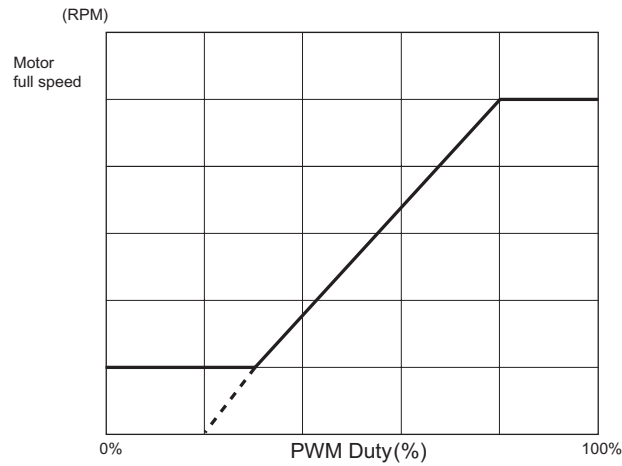


When the speed control diagram origin is set so the motor turns at 0%, the CVO pin to ground potential difference is resistor divided and the midpoint is input to the CVI pin.  
 The speed at 0% can be changed with the resistor ratio.

# LB8503V

## Application Example 4

[Origin shift in the X axis direction (The motor turns at a duty of 10% or higher) plus a minimum speed setting]



When the origin in the speed control diagram is set so that the motor starts turning when the duty is above 0%, the potential difference between the CVO pin and VCC is resistor divided, and that divided level is input to the CVI pin. The duty at which rotation starts can be changed by changing the resistor ratio. Note that the total value of the resistors R4 and R5 must exceed 100kΩ.

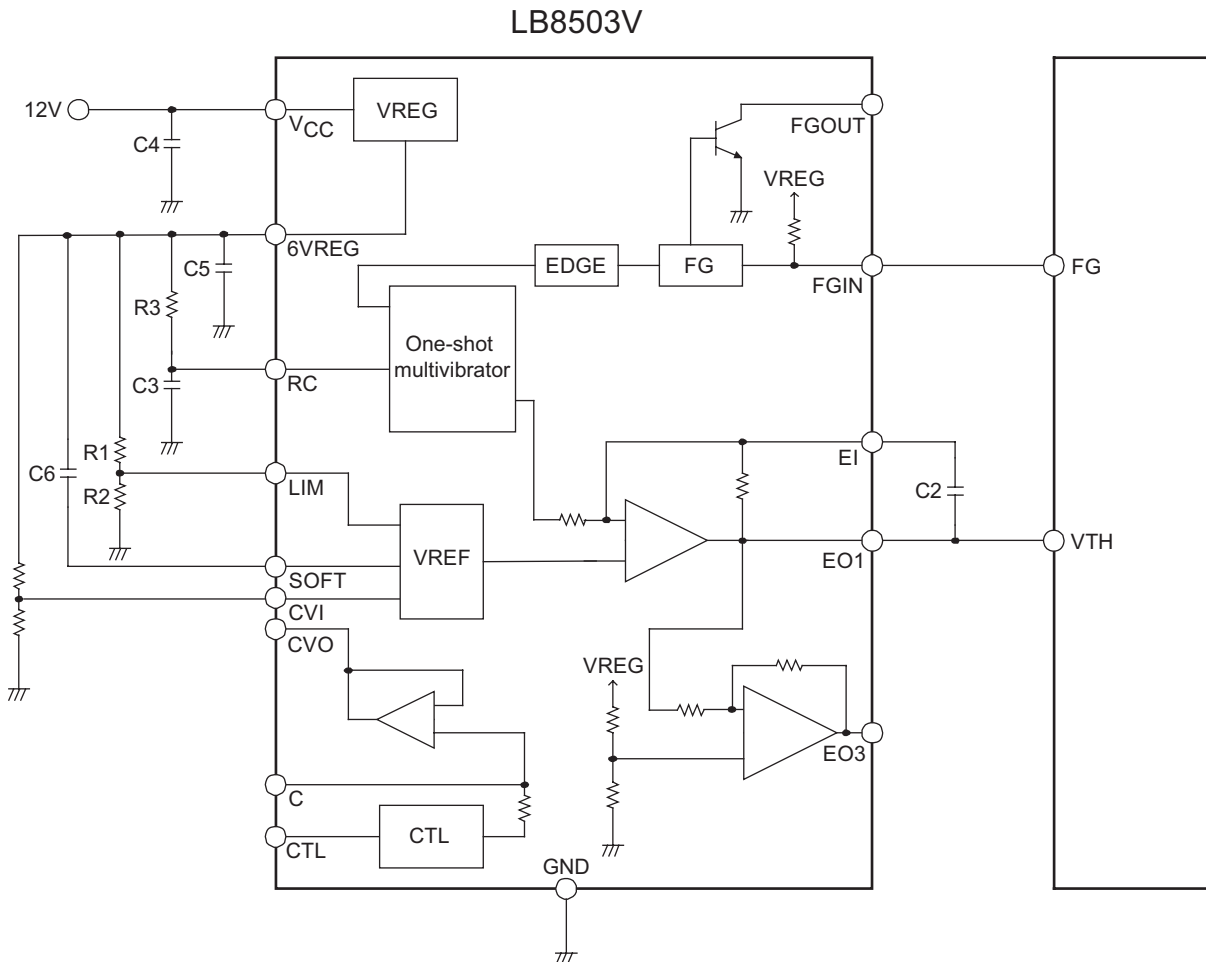
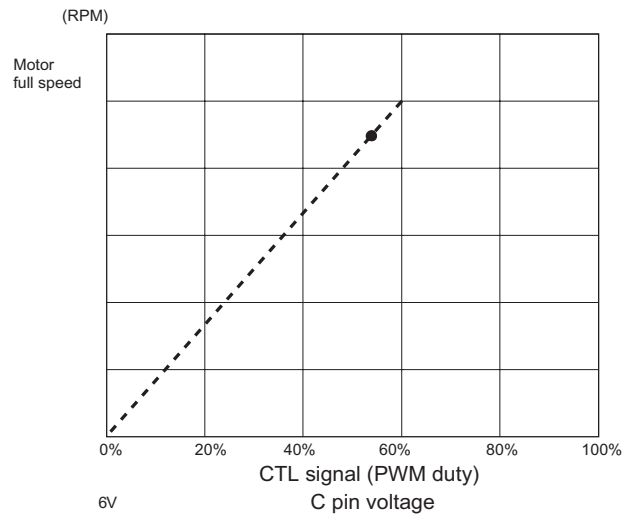




# LB8503V

## Application Example 6

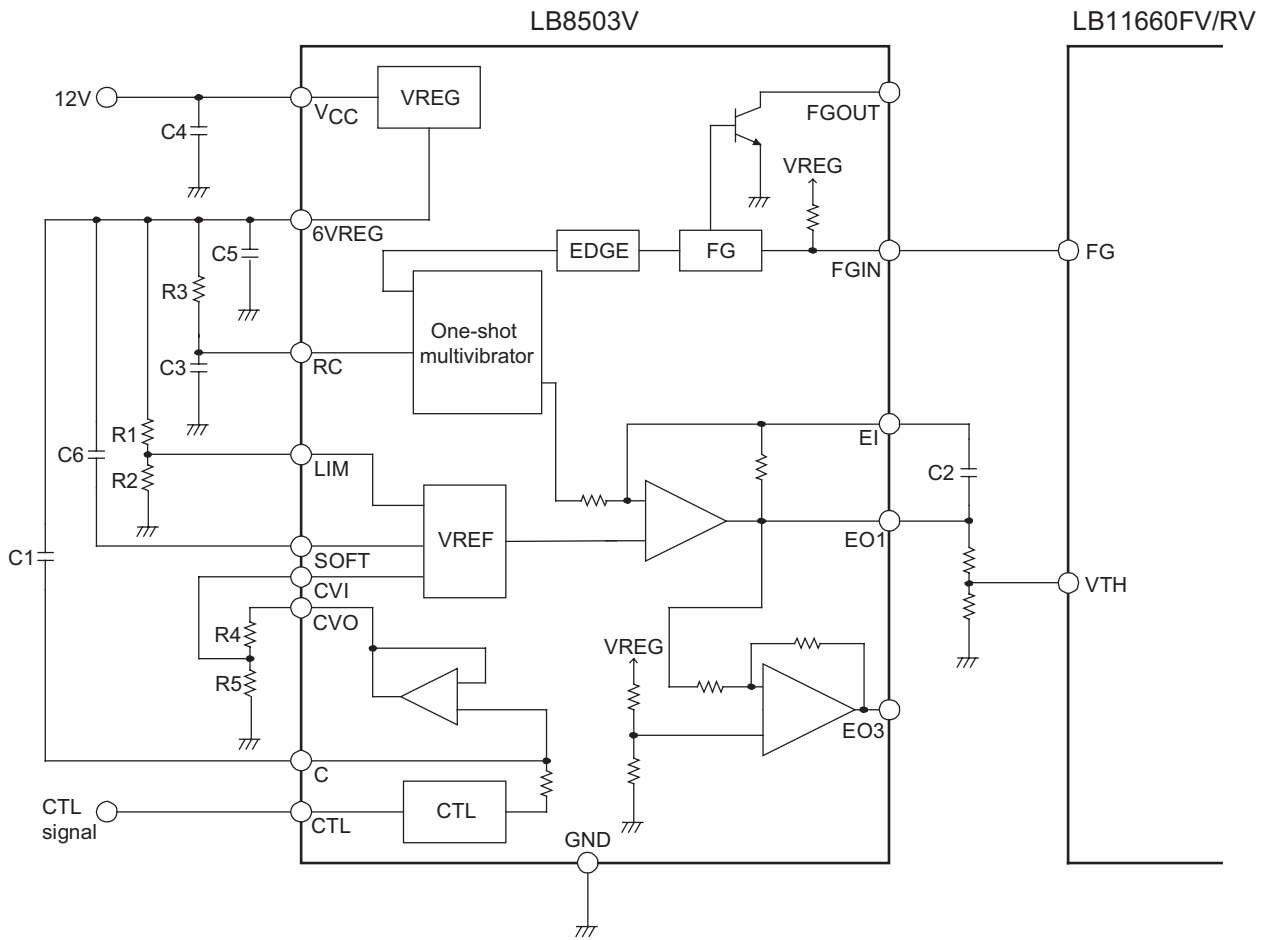
[Fixed Speed + Soft Start]



With this circuit, the motor speed remains constant even if there are fluctuations in the supply voltage or static voltage. It is also possible to input a fixed-duty signal to the CTL pin signal input as an input signal for which soft start is enabled at startup.

Application Example 7

[Used in Combination with the LB11660FV]



In this circuit, the dynamic range of the LB8503V EO pin (the range from the amplifier block output high to output low levels) must be wider than the dynamic range (from the high to low levels of the PWM signal) of VTH pin of driver IC with which this IC is combined.

However, since the LB11660FV PWM low-level voltage is lower than the LB8503V amplifier output low-level voltage, it must be resistor divided.

- SANYO Semiconductor Co.,Ltd. assumes no responsibility for equipment failures that result from using products at values that exceed, even momentarily, rated values (such as maximum ratings, operating condition ranges, or other parameters) listed in products specifications of any and all SANYO Semiconductor Co.,Ltd. products described or contained herein.
- SANYO Semiconductor Co.,Ltd. strives to supply high-quality high-reliability products, however, any and all semiconductor products fail or malfunction with some probability. It is possible that these probabilistic failures or malfunction could give rise to accidents or events that could endanger human lives, trouble that could give rise to smoke or fire, or accidents that could cause damage to other property. When designing equipment, adopt safety measures so that these kinds of accidents or events cannot occur. Such measures include but are not limited to protective circuits and error prevention circuits for safe design, redundant design, and structural design.
- In the event that any or all SANYO Semiconductor Co.,Ltd. products described or contained herein are controlled under any of applicable local export control laws and regulations, such products may require the export license from the authorities concerned in accordance with the above law.
- No part of this publication may be reproduced or transmitted in any form or by any means, electronic or mechanical, including photocopying and recording, or any information storage or retrieval system, or otherwise, without the prior written consent of SANYO Semiconductor Co.,Ltd.
- Any and all information described or contained herein are subject to change without notice due to product/technology improvement, etc. When designing equipment, refer to the "Delivery Specification" for the SANYO Semiconductor Co.,Ltd. product that you intend to use.
- Information (including circuit diagrams and circuit parameters) herein is for example only; it is not guaranteed for volume production.
- Upon using the technical information or products described herein, neither warranty nor license shall be granted with regard to intellectual property rights or any other rights of SANYO Semiconductor Co.,Ltd. or any third party. SANYO Semiconductor Co.,Ltd. shall not be liable for any claim or suits with regard to a third party's intellectual property rights which has resulted from the use of the technical information and products mentioned above.

This catalog provides information as of March, 2007. Specifications and information herein are subject to change without notice.