LB8503V

Monolithic Digital IC

DC Fan Motor Speed Control IC

ON Semiconductor®

http://onsemi.com

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

Specifications

Absolute Maximum Ratings at Ta = 25°C

Parameter	Symbol	Conditions	Ratings	Unit
Supply voltage	V_{CC} max	V_{CC} pin	18	V
Output current	I_O max	E0 pin	3	mA
FG output pin output voltage	V_{FG} max	FG_{OUT} pin	18	V
FG output pin output current	I_{FG} max	FG_{OUT} pin	10	mA
Allowable power dissipation	Pd max	When mounted on a circuit board *[1]	0.8	W
Operating temperature	Topr		-30 to +95	°C
Storage temperature	Tstg		-55 to +150	°C

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

Stresses exceeding Maximum Ratings may damage the device. Maximum Ratings are stress ratings only. Functional operation above the Recommended Operating Conditions is not implied. Extended exposure to stresses above the Recommended Operating Conditions may affect device reliability.

Allowable Operating Range at Ta = 25°C

Parameter	Symbol	Conditions	Ratings	Unit
Supply voltage range 1	$V_{CC}1$	V_{CC} pin	7.5 to 17	V
Supply voltage range 2	$V_{CC}2$	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 Ta = 25°C, V_{CC} = 12V

Parameter	Symbol	Conditions	Ratings			Unit
			min	typ	max	
Supply current	I_{CC}			5.5	6.5	mA
6V constant voltage output (VREG pin)						
Output voltage	VREG		5.8	6.0	6.2	V
Line regulation	ΔVREG1	V_{CC} = 8 to 17V		40	100	mV
Load regulation	ΔVREG2	I_O = -5 to 5mA		10	100	mV
Temperature coefficient	ΔVREG3	Design target*		0		mV/°C
Integrating Amplifier Block (E01)						
Common-mode input voltage range	VICM		2.0		VREG	V
High-level output voltage	V_{OH}(E01)	IEO1 = -0.2mA	VREG - 1.2	VREG - 0.8		V
Low-level output voltage	V_{OL}(E01)	IEO1 = 0.2mA		0.8	1.0	V
Integrating Amplifier Block (E03)						
High-level output voltage	V_{OH}(E03)	IEO1 = -0.2mA	VREG - 1.2	VREG - 0.8		V
Low-level output voltage	V_{OL}(E03)	IEO1 = 0.2mA		0.8	1.0	V
FGIN pin						
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	VFGIN = 6VREG	-10	0	10	μA
Low-level input current	IFGL	VFGIN = 0V	-140	-110		μA
FGOUT pin						
Output low saturation voltage	VFG			0.2	0.3	V
Output leakage current	IFGL				10	μA

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Parameter	Symbol	Conditions	Ratings			Unit
			min	typ	max	
RC pin						
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
CTL pin						
High-level input voltage	VCTH		2.0		VREG	V
Low-level input voltage	VCTL		0		1.0	V
Input open voltage	VCTO		VREG - 0.5		VREG	V
High-level input current	ICTH	VFGIN = 6VREG	-10	0	10	μA
Low-level input current	ICTL	VFGIN = 0V	-140	-110		μA
C pin						
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
LIM pin						
Input bias current	IB(LIM)		-1		1	μA
Common-mode input voltage range	VILIM		2.0		VREG	V
SOFT pin						
Charge current	IC(SOFT)			1.4		μA
Operation voltage range	VISOFT		2.0		VREG	V
VCI pin						
Input bias current	IB(VCI)		-1		1	μA
Common-mode input voltage range	VIVCI		2.0		VREG	V
VCO pin						
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.
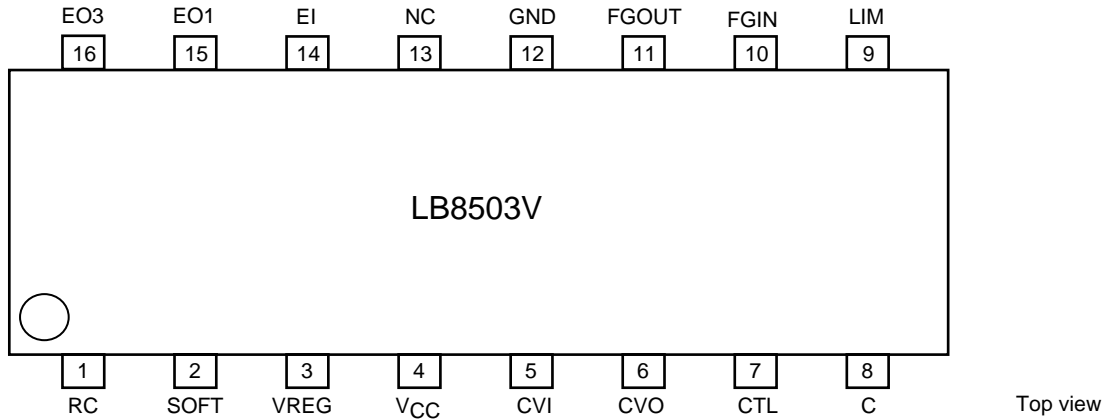
Package Dimensions

unit : mm (typ)

3178B

SSOP16(225mil)
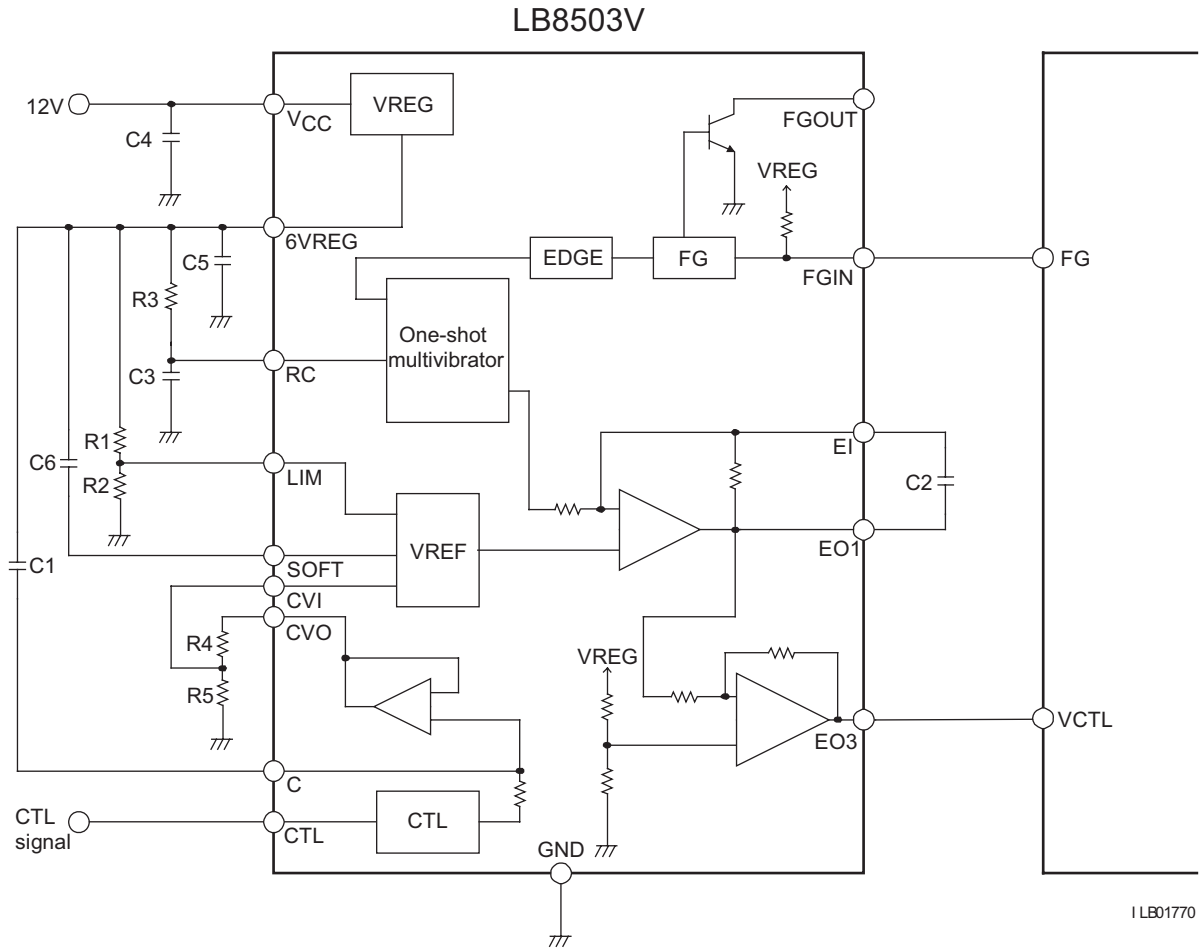
Pd max − Ta

Specified circuit board : 114.3×76.2×1.6mm³ glass epoxy board

Allowable power dissipation, Pd max − W

Ambient temperature, Ta − °C

Pin Assignment

EO3	EO1	EI	NC	GND	FGOUT	FGIN	LIM
16	15	14	13	12	11	10	9

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1	2	3	4	5	6	7	8
RC	SOFT	VREG	V$_{CC}$	CVI	CVO	CTL	C

Top view
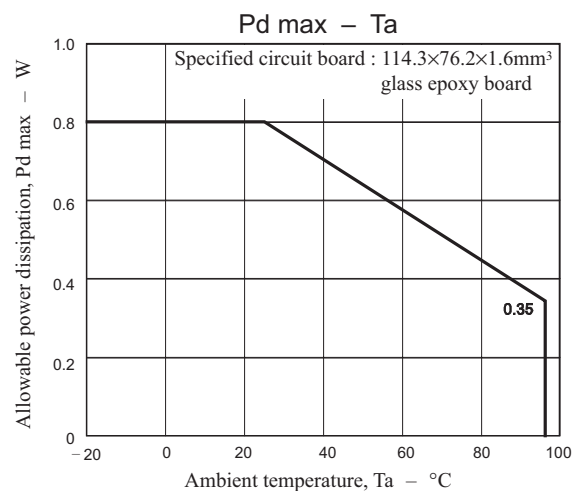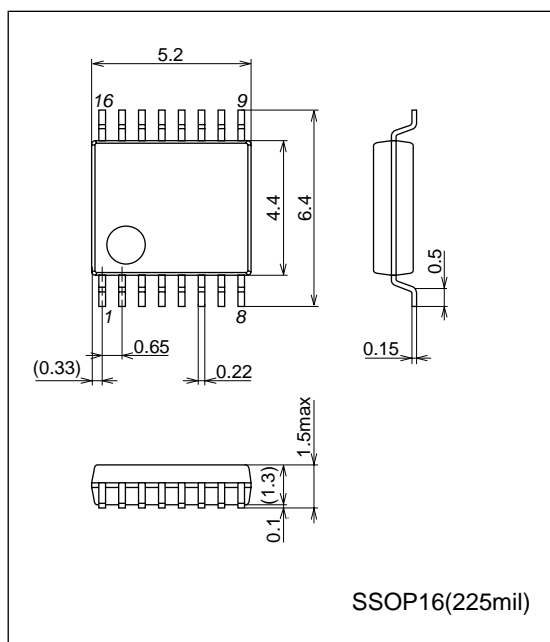
Pin Functions

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$_{CC}$	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).)

Block Diagrams and Application Examples

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

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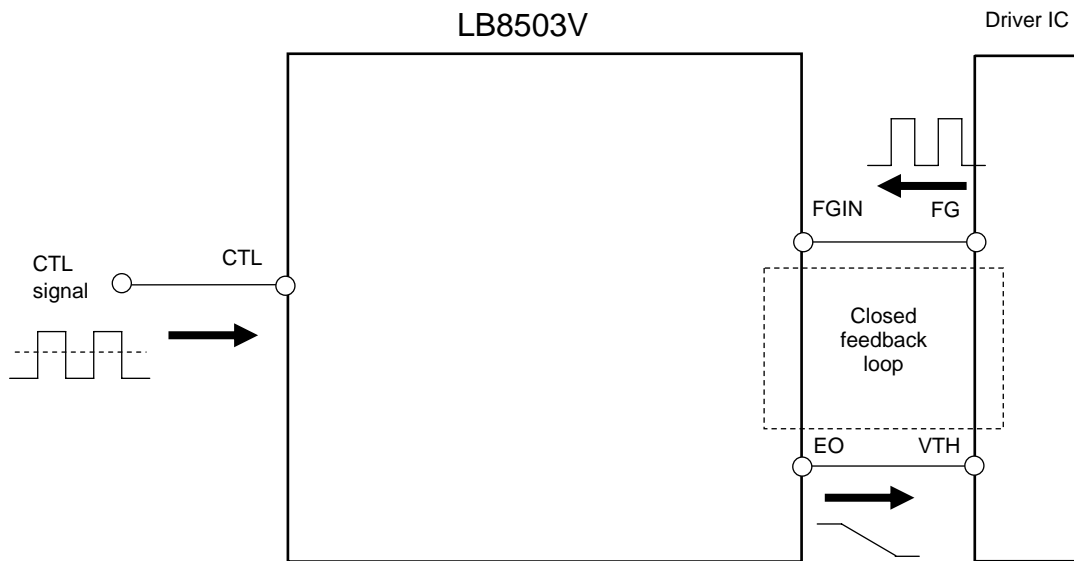
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Speed Control Diagrams

The slope is determined by the external
constant connected to the RC pin.

(RPM)

For a smaller RC
time constant

For a larger RC
time constant

Speed

Minimum
speed

Determined by the LIM pin voltage

| 0% | | 100% |

Low← CTL pin (PWM DUTY) →High
High← EO1 pin voltage (V) →Low
Low← EO3 pin voltage (V) →High

Set minimum
speed | Variable speed | Full speed

Low on duty | | High on duty

CTL pin

6VREG

LIM voltage

EO pin

EO1 voltage

0V

Startup Timing (soft start)

V_CC pin

CTL pin | Stop | Full speed

Soft start
The slope can be changed with the capacitor
connected to the C pin (A larger capacitor increases
the slope.)

SOFT pin | Stop | Full speed
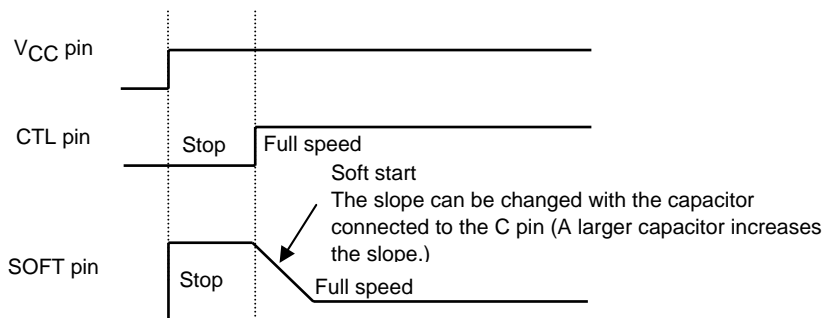
Supplementary Operational Descriptions

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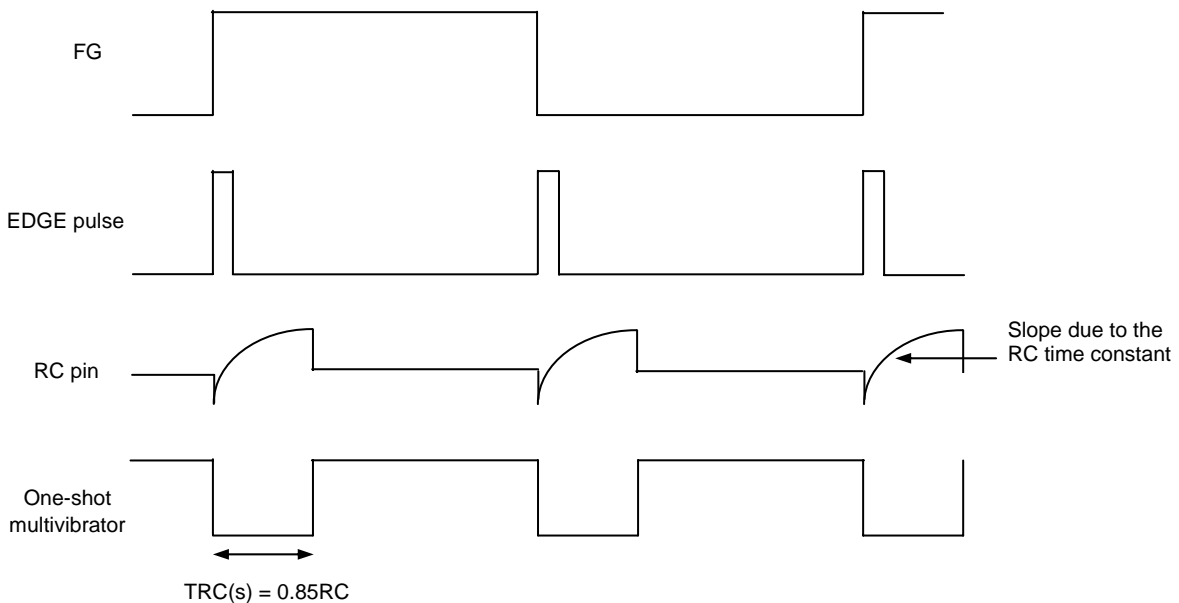
It is also possible to change the slope of the VCTL/speed relationship as shown in the speed control diagram in the previous section by changing the pulse width with the RC time constant.

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.
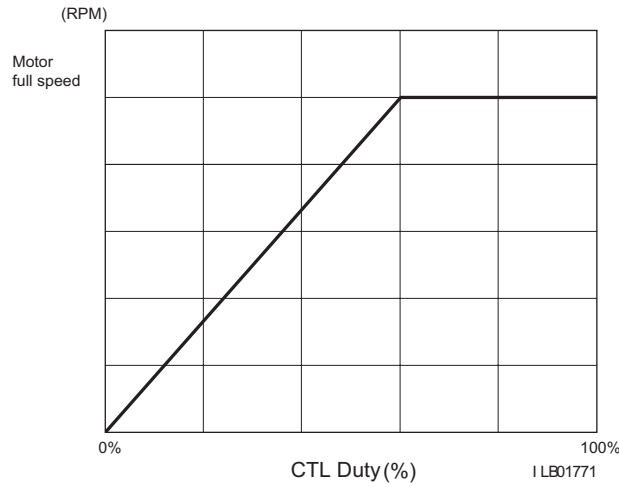
1. Determine the FG signal frequency (f_{FG} (Hz)) at the motor's highest speed.
   (When 2 FG pulses are created on each motor revolution.)
   f_{FG}(Hz)=2rpm/60 ....(1)

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)
   $R \times C$=DUTY/($3 \times 0.85 \times f_{FG}$) .... (2)

3. Determine the resistor and capacitor values
   The range of capacitors that can be used is from 0.01 to 0.015 µF 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=($R \times C$)/0.01µF... (3)
   R=($R \times C$)/0.015µF.. (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.

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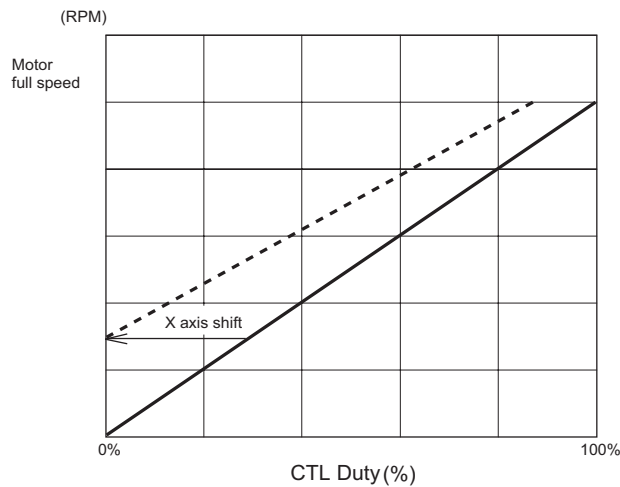
To shift the characteristics from a 0% = 0 rpm origin to a situation where the speed at a duty of 30% is shifted to 0%:
First, determine the required CVI pin input voltage at 0%.

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

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 - ground = 1.2V : 4.8V = 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.
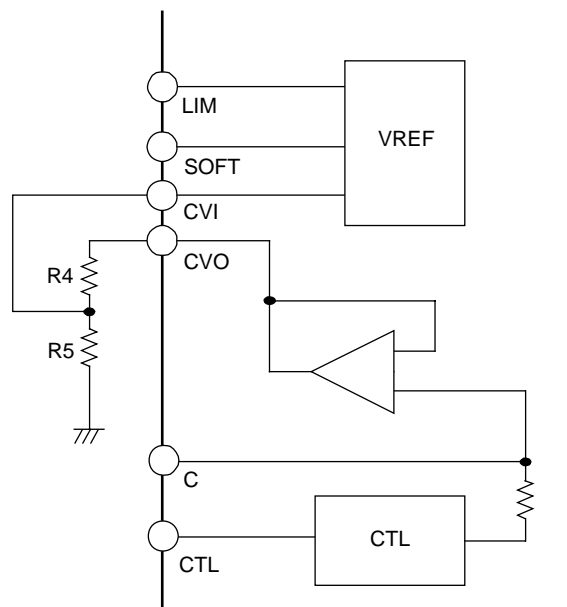
ILB01773

2. Y axis shift (Resistor dividing the CVO to V$_{CC}$ potential)
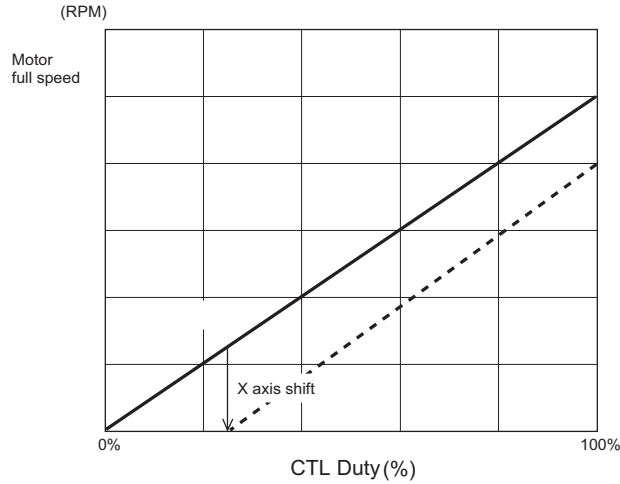
To shift the characteristics from a 0% = 0 rpm origin to a situation where the speed is 0 rpm at a duty of 30%:
First, determine the required CVO pin input voltage at 0%.
CVO = 6 - (4 × DUTY) = 6 - (4 × 0.25) = 6 - 1 = 5V

Determine the resistor values such that at CVO = 5 V, CVI becomes 6V.
CVO - CVI : CVI - V$_{CC}$ = 1 V : 6V = 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.
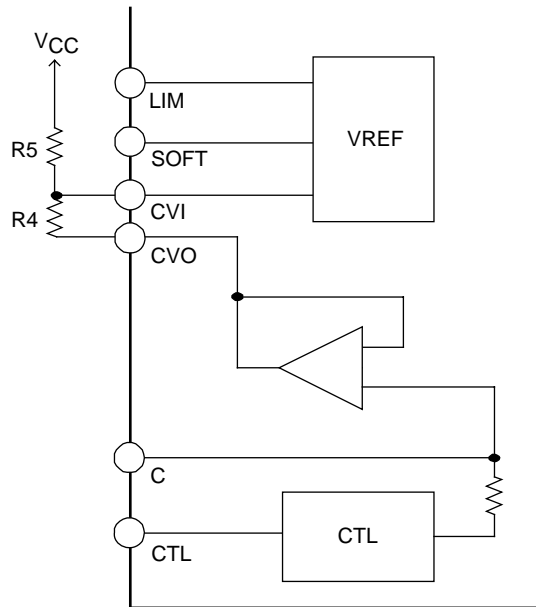
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[LIM Pin]

The minimum speed is determined by the LIM pin voltage.
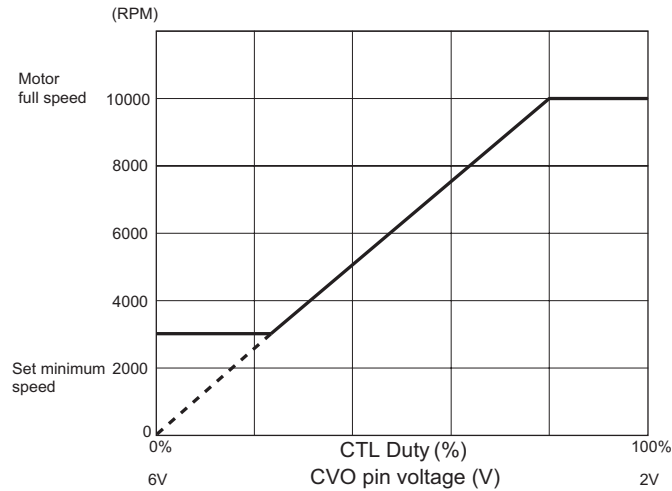
1. Determine the ratio of the required minimum speed and the maximum speed.
   Ra = minimum speed/maximum speed......... (1)
   In the example in the figure above, Ra = minimum speed/maximum speed = 3000/10000 = 0.3

2. Determine the product of the duty that produces the maximum speed and the value from equation 1.
   Ca = maximum speed duty × Ra .... (2)
   For example, Ca = maximum speed duty × Ra = 0.8 × 0.3 = 0.24

3. Determine the required LIM pin voltage
   LIM = 6 - (4 × Ca) .... (3)
   For example, LIM = 6 - (4 × Ca) = 6 - (4 × 0.24) ≈ 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.
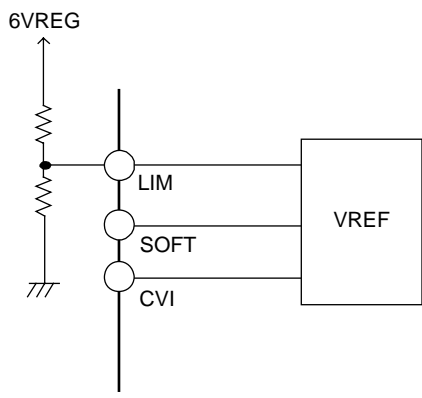
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[C Pin]

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 180Ω (typical).)

$1/f = t < RC$

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

Application Example 2

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

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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.
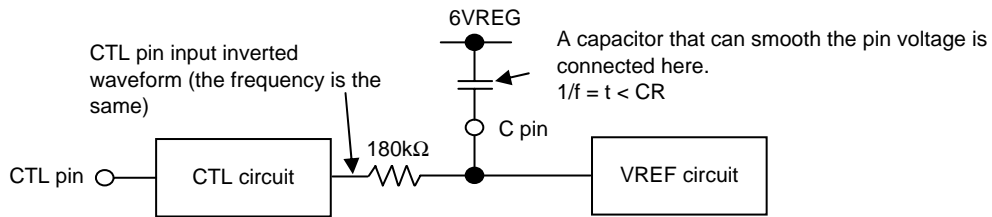
Application Example 3

[Origin shift in the Y direction (the motor turns at 0%)]
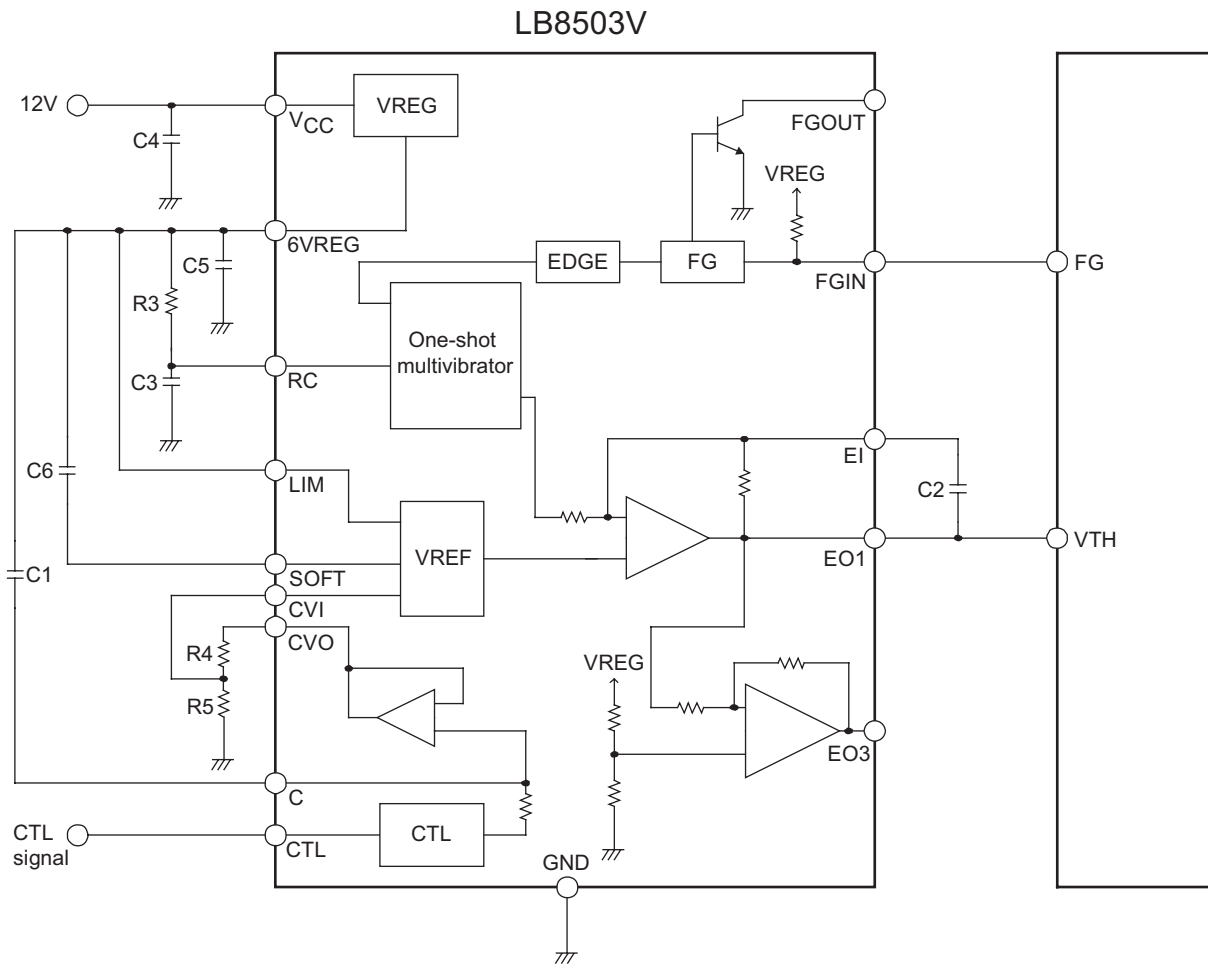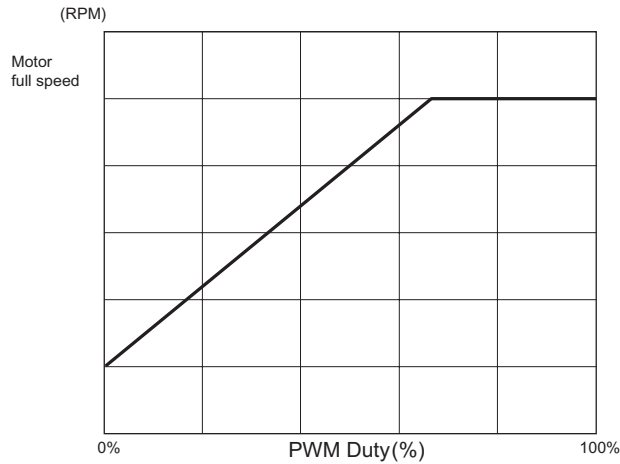
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When the speed control diagram origin is set so the motor turns at 0%, the CVO pin to ground potential difference is resistor divided and the midpoint is input to the CVI pin.

The speed at 0% can be changed with the resistor ratio.

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]

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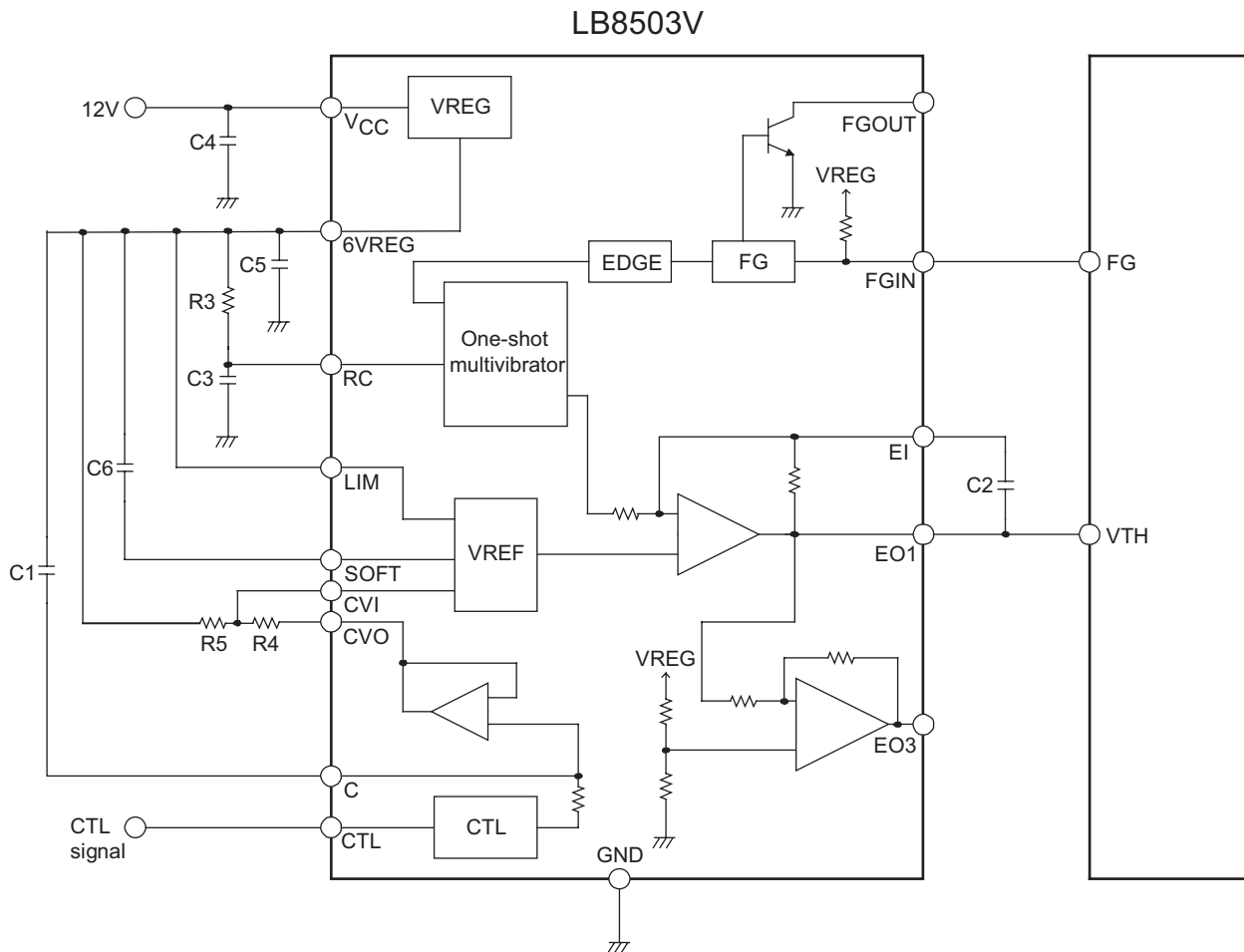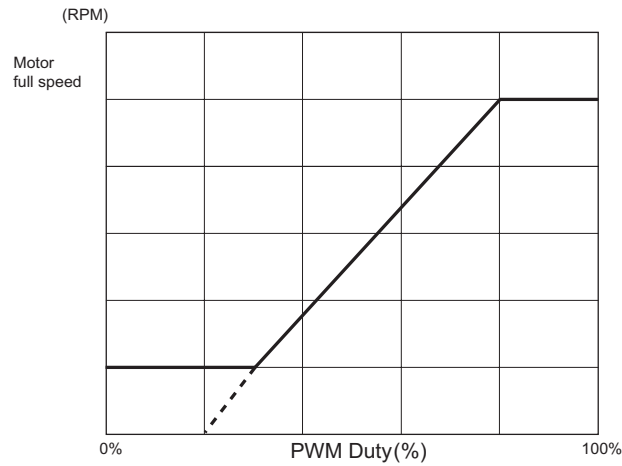
When the origin in the speed control diagram is set so that the motor starts turning when the duty is above 0%. the potential difference between the CVO pin and V_{CC} is resistor divided, and that divided level is input to the CVI pin. The duty at which rotation starts can be changed by changing the resistor ratio.

Note that the total value of the resistors R4 and R5 must exceed 100kΩ.

Application Example 5

[DC Voltage Speed Control]
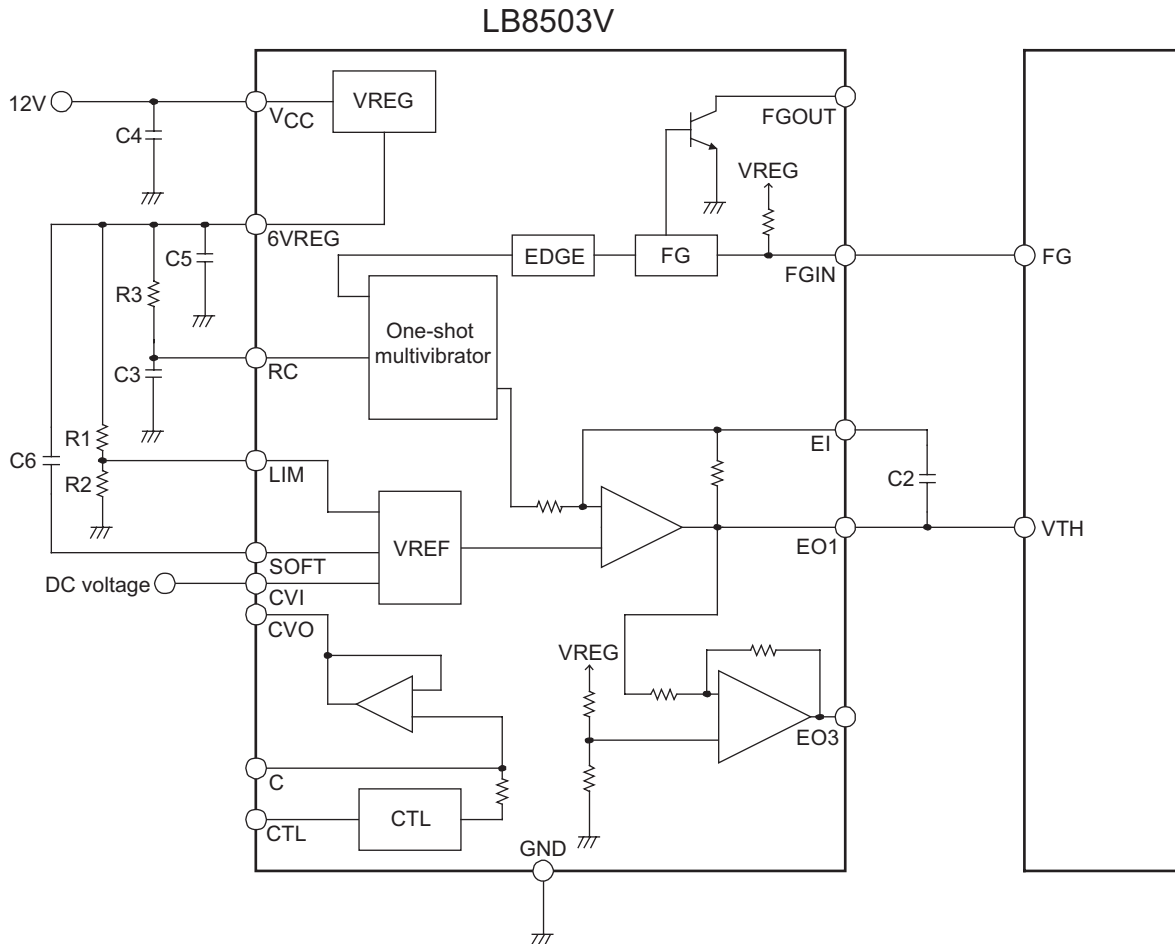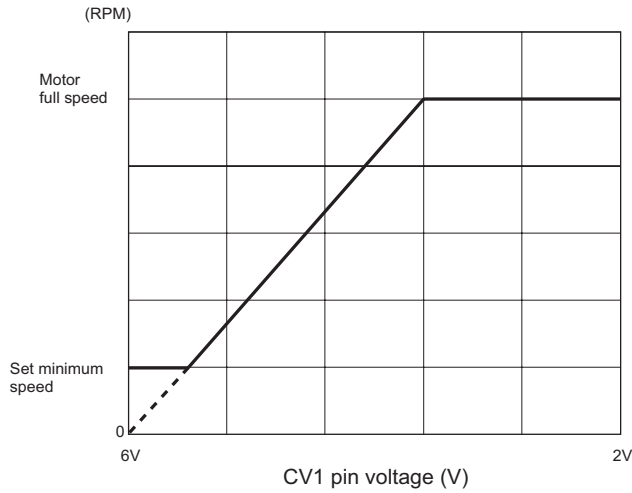
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When the motor speed is controlled by a DC voltage, that voltage must be in the range from 2V to 6VREG.
Note that the motor stops when the control voltage is at 6VREG, and the motor speed increases as the voltage falls.

Application Example 6

[Fixed Speed + Soft Start]

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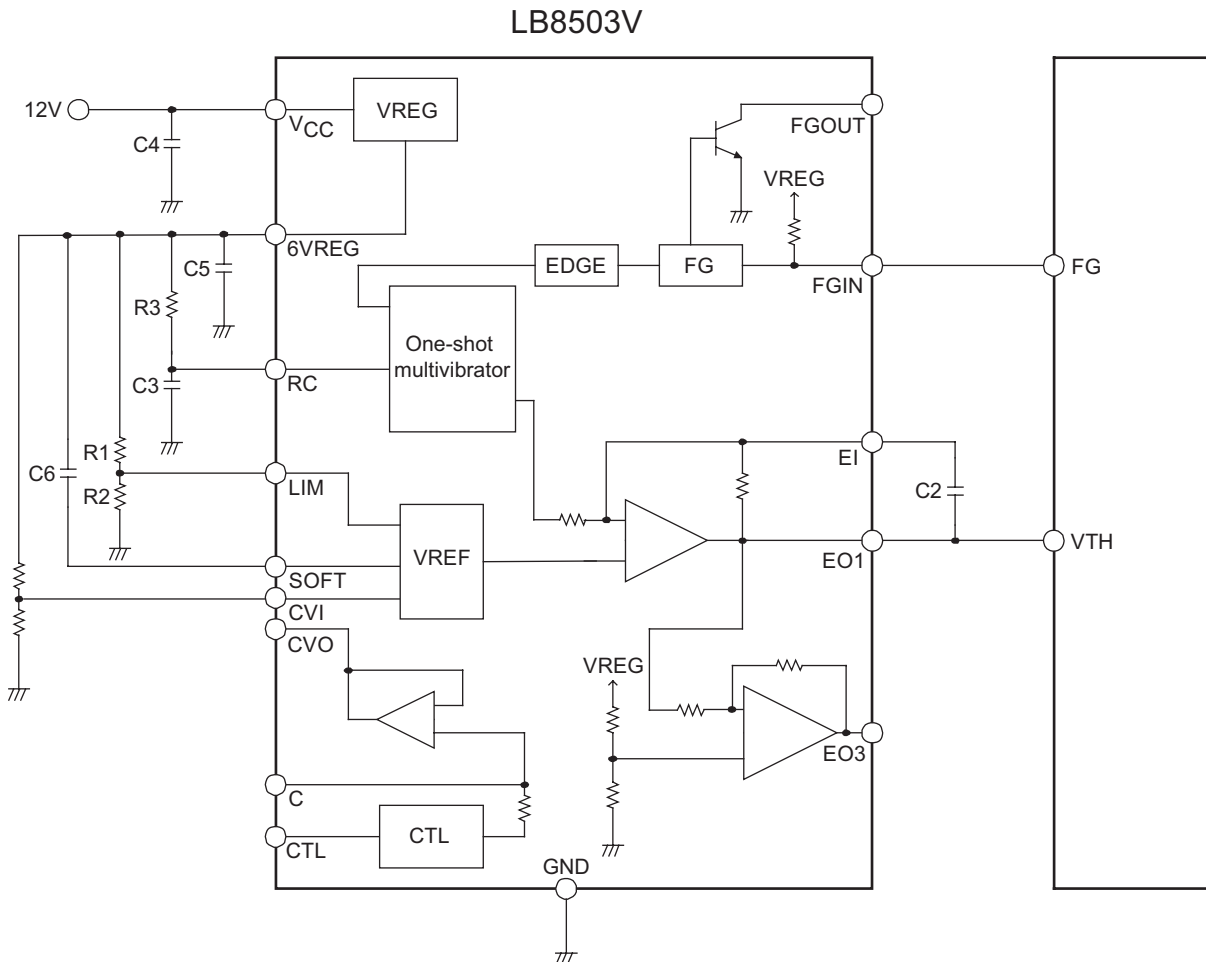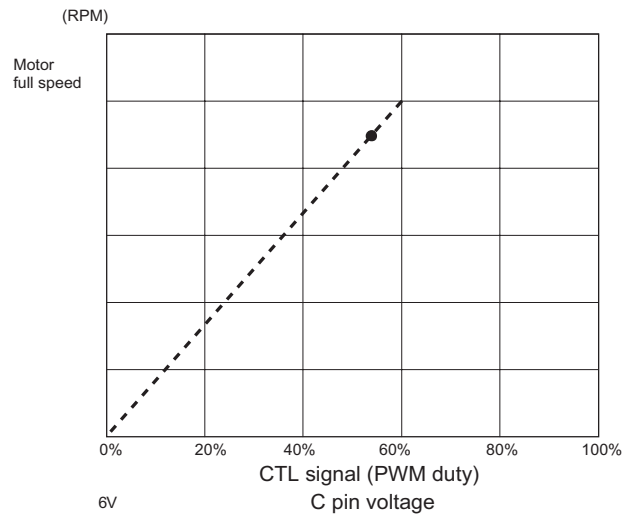
With this circuit, the motor speed remains constant even if there are fluctuations in the supply voltage or static voltage. It is also possible to input a fixed-duty signal to the CTL pin signal input as an input signal for which soft start is enabled at startup.

Application Example 7

[Used in Combination with the LB11660FV]
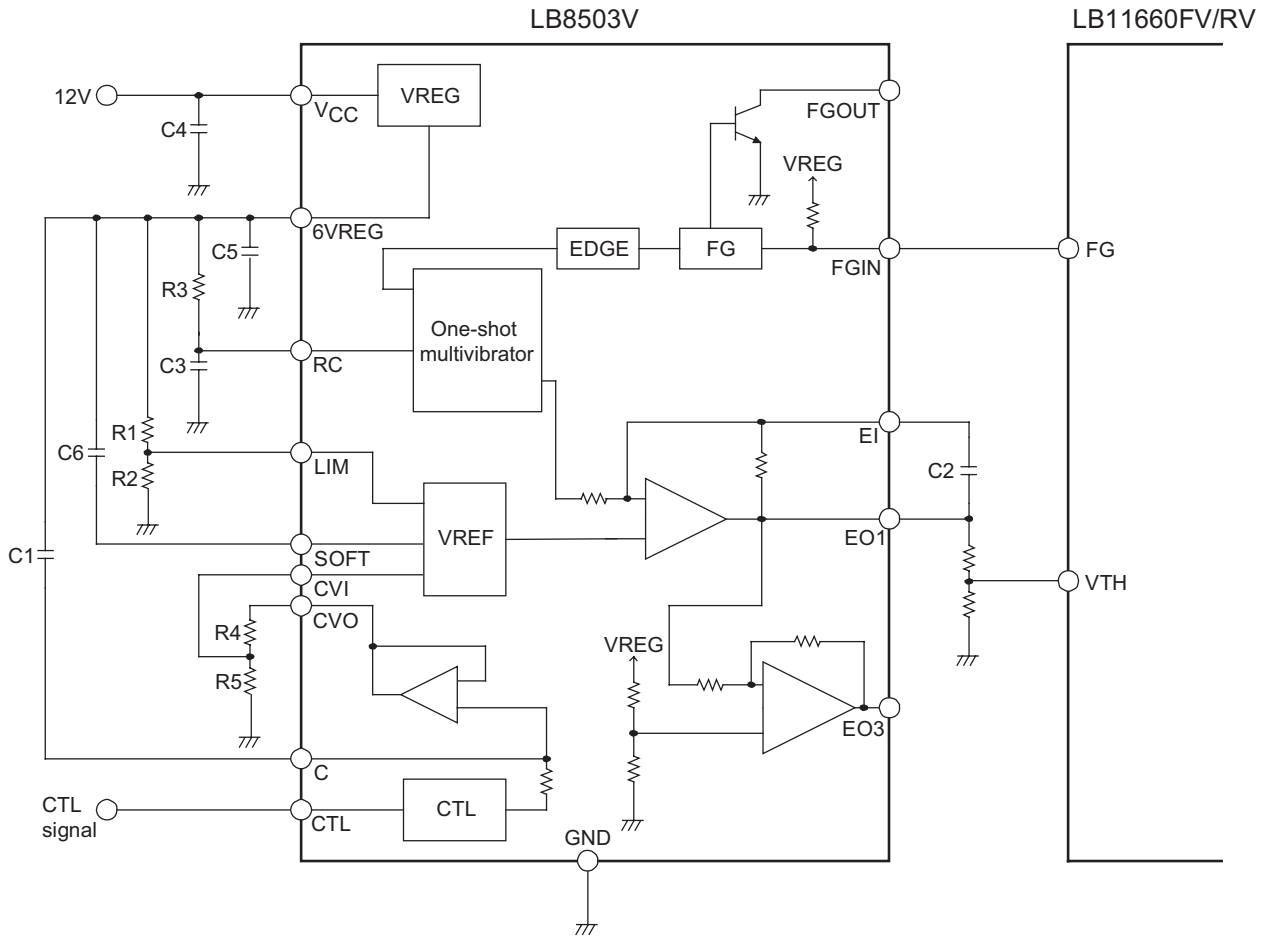
In this circuit, the dynamic range of the LB8503V EO pin (the range from the amplifier block output high to output low levels) must be wider than the dynamic range (from the high to low levels of the PWM signal) of VTH pin of driver IC with which this IC is combined.

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