CORERIVER
Total Solution of MCU

RingCore200

Optimized Vibration Driver

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1 RingCore200 Overview

1.1 General Description

RingCore200 is a linear motor driver IC to drive Linear Resonant Actuator (LRA) and Eccentric Rotating Mass (ERM). It generates a pulse width modulation (PWM) signal for driving a linear motor. It can adjust the frequency of the PWM signal to maximize the vibration amplitude of the linear motor.

RingCore200 operates over the temperature range of -40℃ to +85℃, and is assembled in 8-pin DFN package.

1.2 Features

- Motor Driving Frequency Tuning (Maximum Vibration Frequency Search)
- Supports two actuator types (ERM / LRA)
- Drives low-impedance actuator.
  - The minimum limit: 7.5Ω
- Wide resonant output frequency: 80 ~ 390 Hz
- Almost Rail-to-Rail vibration (Output swing from V_{SS} + 100mV to V_{DD} + 100mV)
- Over-current limitation
- Fast wake-up time (Output available 1ms after EN)
- Single-PWM input for all actuator types (10 kHz ~ 50 kHz)
- Built-in weak pull down on all inputs
- Standby Current: Max. 1uA
- Settable filter in GAIN using an external capacitor
- DC gain settable in GAIN using an external resistor
- Typical 50mV offset on output (Maximum 200mV)
- 2.0mm X 2.0mm DFN package

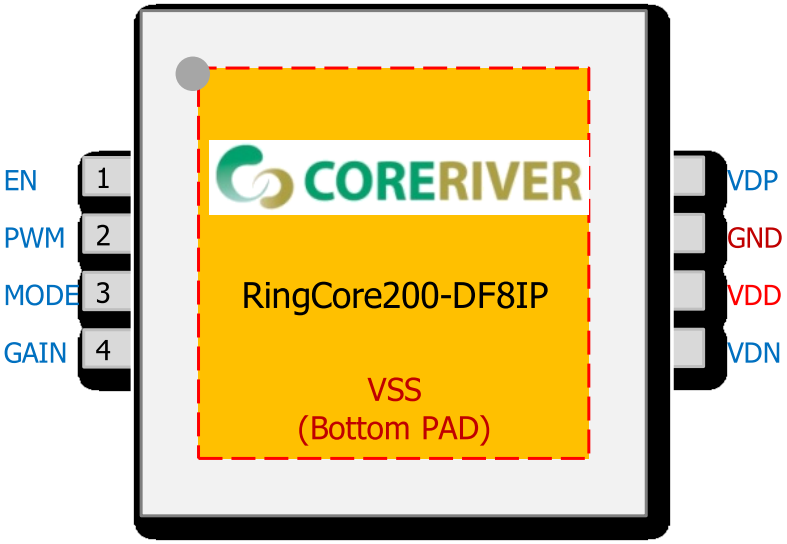
1.3 Applications

- Mobile Phones & Smart Phones
- Portable MP3, MP4
- Navigation Systems
- Joysticks

1.4 Product Family Guide

Product	Output Resonant Frequency [Hz]	PWM input Resonant Frequency [KHz]	Package	Auto Tuning
RingCore200-DF8IP	**80 ~ 390**	**10 ~ 50**	**2 x 2 mm 8-pin DFN**	**-**
RingCore210-DF10IP	80 ~ 390	10 ~ 50	2 x 2 mm 10-pin DFN	Support

2 Pin Configuration

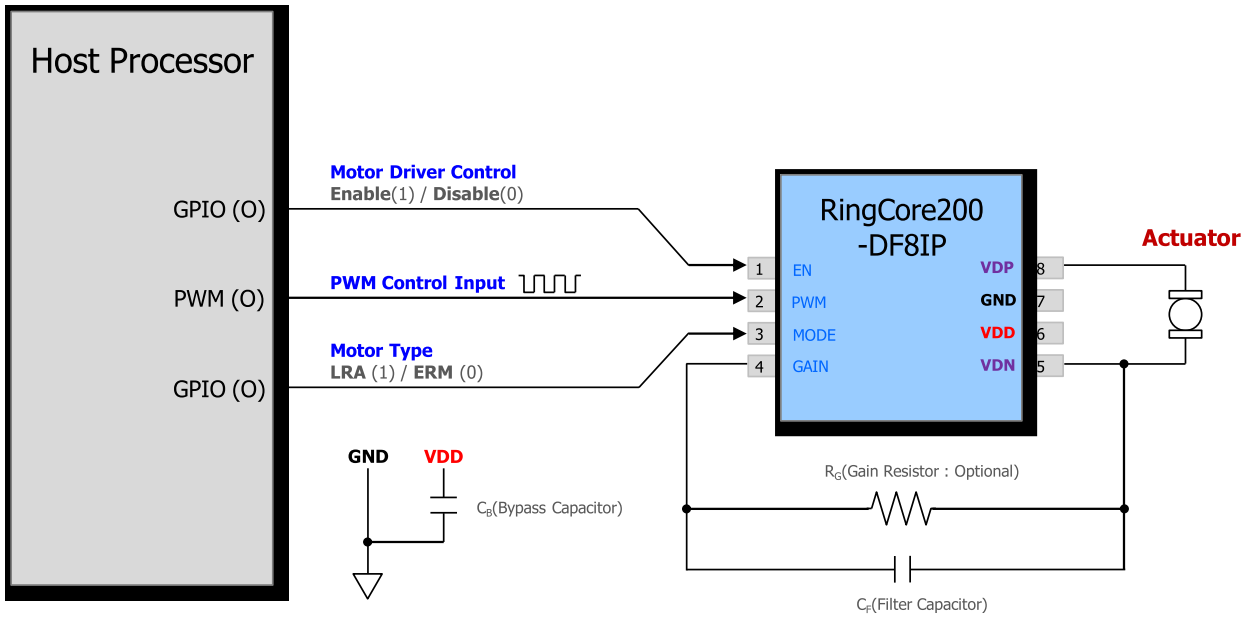


8-pin DFN Package Diagram

3 Pin Description

Pin No.	Name	Type	Description	Share Pins
1	EN	I	Turns the circuit on.	
2	PWM	I	PWM input sets desired vibration magnitude (1% to 99%) with pull-down. - 1% : Full braking - 50% : No vibration - 99% : Full vibration	
3	MODE	I	High: LRA mode. Low: ERM mode.	
4	GAIN	I	Resistor to VDN sets DC Gain. Capacitor to VDN sets Output Filter Frequency.	
5	VDN	O	Negative Actuator Connector.	
6	VDD	PWR	Power supply	
7	GND	GND	Power ground	
8	VDP	O	Positive actuator connector	

4 Typical Application



- V_{DD} power should be supplied by regulated power
- EN pin of RingCore200 should be controlled by GPIO of main CPU to disable RingCore200
- The R_G(Gain Resistor) is used to set the output(VDP, VDN) voltage gain.
  - ✓ The output gain by the R_G optionally. (default output gain is '1' without R_G)
  - ✓ If R_G is 60 kΩ, output gain is half of default value (0.5).
  - ✓ If V_{DD} is higher than required, adjusting the value of R_G to reduce output voltage.
  - ✓ The value of R_G is based on V_{DD} and motor's operating ratings.
  - ✓ Output voltage only can be reduced by R_G.
- The C_F(Filter Capacitor) is used to regulate output high frequency harmonics.
  - ✓ Increasing the value of C_F → Removing high frequency harmonics of the PWM on the outputs.
- In LRA mode, PWM frequency is same to 128 times of the LRA's resonant frequency.
- Don't need any protection component on VDP, VDN

5 Reference Table for R_G

- How to use reference table
  - ✓ Define input V_{DD} voltage and Search actuator's operating ratings (V_{rms})
  - ✓ Tracking down output voltage(VDP, VDN) as you want to use
  - ✓ Find the R_G on left side
  - ✓ For example : V_{DD} is 3.7V, LRA's operating raitngs (Input V_{rms}) is 2.0V_{rms} → R_G value is 91 kΩ

Note : This table's R_G value is estimated value, so should adjust by developer's experiment.

If V_{DD} don't exceed actuator's ratings, R_G can be removed.

R_G \ V_{DD}	2.0V	2.1V	2.2V	2.3V	2.4V	2.5V	2.6V	2.7V	2.8V
68K	0.930	0.980	1.028	1.076	1.123	1.170	1.219	1.265	1.311
75K	0.974	1.025	1.074	1.123	1.173	1.223	1.271	1.318	1.364
82K	1.016	1.067	1.118	1.169	1.222	1.271	1.320	1.369	1.419
91K	1.065	1.117	1.172	1.227	1.278	1.330	1.380	1.434	1.486
100K	1.096	1.150	1.206	1.260	1.312	1.364	1.419	1.473	1.526
110K	1.135	1.192	1.249	1.303	1.357	1.413	1.469	1.523	1.580
120K	1.165	1.223	1.279	1.335	1.391	1.449	1.505	1.563	1.623
130K	1.199	1.257	1.314	1.371	1.431	1.489	1.548	1.608	1.671
150K	1.247	1.305	1.364	1.426	1.487	1.548	1.611	1.676	1.740
160K	1.269	1.329	1.389	1.452	1.514	1.577	1.643	1.709	1.773
180K	1.312	1.373	1.438	1.501	1.567	1.635	1.703	1.770	1.837
200K	1.336	1.400	1.466	1.531	1.599	1.669	1.737	1.805	1.875
220K	1.365	1.431	1.497	1.565	1.636	1.707	1.776	1.847	1.919
240K	1.388	1.456	1.523	1.593	1.666	1.737	1.808	1.881	1.955
270K	1.421	1.487	1.558	1.632	1.705	1.778	1.851	1.927	2.002
300K	1.443	1.511	1.584	1.659	1.733	1.807	1.883	1.960	2.036
330K	1.454	1.524	1.597	1.673	1.747	1.822	1.899	1.977	2.054
360K	1.480	1.552	1.629	1.705	1.780	1.858	1.937	2.015	2.095
390K	1.503	1.576	1.655	1.732	1.808	1.889	1.968	2.049	2.129
430K	1.513	1.588	1.667	1.745	1.822	1.903	1.984	2.065	2.145
470K	1.529	1.606	1.686	1.763	1.843	1.925	2.006	2.089	2.168
510K	1.543	1.621	1.701	1.779	1.860	1.942	2.024	2.107	2.186

R_G \ V_{DD}	2.9V	3.0V	3.1V	3.2V	3.3V	3.4V	3.5V	3.6V	3.7V
68K	1.355	1.401	1.448	1.493	1.539	1.586	1.634	1.682	1.730
75K	1.412	1.461	1.509	1.556	1.605	1.656	1.707	1.757	1.806
82K	1.470	1.518	1.569	1.621	1.674	1.727	1.778	1.830	1.883
91K	1.537	1.591	1.646	1.701	1.756	1.810	1.864	1.921	1.977
100K	1.580	1.637	1.694	1.751	1.806	1.863	1.920	1.977	2.034
110K	1.639	1.698	1.756	1.814	1.872	1.930	1.988	2.046	2.104
120K	1.683	1.744	1.802	1.862	1.924	1.982	2.040	2.098	2.156
130K	1.732	1.793	1.855	1.918	1.982	2.045	2.108	2.171	2.234
150K	1.803	1.868	1.934	2.000	2.066	2.132	2.198	2.264	2.330
160K	1.838	1.905	1.973	2.039	2.107	2.174	2.237	2.298	2.359
180K	1.906	1.976	2.045	2.116	2.184	2.249	2.313	2.377	2.441
200K	1.947	2.017	2.089	2.159	2.227	2.291	2.357	2.422	2.487
220K	1.992	2.065	2.138	2.208	2.274	2.340	2.408	2.474	2.540
240K	2.028	2.103	2.175	2.244	2.312	2.380	2.448	2.516	2.584
270K	2.078	2.153	2.225	2.294	2.363	2.432	2.502	2.573	2.644
300K	2.114	2.189	2.259	2.330	2.401	2.471	2.543	2.615	2.687
330K	2.132	2.206	2.277	2.348	2.420	2.490	2.563	2.637	2.711
360K	2.172	2.245	2.318	2.390	2.462	2.536	2.611	2.686	2.761
390K	2.206	2.279	2.353	2.427	2.500	2.576	2.652	2.730	2.808
430K	2.221	2.295	2.370	2.444	2.519	2.595	2.672	2.751	2.830
470K	2.244	2.319	2.394	2.489	2.545	2.623	2.702	2.783	2.864
510K	2.262	2.338	2.414	2.489	2.567	2.645	2.725	2.807	2.889

6 Absolute Maximum Ratings

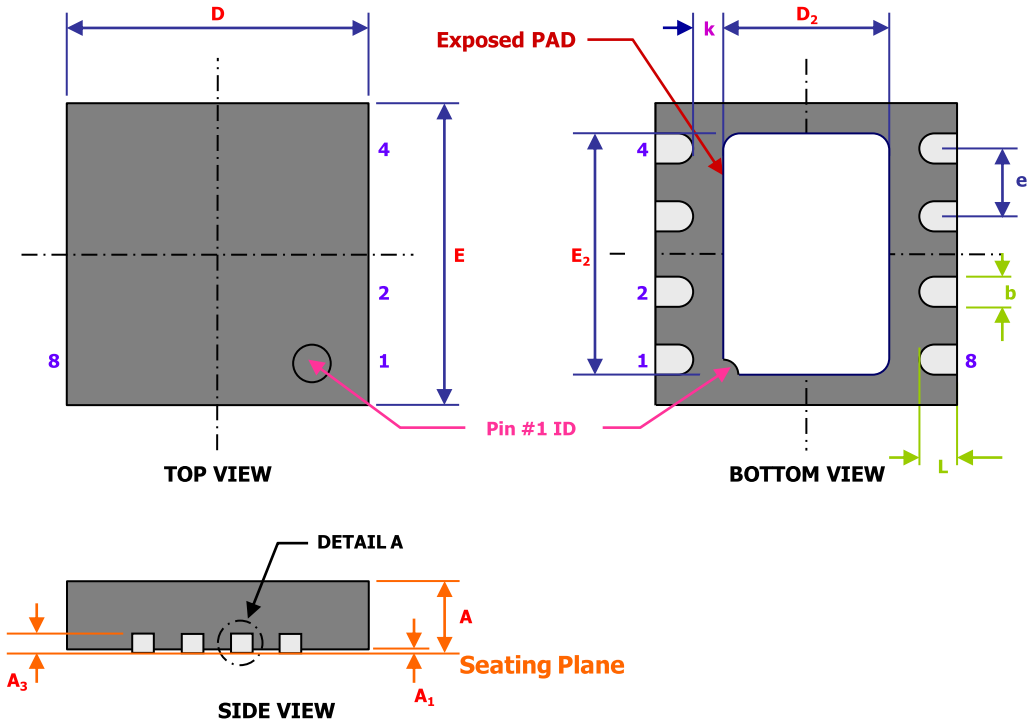
Item	Conditions	Range
Voltage on any pin relative to Ground	-	-0.5 V to (V_{DDIO}+0.5V)
Voltage in V_{DD} relative to Ground	-	-0.5V to 3.7V
Output Voltage	-	-0.5 V to (V_{DD}+0.5V)
Output Current High	One I/O pin active	-25mA
	All I/O pin active	-100mA
Output Current Low	One I/O pin active	+30mA
	All I/O pin active	+150mA
Storage Temperature	-	< 40℃
Soldering Temperature	-	260℃, 10 seconds within 5℃ of actual peak temperature

7 DC Characteristics

* T_A= -40°C ~ +85°C, V_{DD}=2.7V ~ 3.7V unless otherwise specified

Parameter	Symbol	Pin	Conditions	Value			Unit
				Min	Typ	Max	
Input Low Voltage	V_{IL}	EN, PWM	V_{DD} = 2.7V~3.7V	-	-	0.4	V
Input high Voltage	V_{IH}	EN, PWM	V_{DD} = 2.7V~3.7V	1.0	-	-	V
Quiescent Power Supply Current	I_{DDQ}	VDP, VDN	V_{PWM} = 50% Duty, R_L = 30Ω	8	13	17	mA
Output Offset Voltage	V_{OS}	VDP, VDN	V_{PWM} = 50% Duty, R_L = 30Ω	-55	25	55	mV
Output Current	I_{OUT}	VDP, VDN	V_{OH}, V_{OL} ≤ 200mV	-	200	-	mA
Input Leakage Current	I_{IL}	All Pins	V_{IN} = V_{IH} or V_{IL} (V_{EN} = 0)	-	-	±1	μA
Pin Capacitance	C_{IO}	All Pins	V_{DDIO} = 3.7V	-	10	-	pF

8 Package Dimension



Symbol	Dimensions [mm]		
	Min.	Nom.	Max.
A	0.50	0.55	0.60
A_1	0.00	0.01	0.05
A_3		0.15 REF	
D	1.90	2.00	2.10
E	1.90	2.00	2.10
D_2	0.80	0.90	1.00
E_2	1.60	1.70	1.80
B	0.15	0.20	0.25
E		0.50 BSC	
L	0.25	0.30	0.35
k	-	0.25	-

Notes:

1. All dimension are in mm. Angles in Degrees.
2. Dimension b applies to Plated Terminal & is measured between 0.05 and 0.10mm from terminal tip. If the terminal has the optional radius on the other end of the terminal.

The Dimension b should not be measured in that radius area.

3. Max. package warpage is 0.05mm.
4. Max. allowable burrs is 0.076mm in all directions.
5. Bilateral coplanarity zone applies to the exposed heat sink slug as well as the terminals.