LINFINITY MICROELECTRONICS

THE INFINITE POWER OF INNOVATION

RangeMAX™ LX1686

DIGITAL DIMMING CCFL CONTROLLER IC

PRELIMINARY DATA SHEET

DESCRIPTION

The LX1686 Backlight Controller IC provides all the control functions needed to implement Linfinity's direct drive inverters used to operate cold cathode fluorescent lamps (CCFL's). This IC can be used to control single or multiple-lamp configurations. CCFL's are used for back or edge lighting of liquid crystal flat panel displays (LCD's) and typically find application in notebook computers, web browsers, automotive and industrial instrumentation, and entertainment systems.

The LX1686 includes a PWM controlled lamp current burst circuit that can provide a >100:1 dimming range from a simple zero to 2.5V potentiometer input. The PWM dimming burst rate is easily synchronized to the LCD panel's frame rate to prevent interference from optical beat frequencies.

Safety and reliability features include a new dual feedback contol loop that permits regulation of maximum lamp strike voltage as well as lamp current. Regulating maximum lamp voltage permits the designer to provide for ample worst case lamp strike voltage while at the same time conservatively limit maximum open circuit voltage.

An innovative new strike voltage generation technique enables the module designer to optimize high voltage transformer design for maximum operating efficiency with no power dissipating overhead to guarantee strike capability.

Direct drive topology is a non-resonant, oscillator-controlled PWM regulation method. The LX1686 allows a wide choice of fixed operating frequencies to match lamp current frequency to the lamp's most efficient operating point, and to minimize high frequency interference.

NOTE: For current data & package dimensions, visit our web site: **http://www.linfinity.com.**

KEY FEATURES

- RangeMAX™ Wide Range Dimming (>100:1)
- Synchronizable To Display Video Frequency
- High Voltage Feedback Loop Directly Controls Maximum Open Lamp And Minimum Strike Voltages
- Transformer Protected From Over-Heating During Lamp Striking
- Micro-Amp Sleep Mode
- User-Programmable Fixed Frequency Operation
- Under-Voltage Lockout Feature With Power-Up Reset
- Built-In Soft-Start Feature
- Operates With 3.3V or 5V Power Supplies
- 100mA Output Drive Capability

APPLICATIONS

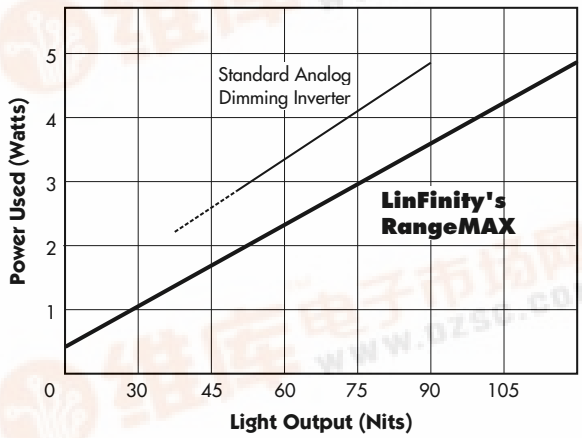
- Notebooks
- Instrumentation Displays
- Desktop Computer Monitors
- Low Ambient Light Displays (used in Aircraft, Automobiles, and Hand-held Equipment)

BENEFITS

- Extemely High Efficiency From 3.3V or 5V Power Supplies
- Lower Cost Than Conventional Buck / Royer Inverter Topologies
- Improved Lamp Strike Capability
- Improved Over-Voltage Control

PRODUCT HIGHLIGHT

RANGEMAX VS. ANALOG DIMMING



Light emitted by a CCFL is proportional to the current flowing through it. There are two ways to control the current: by adjusting the amplitude of a continuous AC current; or, as with RangeMAX technology, by varying the amount of time a burst of full current is present. RangeMAX technology frees the backlight inverter module designer to operate in a lower brightness and lower power consumption mode than is possible with conventional amplitude control methods.

PACKAGE ORDER INFO

T_A (°C)	PW Plastic TSSOP 24-pin
0 to 85	LX1686CPW

Note: All surface-mount packages are available in Tape & Reel. Append the letter "T" to part number. (i.e. LX1686CPWT)

DIGITAL DIMMING CCFL CONTROLLER IC

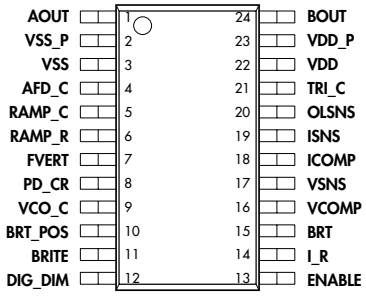
PRELIMINARY DATA SHEET

ABSOLUTE MAXIMUM RATINGS (Note 1)

Supply Voltage (VDD, VDD_P) 6.5V
Digital Inputs ..... -0.3 to VDD+0.5V
Analog Inputs ..... -0.3 to VDD+0.5V
Digital Outputs ..... -0.3 to VDD+0.5V
Analog Outputs ..... -0.3 to VDD+0.5V
Operating Junction Temperature
Plastic (DB, PW Packages) ..... 150°C
Storage Temperature Range ..... -65°C to 150°C
Lead Temperature (Soldering, 10 seconds) ..... 300°C

Note 1. Exceeding these ratings could cause damage to the device. All voltages are with respect to Ground. Currents are positive into, negative out of the specified terminal.

PACKAGE PIN OUTS



PW PACKAGE
(Top View)

THERMAL DATA

PW PACKAGE:

THERMAL RESISTANCE-JUNCTION TO AMBIENT, θ_{JA}	100°C/W

Junction Temperature Calculation: $T_J = T_A + (P_D \times \theta_{JA})$.
The θ_{JA} numbers are guidelines for the thermal performance of the device/pc-board system. All of the above assume no ambient airflow.

ELECTRICAL CHARACTERISTICS

(Unless otherwise specified, these specifications apply over the recommended operating conditions of T_A = 0 to 85°C, VDD=VDD_P= 3.0 to 5.5V) (Ri = 40kΩ, C_{VCO}= 0.01µF, C_{AFD}= 0.22µF, C_{TRI}= 0.83µF, C_{RAMP}= 208pF, R_{RAMP} = 15kΩ, C_{PD}= 0.22µF, C_{PDC}= 0.047µF, R_{PD}= 110kΩ.)

Parameter	Symbol	Test Conditions	LX1686 Min.	LX1686 Typ.	LX1686 Max.	Units
Power Supply Voltage	VDD	VDD = VDD_P	3		5.5	V
Operating Current	I_{DD}	VDD = VDD_P = 5V		5	7	mA
Power Supply Voltage	VDD_P	VDD = VDD_P	3		5.5	V
Output Buffer Operating Current	I_{DD_P}	Volsns = VDD = VDD_P = 5V, C_A = C_B = 1000pF		2	10	mA
UVLO Threshold	V_{TH_UVLO}		2.7		2.9	V
UVLO Hysteresis	V_{H_UVLO}			160		mV
Direct Drive Ramp Block						
Triangular Wave Generator Analog Output Peak Voltage	V_{P_TRI}			2.25		V
Triangular Wave Generator Analog Output Valley Voltage	V_{V_TRI}			0.75		V
Triangular Wave Generator Oscillation Frequency	$F_{\_TRI}$			10		Hz
Triangular Wave Generator Oscillation Charge Current	I_{CHG_TRI}	Tri_c = 0V	-2.3	-2.55	-2.9	µA
Triangular Wave Generator Oscillation Discharge Current	I_{DISCHG_TRI}	Tri_c = 3V	2.3	2.65	2.9	µA
Ramp Generator Analog Output Peak Voltage	V_{P_RAMP}			2.25		V
Ramp Generator Analog Output Valley Voltage	V_{V_RAMP}			0.75		V
Ramp Frequency Change Threshold	$V_{TH\_RAMP\_R}$	VDD = 3V	1.4	1.5	1.65	V
		VDD = 5.5V	1.55	1.65	1.8	V
Ramp Generator Oscillation Frequency - Nominal	F_{RAMP}	V_{TRI_C} = 1.4V	84	100	116	KHz
Ramp Generator Oscillation Frequency - Maximum	F_{RAMP_HI}	V_{TRI_C} = 2.25V	170	200	256	KHz
OLSNS Threshold Voltage	V_{TH_OLSNS}	VDD = 3V	250	300	360	mV
OLSNS Hysteresis	V_{H_OLSNS}	VDD = 3V		45		mV
OLSNS-to-ICOMP Propagation Delay	T_{D_OLSNS}	GBD		1		µS

ELECTRICAL CHARACTERISTICS (continued)

Parameter	Symbol	Test Conditions	LX1686 Min.	LX1686 Typ.	LX1686 Max.	Units
Digital Dimmer Block						
FVERT Input Frequency Capture Range	F_{R_FVERT}		40		200	Hz
FVERT Logic Threshold	V_{TH_FVERT}	Design Reference Only		VDD/2		V
FVERT Input Resistance	R_{FVERT}	Design Reference Only		50		kΩ
VCO Analog Output Peak Voltage	V_{P_VCO}			2.5		V
VCO Analog Output Valley Voltage	V_{V_VCO}			0.65		V
VCO Forced Source Current	$F_{R\_VCO\_I\_SRC}$	V_{PD_CR} = 3V, VDD = 3V	-6.4	-5.8	-5.2	µA
Forced VCO Oscillation Frequency	F_{X_VCO}	AFC_C = 0V, C_{VCO} = 0.01µF		250		Hz
Auto-Frequency Detection Response	T_{D_AFD}	FVERT Frequency is 200Hz, VDD = 3V		1000		ms
BRITE Voltage Range	V_{R_BRITE}		0		VDD	V
Full-Brightness Brite Input Voltage	V_{BRITE_FULL}	V_{BRT_POS} = VDD or float; BRITE = 2.5V	2.35	2.5	2.65	V
		V_{BRT_POS} = 0V, BRITE = 0.5V	2.35	2.5	2.65	V
Full-Darkness Brite Input Voltage	V_{BRITE_DARK}	V_{BRT_POS} = VDD or float BRITE = 0.5V	0.35	0.5	0.65	V
		V_{BRT_POS} = 0V, BRITE = 2.5V	0.35	0.5	0.65	V
BRITE-to-ICOMP Propagation Delay	T_{D_BRITE}			300		ns
BRITE_POS Logic Threshold				VDD/2		V
DIG_DIM Logic Threshold				VDD/2		V
Direct Drive PWM Block						
ISNS Threshold Voltage Range	V_{R_ISNS}	DIG_DIM = VDD	0		2.5	V
VAMP Transconductance	G_{M_VAMP}	VCOMP = 1.25V		400		µmho
VAMP Output Source Current	I_{S_VAMP}	VCOMP = 1.5V	10	50	110	µA
VAMP Output Sink Current	I_{SK_VAMP}	VCOMP = 1.5V	20	70	120	µA
VAMP Output Voltage Range	V_{R_VAMP}		0		VDD	V
VSNS Threshold Voltage	V_{TH_VSNS}	VCOMP = VSNS	1.12	1.25	1.38	V
VCOMP Discharge Current	I_{D_VCOMP}	VCOMP = 0.5V, VDD = 3V	0.8	1.5	10	mA
IAMP Transconductance	G_{M_IAMP}	BRITE = 0.5 - 2.6V	70	200	700	µmho
IAMP Output Source Current	I_{S_IAMP}	ICOMP = 1.5V, VDD = 3V	-15	-40	-80	µA
IAMP Output Sink Current	I_{SK_IAMP}	ICOMP = 1.5V, VDD = 3V	20	60	100	µA
IAMP Output Voltage Range	V_{R_IAMP}		0		VDD	V
IAMP Input Offset Voltage	T_{SS}	C_{VCOMP} = 1µF		40		ms
VCMP Input Offset Voltage	V_{OS_VCMP}	VCOMP = 1.25V, VDD = 3V	-10	3	10	mV
VCOMP-to-Output Propagation Delay	T_{D_VCOMP}	VDD = 3V		250	500	ns
ICMP Input Offset Voltage	V_{OS_ICMP}	ICOMP = 0.5 to 2.25V, VDD = 3V	-10	3	10	mV
ICOMP-to-Output Propagation Delay	T_{D_ICOMP}	BRITE = 1.25V, RAMP_C = 2V, VDD = 3V		1100		ns
Output Buffer Block						
Output Sink Current	I_{SK_OUTBUF}	AOUT, BOUT = VDD = 3V	25	45	80	mA
		AOUT, BOUT = 1V, VDD = 3V	20	35	55	mA
Output Source Current	I_{S_OUTBUF}	AOUT, BOUT = 0V, VDD = 3V	-35	-50	-80	mA
		AOUT, BOUT = 2V, VDD = 3V	-20	-40	-55	mA
Bias Control Block						
Voltage at Pin I_R	V_{IR}		0.98		1.02	V
Pin I_R Maximum Source Current	I_{MAX_IR}	Design Reference Only		50		µA
VBG Output Resistance	R_{O_VBG}	Design Reference Only		10		kΩ
ENABLE Logic Threshold - 3V	V_{EN3V}	VDD = 3V	1.5	1.9	2.4	V
ENABLE Logic Threshold - 5.5V	$V_{EN5.5}$	VDD = 5.5V	2.7	3.2	3.6	V
ENABLE Threshold Hysteresis - 3V	V_{H_EN3}			0.45		V
ENABLE Threshold Hysteresis - 5.5V	$V_{H\_EN5.5}$			350		mV

FUNCTIONAL PIN DESCRIPTION

Pin Number	Pin Designator	Description
1	AOUT	Output driver A.
2	VSS_P	Power ground for output drivers only.
3	VSS	Signal ground.
4	AFD_C	Connects to an external cap, C_{AFD}. Forcing to ground or VDD will make the VCO oscillate at approximately 50% of the maximum VCO frequency. Forcing to VDD/2 will make the VCO oscillate at 2x the FVERT frequency.
5	RAMP_C	Connects to external capacitor C_{RAMP} for setting Direct Drive PWM operating frequency.
6	RAMP_R	Connects to external resistor R_{RAMP} for setting Direct Drive PWM operating frequency.
7	FVERT	Vertical frequency reference digital input. Has internal pull down.
8	PD_CR	Phase Detector Filter. Part of phase lock loop. Connects to external capacitor and resistor network.
9	VCO_C	Connects to external capacitor C_{VCO}.
10	BRT_POS	Brightness control polarity. Has internal pullup. Leave open or pull up to VDD for dimming brightness proportional to BRITE voltage, connec to ground for brightness inversely proportional to BRITE voltage.
11	BRITE	Analog voltage input for brightness control.
12	DIG_DIM	Digital Dimming Enable internal pullup. Leave open or pull up to VDD for operating in digital dimming mode. Connect to ground for analog dimming mode.
13	ENABLE	Chip Enable internal pullup. High enables the chip. Low disables.
14	I_R	Current Reference Resistor. External resistor to ground (Ri) determines internal capacitor C_{ICOMP}.
15	BRT	Current Error Amplifier non-inverting input.
16	VCOMP	Voltage Error Amplifier output. Connects to external frequency compensation capacitor C_{VCOMP}. Controls soft-start timing.
17	VSNS	Voltage Error Amplifier inverting input.
18	ICOMP	Current Error Amplifier output. Connects to external frequency compensation capacitor C_{ICOMP}.
19	ISNS	Current Error Amplifier inverting input.
20	OLSNS	Open Lamp Sense Input.
21	TRI_C	Connects to external capacitor C_{TRI} for setting strike frequency ramp slope.
22	VDD	VDD
23	VDD_P	Dedicated VDD for output buffers only.
24	BOUT	Output driver B.

BLOCK DIAGRAM

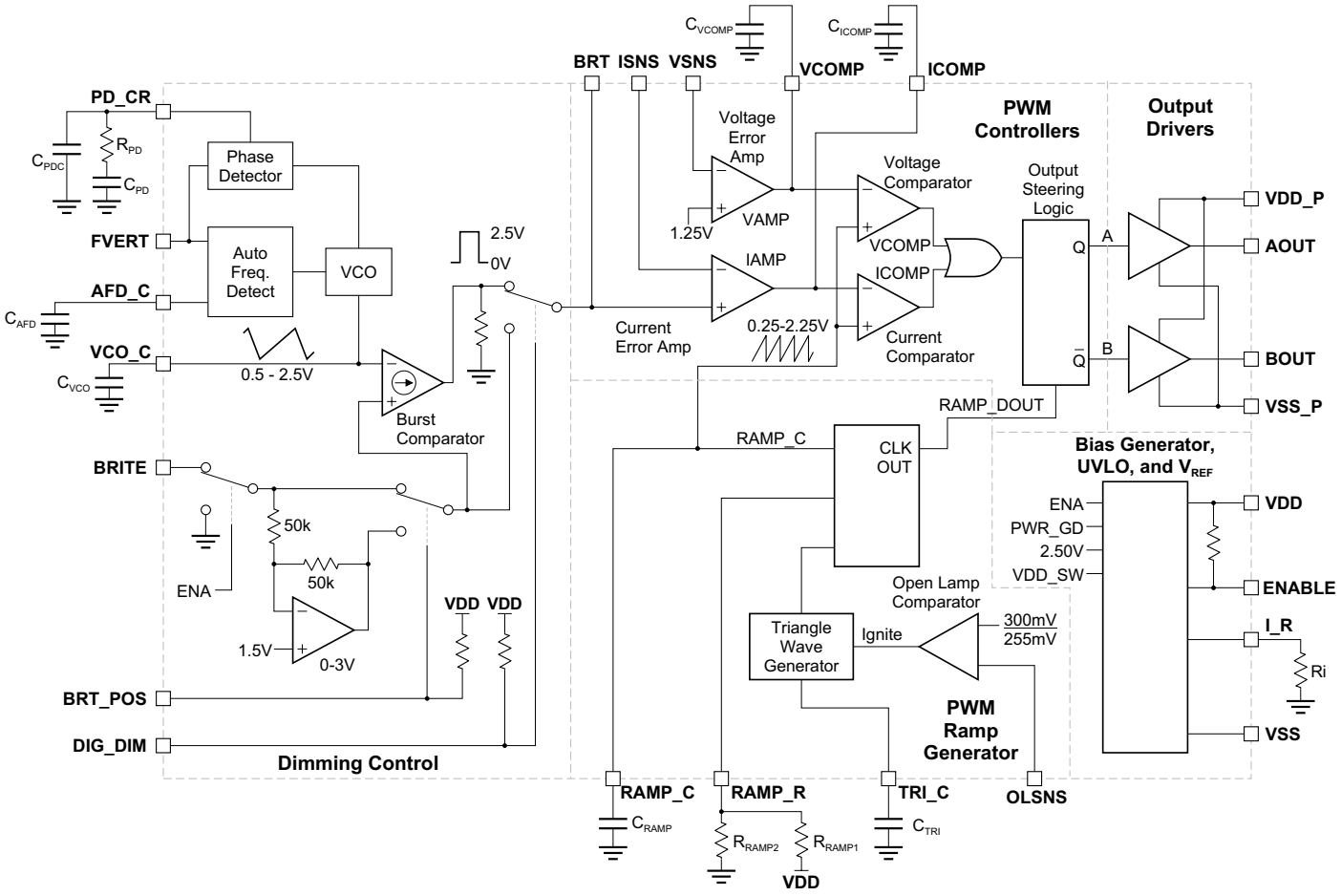


FIGURE 1 — LX1686 Block Diagram