FUDAN MICROELECTRONICS

复旦微电子

FM2141 (GFCI) Low Power Ground Fault Interrupter

Specification

Oct. 2007

Product Overview

Introduction

FM2141 is a low power controller for AC receptacle ground fault circuit interrupters. The devices detect hazardous current paths to ground and ground to neutral faults. The circuit interrupter then disconnects the load from the line before a harmful or lethal shock occurs.

FM2141 contains a diode rectifier, shunt regulator, precision sense amplifier, current reference, time delay circuit and SCR driver internally. Two sense transformers, SCR, solenoid, three resistors and four capacitors complete the design of the basic circuit interrupter.

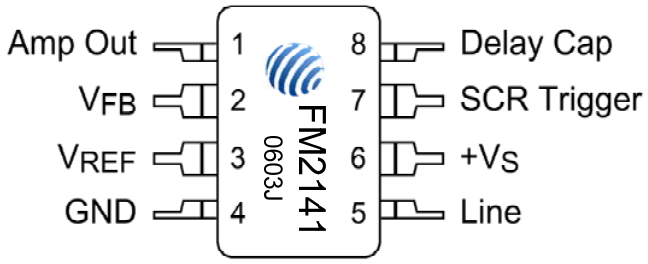
The simple layout and minimum components insure ease of application and long term reliability. Features not found in other GFCI controllers include a low offset voltage sense amplifier eliminating the need for a coupling capacitor between the sense transformer and sense amplifier, and an internal rectifier to eliminate high voltage rectifying diodes.

FM2141 is powered only during the positive half period of the line voltage, but can sense current faults independent of its phase relative to the line voltage. The gate of the SCR is driven only during the positive half cycle of the line voltage.

Features

- Powered from the AC line
- Built-in rectifier
- Direct interface to SCR
- 500μA quiescent current
- Precision sense amplifier
- Adjustable time delay
- Minimum external components
- Meets UL 943 requirements
- For use with 110V or 220V systems
- Available in 8 pin SOP or DIP package

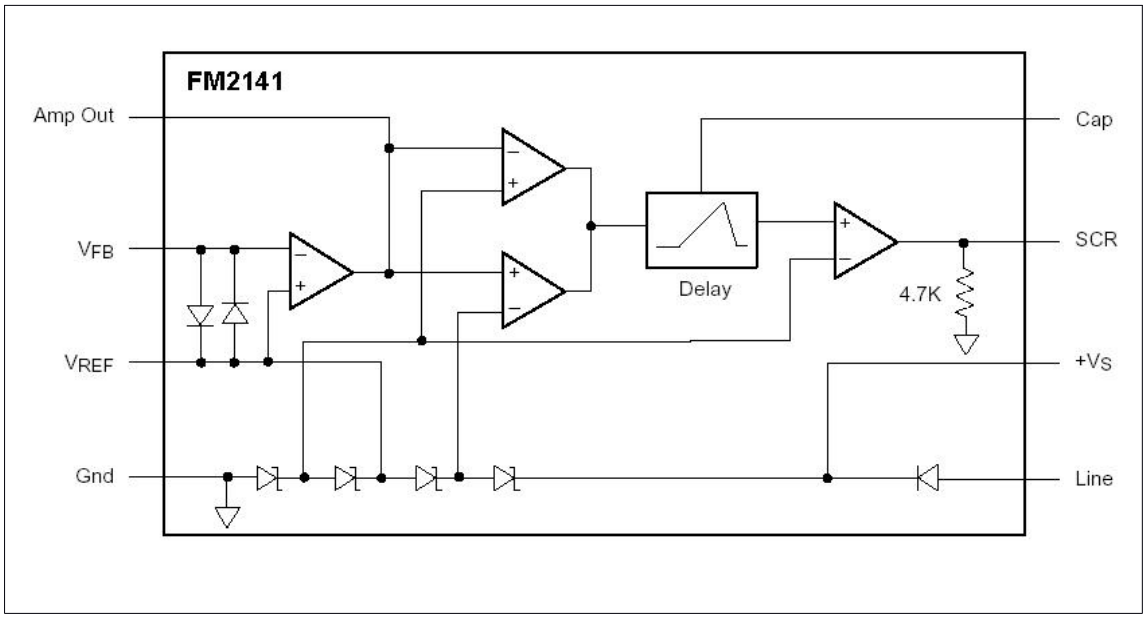
Pin Assignment



Pin Description

PIN	SYM	PIN	SYM	PIN	SYM	PIN	SYM
1	Amp Out	3	V_{REF}	5	LINE	7	SCR Trigger
2	V_{FB}	4	GND	6	$+V_S$	9	Delay Cap

Block Diagram



Electrical Characteristics

Absolute Maximum Ratings

Parameters		Min	Typ	Max	Units
Supply Current	-	-	-	10	mA
Internal Power Dissipation	-	-	-	500	mW
Storage Temperature Range	-	-65	-	+150	℃
Operating Temperature Range	-	-35	-	+80	℃
Junction Temperature	-	-	-	125	
Leading Soldering Temperature	60 Sec DIP	-	-	300	℃
	10 Sec SOP	-	-	260	℃

DC Characteristics

(I_{LINE} = 1.5mA, T_A = +25℃, R_{SET} = 650KΩ)

Parameters	Sym	Test Conditions	Min	Typ	Max	Units
Shunt Regulator（Pins 5 to 4）						
Regulated Voltage	$V_{reg}1$	I_{2-3} = 11μA	25.0	27.0	29.0	V
Regulated Voltage	$V_{reg}2$	I_{LINE} = 740μA，I_{2-3} = 9μA	25.0	27.0	29.0	V
Quiescent	I_{LINE}	V_{5-4} = 24V	-	500	-	μA
Sensibility（Pin 2 to 7）						
Offset voltage	V_{offset}		-200	0	200	μV
Gain bandwidth	GB	（设计值）	—	1.5	—	MHz
Input bias current	I_{Bias}	（设计值）		30	100	nA
Sensibility	I_{SEN}	Pin 7 ⎽↑‾	3.49	4.5	5.9	μA
SCR Trigger						
Output	R_O	V_{7-4} = Open，V_{5-4} = Open	3.8	4.7	5.6	kΩ
Output	VOL	I_{2-3} = 9μA	0	0.1	10	mV
Output	VOH	I_{2-3} = 11μA	2.4	3.0	4.0	V
Reference Voltage（Pins 3 to 4）						
Reference Voltage	V_{Ref}	I_{LINE} = 740μA	12.0	13.0	14.0	V

AC Characteristics

(I_{LINE} = 1.5mA, T_A = +25℃, R_{SET} = 650KΩ)

Parameters	Sym	Test Conditions	Min	Typ	Max	Units
Delay Timer						
Delay Time	TD	C_{8-4}= 1.2 nF	-	0.2	-	ms

GFCI Application

The GFCI detects a ground fault by sensing a difference current in the line and neutral wires. The difference current is assumed to be a fault current creating a potentially hazardous path from line to ground. Since the line and neutral wires pass through the center of the sense transformer, only the differential primary current is transferred to the secondary. Assuming the turns ratio is 1:1000, the secondary current is 1/1000th the fault current. FM2141's sense amplifier converts the secondary current to a voltage which is compared with either of the two window detector reference voltages. If the fault current exceeds the design value for the duration of the programmed time delay, FM2141 will send a current pulse to the gate of the SCR.

Detecting ground to neutral faults is more difficult. RB represents a normal ground fault resistance, RN is the wire resistance of the electrical circuit between load/neutral and earth ground. RG represents the ground to neutral fault condition. According to UL 943, the GFCI must trip when RN=0.4Ω, RG=1.6Ωand the normal ground fault is 6 mA.

Assuming the ground fault to be 5mA, 1mA and 4mA will go through RG and RN, respectively, causing an effective 1mA fault current. This current is detected by the sense amplifier and amplifier by the sense amplifier. Now the ground/neutral and sense transformers are mutually coupled by RG, RN and neutral wire ground loop, producing a positive feedback loop through the sense amplifier. The newly created feedback loop causes the sense amplifier to oscillate at a frequency determined by ground/neutral transformer secondary inductance and C4. Typically it occurs at 8 KHz.

C2 is used to program the time required for the fault to be present before the SCR is triggered. Refer to the equation below for calculating the value of C2.

$$C2 = 6 \times T$$

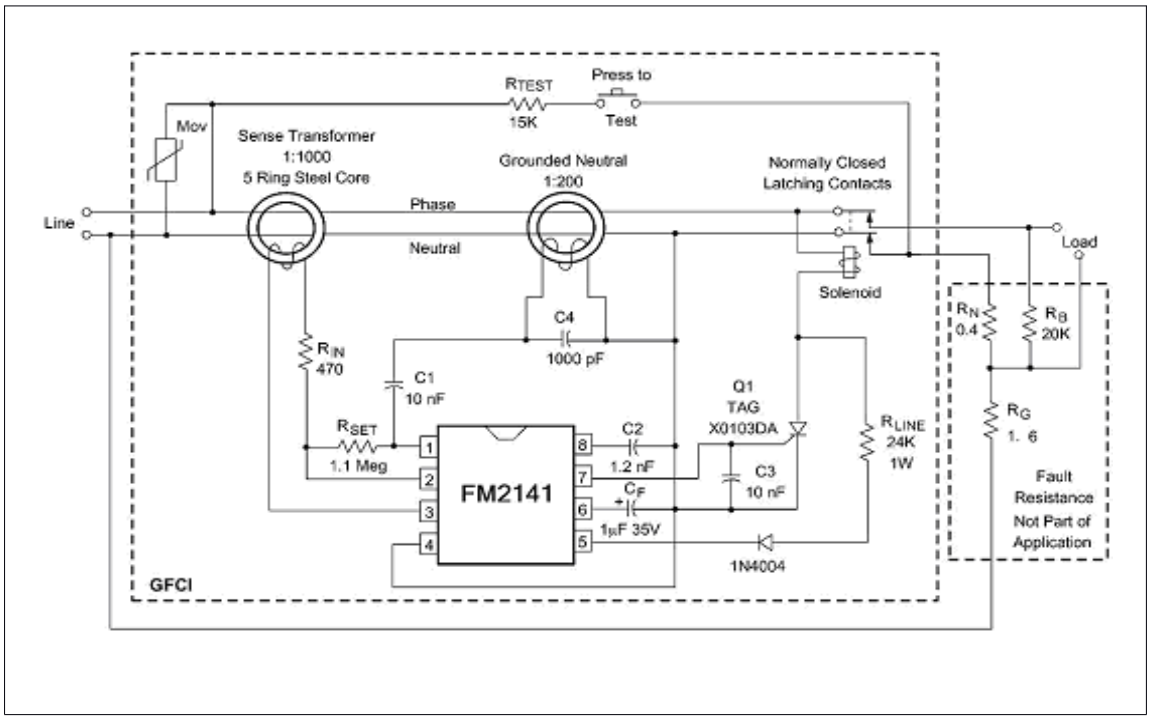
Unit of C2 is nF, Unit of T is ms.

RSET is used to set the fault current at which the GFCI trips.

$$R_{SET} = \frac{4.6 \times N}{I_{FAULT} \times COS180\ (T/P)}$$

When used with a 1:1000 sense transformer, its typical value is 1MΩ for a GFCI designed to trip at 5mA.

Application Circuit



Revision History

Version	Publication date	Pages	Paragraph or Illustration	Revise Description
1.0	Oct. 2007	9		Initial Release.

Sales and Service

Shanghai Fudan Microelectronics Co., Ltd.
Address: Bldg No. 4, 127 Guotai Rd,
Shanghai City China.
Postcode: 200433
Tel: (86-21) 6565 5050
Fax: (86-21) 6565 9115

Shanghai Fudan Microelectronics (HK) Co., Ltd.
Address: Flat 12, 7/F, East Ocean Centre, 98 Granville Rd,
Tsimshatsui East, Kowloon, Hong Kong.
Tel: (852) 2116 3288 2116 3338
Fax: (852) 2116 0882

Beijing Office
Address: Room.1208, Bldg C,
Zhongguancun Science and Technology Development Edifice,
34 zhongguancun Street (South),
Hai Dian District, Beijing City, China.
Tel: (86-10) 6212 0682 6213 9558
Fax: (86-10) 6212 0681

Shenzhen Office
Address: Room.1301, Century Bldg, Shengtingyuan Hotel,
Huaqiang Rd (North),
Shenzhen City, China.
Tel: (86-755) 8335 1011 8335 0911
Fax: (86-755) 8335 9011

Web Site: http://www.fmsh.com/