US009411353B2

(12) **United States Patent**
Gopalraju et al.

(10) **Patent No.: US 9,411,353 B2**
(45) **Date of Patent: Aug. 9, 2016**

(54) **METHOD AND CIRCUITRY FOR REGULATING A VOLTAGE**

(71) Applicant: **Texas Instruments Incorporated**, Dallas, TX (US)

(72) Inventors: **Seenu Gopalraju**, San Jose, CA (US); **Patrick Michael Teterud**, Plano, TX (US); **Shanmuganand Chellamuthu**, Richardson, TX (US)

(73) Assignee: **TEXAS INSTRUMENTS INCORPORATED**, Dallas, TX (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 173 days.

(21) Appl. No.: **14/194,103**

(22) Filed: **Feb. 28, 2014**

(65) **Prior Publication Data**

US 2015/0248137 A1 Sep. 3, 2015

(51) **Int. Cl.**

G06F 1/00	(2006.01)
G11C 7/06	(2006.01)
G05F 1/00	(2006.01)
G05F 3/02	(2006.01)
G06F 1/26	(2006.01)
G05F 3/30	(2006.01)

(52) **U.S. Cl.**
CPC .. ***G05F 3/02*** (2013.01); ***G05F 3/30*** (2013.01); ***G06F 1/26*** (2013.01)

(58) **Field of Classification Search**
CPC G06F 1/3203
USPC 713/300
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

6,753,722	B1 *	6/2004	Kondapalli et al.	327/540
7,170,272	B2 *	1/2007	Yoshida	323/284
8,929,157	B2 *	1/2015	Mozak et al.	365/189.07
2003/0043640	A1	3/2003	Marr et al.	
2009/0080276	A1	3/2009	Cai et al.	
2010/0060083	A1 *	3/2010	Rolland	307/80
2012/0001603	A1 *	1/2012	Ouyang et al.	323/271
2014/0032942	A1 *	1/2014	Takehara et al.	713/300

FOREIGN PATENT DOCUMENTS

WO	WO0247244	A1	6/2002
WO	WO2013101718	A1	7/2013

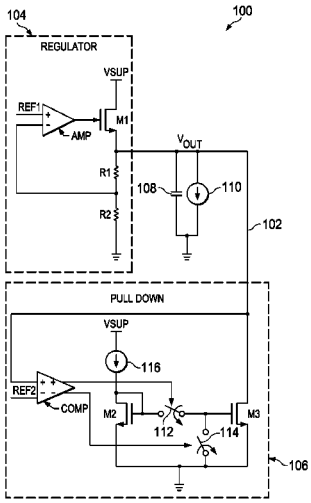
OTHER PUBLICATIONS

International Search Report and Written Opinion for PCT/US2014/058078 mailed Mar. 26, 2015.

* cited by examiner

Primary Examiner — Suresh Suryawanshi
(74) *Attorney, Agent, or Firm* — Michael A. Davis, Jr.; Frank D. Cimino

(57) **ABSTRACT**

In response to a first reference voltage, a regulator regulates an output voltage of a line, so that the output voltage is approximately equal to a target voltage. In response to the output voltage rising above a second reference voltage, pull down circuitry draws current from the line. In response to the output voltage falling below the second reference voltage by at least a predetermined amount, the pull down circuitry ceases to draw current from the line. The first and second reference voltages are based upon a same band gap reference as one another.

24 Claims, 3 Drawing Sheets