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SEMICONDUCTOR TECHNICAL DATA

Advance Information

Switching Power Supply with Linear Regulators

The 33997 is a medium-power, multi-output power supply integrated circuit that is capable of operating over a wide input voltage range, from 6.0 V up to 26.5 V with 40 V transient capability. It incorporates a sensorless current mode control step-down switching controller regulating directly to 5.0 V. The 3.3 V linear regulator uses an external pass transistor to reduce the 33997 power dissipation. The 33997 also provides a 3.3 V linear standby regulator and two 5.0 V sensor supply outputs protected by internal low-resistance LDMOS transistors.

There are two separate enable pins for the main and sensor supply outputs and standard supervisory functions such as resets with power-up reset delay.

The 33997 provides proper power supply sequencing for advanced microprocessor architectures such as the Motorola MPC5xx and 683xx microprocessor families.

Features

- Operating Voltage Range 6.0 V up to 26.5 V (40 V transient)
- Step-Down Switching Regulator Output V_{DDH} = 5.0 V @ 1400 mA (total)
- Linear Regulator with External Pass Transistor V_{DDL} = 3.3 V @ 400 mA
- Low-Power Standby Linear Regulator V_{KAM} = 3.3 V @ 10 mA
- Two 5.0 V @ 200 mA (typical) Sensor Supplies V_{REF} Protected Against Short-to-Battery and Short-to-Ground with Retry Capability
- Undervoltage Shutdown on the V_{DDL}, V_{DDH} Outputs with Retry Capability
- Reset Signals
- Power-Up Delay
- Enable Pins for Main Supplies (EN) and Sensor Supplies (SNSEN)
- Power Sequencing for Advanced Microprocessor Architectures
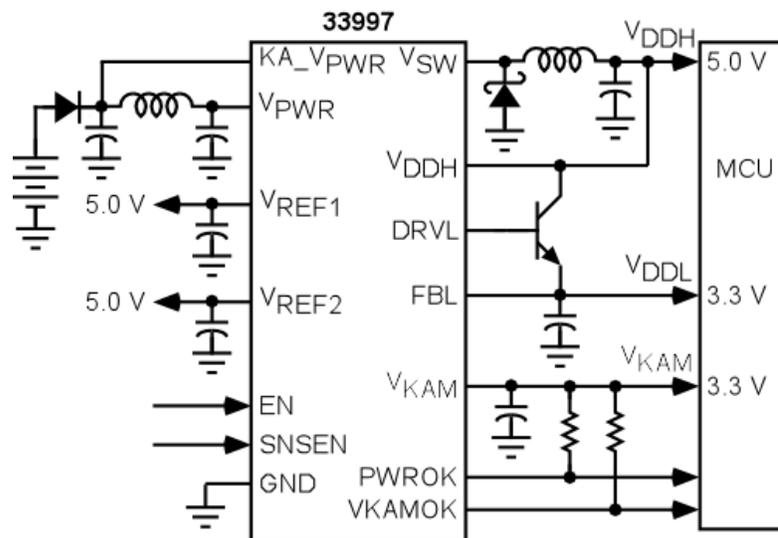- SOIC-24WB Package

33997

**POWER SUPPLY
INTEGRATED CIRCUIT**
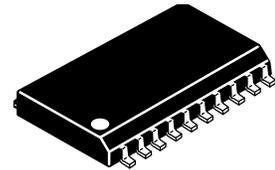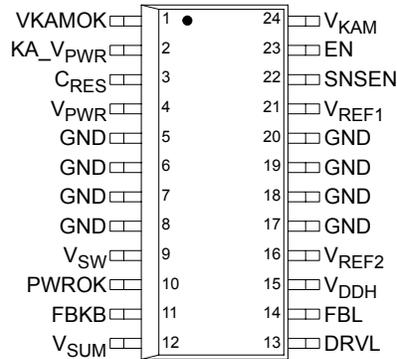

**DW SUFFIX
24-LEAD SOICW
CASE 751E**

ORDERING INFORMATION

Device	Temperature Range (T_A)	Package
MC33997DW/R2	-40°C to 125°C	24 SOICW

33997 Simplified Application Diagram

This document contains certain information on a new product.
Specifications and information herein are subject to change without notice.

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Figure 1. 33997 Simplified Block Diagram

```
VKAMOK   1 •      24   V_KAM
KA_V_PWR  2        23   EN
C_RES     3        22   SNSEN
V_PWR     4        21   V_REF1
GND       5        20   GND
GND       6        19   GND
GND       7        18   GND
GND       8        17   GND
V_SW      9        16   V_REF2
PWROK    10        15   V_DDH
FBKB     11        14   FBL
V_SUM    12        13   DRVL
```

PIN FUNCTION DESCRIPTION

Pin	Pin Name	Description
1	VKAMOK	Keep-Alive Output Monitoring. This pin is an "open-drain" output that will be used with a discrete pull-up resistor to V_{KAM}. When the supply voltage to the 33997 is disconnected or lost, the VKAMOK signal goes low.
2	KA_V_{PWR}	Keep Alive Power Supply Pin. This supply pin is used in modules that have both direct battery connections and ignition switch activated connections.
3	C_{RES}	Reservoir Capacitor. This pin is tied to an external "reservoir capacitor" for the internal charge pump.
4	V_{PWR}	Power Supply Pin. Main power input to the IC. This pin is directly connected to the switching regulator power MOSFET. In automotive applications this pin must be protected against reverse battery conditions by an external diode.
5−8	GND	Ground of the integrated circuit.
9	V_{SW}	Internal P-Channel Power MOSFET Drain. V_{SW} is the "switching node" of the voltage buck converter. This pin is connected to the V_{PWR} pin by an integrated p-channel MOSFET.
10	PWROK	Power OK Reset Pin. This pin is an "open-drain" output that will be used with a discrete pull-up resistor to V_{KAM}, V_{DDH}, or V_{DDL}. When either V_{DDH} or V_{DDL} output voltage goes out of the regulation limits this pin is pulled down.
11	FBKB	Step-Down Switching Regulator Feedback Pin. The FBKB pin is the V_{DDH} feedback signal for the switching regulator.
12	V_{SUM}	Error Amplifier "Summing Node". The V_{SUM} pin is connected to the inverting input of the error amplifier. This node is also the "common" point of the integrated feedback resistor divider.
13	DRVL	Drive for V_{DDL} (3.3 V) Regulator. The DRVL pin drives the base of an external NPN pass transistor for the V_{DDL} linear post regulator. The collector of the VDDL pass transistor is connected to V_{DDH}. An example of a suitable pass transistor is BCP68.
14	FBL	Feedback for V_{DDL} (3.3 V) Regulator. The FBL pin is the voltage feedback sense signal from the V_{DDL} (3.3 V) linear post regulator.
15	V_{DDH}	V_{DDH} is an input supply pin providing power for the buffered sensor supplies and the drive circuitry for the 3.3 V linear power regulator. The V_{DDH} pin is supplied from the switching regulator output, capable of providing 5.0 V @ 1400 mA total output current.
16	V_{REF2}	Sensor Supply #2 Output. The V_{REF2} pin is sensor supply output #2.
17−20	GND	Ground of the integrated circuit.
21	V_{REF1}	Sensor Supply #1 Output. The V_{REF1} pin is sensor supply output #1.

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PIN FUNCTION DESCRIPTION (continued)

Pin	Pin Name	Description
22	SNSEN	Sensor Supply Enable Input. The SNSEN pin is an input, which enables the V_{REF1} and V_{REF2} supplies. It allows the control module hardware/software to shut down the sensor supplies.
23	EN	Enable Input. The EN pin is an input, which enables the main switching regulator and all other functions. When this pin is low, the power supply is in a low quiescent state.
24	V_{KAM}	Keep-Alive (standby) 3.3 V Regulator Output. This is a 3.3 V low quiescent, low dropout regulator for Keep Alive memory.

MAXIMUM RATINGS

All voltages are with respect to ground unless otherwise noted.

Rating	Symbol	Value	Unit
Main Supply Voltage	V_{PWR}	-0.3 to 45	V
Keep-Alive Supply Voltage	KA_V_{PWR}	-0.3 to 45	V
Switching Node	V_{SW}	-0.5 to 45	V
5.0 V Input Power	V_{DDH}	-0.3 to 6.0	V
Sensor Supply	V_{REF1} V_{REF2}	-0.3 to 18 -0.3 to 18	V
Keep-Alive Supply Voltage	V_{KAM}	-0.3 to 6.0	V
Maximum Voltage at Logic I/O Pins	EN SNSEN PWROK VKAMOK	-0.3 to 6.0 -0.3 to 6.0 -0.3 to 6.0 -0.3 to 6.0	V
Charge Pump Reservoir Capacitor Voltage	C_{RES}	-0.3 to 18	V
Error Amplifier Summing Node	V_{SUM}	-0.3 to 6.0	V
Switching Regulator Output Feedback	FBKB	-0.3 to 6.0	V
V_{DDL} Base Drive	DRVL	-0.3 to 6.0	V
V_{DDL} Feedback	FBL	-0.3 to 6.0	V
ESD Voltage Human Body Model (all pins) (Note 1) Machine Model (all pins) (Note 2)	V_{ESD1} V_{ESD2}	±500 ±100	V
Power Dissipation (T_A = 25°C) (Note 3)	P_D	800	mW
Thermal Resistance, Junction to Ambient (Note 4), (Note 5)	$R_{\theta J-A}$	60	°C/W
Thermal Resistance, Junction to Board (Note 6)	$R_{\theta J-B}$	20	°C/W
Operational Package Temperature [Ambient Temperature] (Note 7)	T_A	-40 to 125	°C
Operational Junction Temperature	T_J	-40 to 150	°C
Storage Temperature	T_{STG}	-55 to 150	°C
Lead Soldering Temperature (Note 8)	T_S	260	°C

Notes
1. ESD1 testing is performed in accordance with the Human Body Model (C_{ZAP}=100 pF, R_{ZAP}=1500 Ω).
2. ESD2 testing is performed in accordance with the Machine Model (C_{ZAP}=200 pF, R_{ZAP}=0 Ω)
3. Maximum power dissipation at indicated junction temperature.
4. Junction temperature is a function of on-chip power dissipation, package thermal resistance, mounting site (board) temperature, ambient temperature, air flow, power dissipation of other components on the board, and board thermal resistance.
5. Per SEMI G38-87 and JEDEC JESD51-2 with the single layer board horizontal.
6. Thermal resistance between the die and the printed circuit board per JEDEC JESD51-8. Board temperature is measured on the top surface of the board near the package.
7. The limiting factor is junction temperature, taking into account the power dissipation, thermal resistance, and heat sinking.
8. Lead soldering temperature limit is for 10 seconds maximum duration. Not designed for immersion soldering. Exceeding these limits may cause malfunction or permanent damage to the device.

STATIC ELECTRICAL CHARACTERISTICS

Characteristics noted under conditions 9.0 V $\leq$ V$_{PWR}$ $\leq$ 16 V, -40°C $\leq$ T$_J$ = T$_A$ $\leq$ 125°C, using the typical application circuit (see Figure 8) unless otherwise noted. Typical values noted reflect the approximate parameter mean at T$_A$ = 25°C under nominal conditions unless otherwise noted.

Characteristic	Symbol	Min	Typ	Max	Unit
GENERAL					
Supply Voltage Range Normal Operating Voltage Range (Note 9) Extended Operating Voltage Range (Note 9)	V$_{PWR(N)}$ V$_{PWR(E)}$	6.0 18	– –	18 26.5	V
Maximum Transient Voltage - Load Dump (Note 10)	V$_{PWR(LD)}$	–	–	40	V
V$_{PWR}$ Supply Current EN = 5.0 V, V$_{PWR}$ = 14 V, No Loads	I$_{VPWR}$	25	–	150	mA
V$_{PWR}$ Quiescent Supply Current EN = 0 V, V$_{PWR}$ = 12 V	I$_{Q\_VPWR}$	5.0	–	15	µA
KA_V$_{PWR}$ Supply Current, EN = 5.0 V, KA_V$_{PWR}$ = 14 V, No Load on V$_{KAM}$	I$_{KAVPWR}$	0.5	–	3.0	mA
KA_V$_{PWR}$ Quiescent Supply Current EN = 0 V, KA_V$_{PWR}$ = 12 V	I$_{Q\_KAVPWR}$	50	–	350	µA
BUCK REGULATOR V$_{DDH}$					
Buck Converter Output Voltage I$_{VDDH}$ = 200 mA to 1.4 A, V$_{PWR}$ = KA_V$_{PWR}$ = 14 V	V$_{DDH}$	4.9	–	5.1	V
Buck Converter Output Voltage I$_{VDDH}$ = 1.4 A, V$_{PWR}$ = KA_V$_{PWR}$ = 6.0 V	V$_{DDH}$	4.9	–	5.1	V
V$_{DDH}$ Line Regulation V$_{PWR}$ = KA_V$_{PWR}$ = 10 V to 14 V, I$_{VDDH}$ = 200 mA	RegLn$_{VDDH}$	-20	–	30	mV
V$_{DDH}$ Load Regulation V$_{PWR}$ = KA_V$_{PWR}$ = 14 V, I$_{VDDH}$ = 200 mA to 1.4 A V$_{PWR}$ = KA_V$_{PWR}$ = 6.0 V, I$_{VDDH}$ = 200 mA to 1.4 A	RegLd$_{VDDH}$	-20 -20	– –	20 20	mV
V$_{DDH}$ Active Discharge Resistance V$_{PWR}$ = KA_V$_{PWR}$ = 14 V, EN = 0 V, I$_{VDDH}$ = 10 mA	R$_{HDisch}$	1.0	–	15	Ω
P-CHANNEL MOSFET					
Drain-Source Breakdown Voltage—Not Tested (Note 11)	BV$_{DSS}$	45	–	–	V
Drain-Source Current Limit—Not Tested (Note 11)	Isc$_{SW1}$	–	-7.0	–	A

Notes
9. V$_{DDH}$ is fully functional when the 33997 is operating at higher battery voltages, but these parameters are not tested. The test condition as are:
    a) V$_{DDH}$ must be between 4.9 V and 5.1 V (200 mA to 1.4 A) for V$_{PWR}$ = 14 V to 18 V.
    b) V$_{DDH}$ must be between 4.8 V and 5.5 V (200 mA to 1.4 A) for V$_{PWR}$ = 18 V to 26.5 V.
10. Part can survive, but no parameters are guaranteed.
11. Guaranteed by design but not production tested.

STATIC ELECTRICAL CHARACTERISTICS (continued)

Characteristics noted under conditions 9.0 V $\leq$ V$_{PWR}$ $\leq$ 16 V, -40°C $\leq$ T$_J$ = T$_A$ $\leq$ 125°C, using the typical application circuit (see Figure 8) unless otherwise noted. Typical values noted reflect the approximate parameter mean at T$_A$ = 25°C under nominal conditions unless otherwise noted.

Characteristic	Symbol	Min	Typ	Max	Unit
LINEAR REGULATOR V$_{DDL}$					
V$_{DDL}$ Output Voltage V$_{PWR}$ = KA_V$_{PWR}$ = 14 V, I$_{VDDL}$ = 200 mA	V$_{DDL}$	3.15	–	3.45	V
V$_{DDL}$ Line Regulation V$_{DDH}$ = 4.8 V to 5.2 V, I$_{VDDL}$ = 400 mA	RegLn$_{VDDL}$	-70	–	70	mV
V$_{DDL}$ Load Regulation V$_{PWR}$ = KA_V$_{PWR}$ = 14 V, I$_{VDDL}$ = 10 mA to 400 mA	RegLd$_{VDDL}$	-70	–	70	mV
DRVL Output Current V$_{PWR}$ = KA_V$_{PWR}$ = 14 V, VDRVL = 1.0 V	I$_{DRVL}$	5.0	11	25	mA
V$_{DDL}$ Active Discharge Resistance V$_{PWR}$ = KA_V$_{PWR}$ = 14 V, EN = 0 V, I$_{FBL}$ = 10 mA	R$_{LDisch}$	1.0	–	10	Ω
V$_{DDH}$ to V$_{DDL}$ Active Clamp Resistance V$_{PWR}$ = KA_V$_{PWR}$ = 14 V, EN = 0 V, I$_{VDDH}$ = 50 mA, V$_{FBKB}$ = 0 V	R$_{CLAMP}$	0.6	–	10	Ω
V$_{DDL}$ Output Capacitor Capacitance (Note 12)	C$_{VDDL}$	–	68	–	μF
V$_{DDL}$ Output Capacitor ESR (Note 12)	ESR$_{VDDL}$	–	0.125	–	Ω
KEEP-ALIVE (STANDBY) REGULATOR V$_{KAM}$					
V$_{KAM}$ Output Voltage I$_{VKAM}$ = 5.0 mA, VPWR = KA_V$_{PWR}$ = 18 V, EN = 5.0 V	V$_{KAM}$	3.0	–	3.6	V
V$_{KAM}$ Output Voltage, EN = 0 V (Standby Mode) V$_{PWR}$ = KA_V$_{PWR}$ = 26 V, I$_{VKAM}$ = 0.5 mA V$_{PWR}$ = KA_V$_{PWR}$ = 18 V, I$_{VKAM}$ = 5.0 mA V$_{PWR}$ = KA_V$_{PWR}$ = 5.0 V, I$_{VKAM}$ = 10.0 mA V$_{PWR}$ = 0 V, KA_V$_{PWR}$ = 3.5 V, I$_{VKAM}$ = 5.0 mA	V$_{KAM}$	3.0 3.0 3.0 2.0	– – – –	3.6 3.6 3.6 3.5	V
V$_{KAM}$ Line Regulation, EN = 0 V (Standby Mode) V$_{PWR}$ = KA_V$_{PWR}$ = 5.0 V to 18 V, I$_{VKAM}$ = 2.0 mA	RegLn$_{VKAM}$	-20	–	20	mV
V$_{KAM}$ Load Regulation, EN = 0 V (Standby Mode) V$_{PWR}$ = KA_V$_{PWR}$ = 14 V, I$_{VKAM}$ = 1.0 mA to 10 mA	RegLd$_{VKAM}$	0	–	100	mV
Differential Voltage V$_{KAM}$ - V$_{DDL}$ EN = 5.0 V, I$_{VKAM}$ = 5.0 mA, V$_{PWR}$ = KA_V$_{PWR}$ = 14 V, I$_{VDDL}$ = 200 mA	Reg$_{VKAM}$	-20	–	20	mV
V$_{KAM}$ Output Capacitor Capacitance (Note 12)	C$_{VKAM}$	–	4.7	–	μF
V$_{KAM}$ Output Capacitor ESR (Note 12)	ESR$_{VKAM}$	–	1.4	–	Ω

Notes
12. Recommended value.

STATIC ELECTRICAL CHARACTERISTICS (continued)

Characteristics noted under conditions 9.0 V $\leq$ V$_{PWR}$ $\leq$ 16 V, -40°C $\leq$ T$_J$ = T$_A$ $\leq$ 125°C, using the typical application circuit (see Figure 8) unless otherwise noted. Typical values noted reflect the approximate parameter mean at T$_A$ = 25°C under nominal conditions unless otherwise noted.

Characteristic	Symbol	Min	Typ	Max	Unit
SENSOR SUPPLIES V$_{REF1}$, V$_{REF2}$					
V$_{REF}$ On-Resistance, T$_A$ = -40°C I$_{VREF}$ = 200 mA, I$_{VDDH}$ = 200 mA, V$_{PWR}$ = KA_V$_{PWR}$ = 14 V, EN = 5.0 V	R$_{DS(on)}$	–	–	280	mΩ
V$_{REF}$ On-Resistance, T$_A$ = +25°C I$_{VREF}$ = 200 mA, I$_{VDDH}$ = 200 mA, V$_{PWR}$ = KA_V$_{PWR}$ = 14 V, EN = 5.0 V	R$_{DS(on)}$	–	–	350	mΩ
V$_{REF}$ On-Resistance, T$_A$ = +125°C I$_{VREF}$ = 200 mA, I$_{VDDH}$ = 200 mA, V$_{PWR}$ = KA_V$_{PWR}$ = 14 V, EN = 5.0 V	R$_{DS(on)}$	–	–	455	mΩ
V$_{REF}$ Short-to-Battery Detect Current V$_{PWR}$ = KA_V$_{PWR}$ = 14 V, EN = 5.0 V, SNSEN = 5.0 V	I$_{SC\_Bat}$	500	–	900	mA
V$_{REF}$ Short-to-Ground Detect Current V$_{PWR}$ = KA_V$_{PWR}$ = 14 V, EN = 5.0 V, SNSEN = 5.0 V	I$_{SC\_Gnd}$	500	–	900	mA
Maximum Output Capacitance (Total) (Note 13)	C$_{VREF}$	33	–	39	nF
SUPERVISORY CIRCUITS					
PWROK Undervoltage Threshold on V$_{DDL}$, FBL Ramps Down V$_{PWR}$ = KA_V$_{PWR}$ = 14 V, I$_{VDDH}$ = 200 mA	V$_{FBL(thL)}$	2.6	–	3.1	V
PWROK Undervoltage Threshold on V$_{DDH}$ V$_{PWR}$ = KA_V$_{PWR}$ = 14 V, I$_{VDDH}$ = 200 mA	V$_{DDH(thL)}$	4.5	–	4.8	V
V$_{DDH}$ Overvoltage Threshold V$_{PWR}$ = KA_V$_{PWR}$ = 10 V, I$_{VDDH}$ = 200 mA	V$_{DDH(thH)}$	5.12	–	5.7	V
PWROK Open Drain On-Resistance V$_{PWR}$ = KA_V$_{PWR}$ = 14 V, EN = 5 V, I$_{PwrOK}$ = 5.0 mA	R$_{DS(on)}$	–	–	200	Ω
VKAMOK Threshold, V$_{PWR}$ = KA_V$_{PWR}$ = 14 V, I$_{VDDH}$ = 200 mA	V$_{KAM(thL)}$	0.9	–	1.9	V
VKAMOK Threshold on V$_{PWR}$, V$_{PWR}$ Ramps Up KA_V$_{PWR}$ = 14 V, I$_{VDDH}$ = 200 mA	V$_{PWRok(th)}$	4.0	–	5.0	V
VKAMOK Open Drain On-Resistance V$_{PWR}$ = KA_V$_{PWR}$ = 14 V, EN = 0 V, I$_{VKAMOK}$ = 10 mA	R$_{DS(on)}$	50	–	200	Ω
Enable Input Voltage Threshold (Pin EN)	V$_{IH}$	1.0	–	2.0	V
Enable Pull-Down Current (Pin EN), EN = 1.0 V V$_{DDH}$ to V$_{IL(min)}$	I$_{PD}$	500	–	1200	nA
Sensor Enable Input Voltage Threshold (Pin SNSEN)	V$_{IH}$	1.0	–	2.0	V
Sensor Enable Pull-Down Current (Pin SNSEN) SNSEN = 1.0 V V$_{DDH}$ to V$_{IL(min)}$	I$_{PD}$	500	–	1200	nA

Notes
13. Recommended value.

STATIC ELECTRICAL CHARACTERISTICS (continued)

Characteristics noted under conditions 9.0 V $\leq V_{PWR} \leq$ 16 V, -40°C $\leq T_J = T_A \leq$ 125°C, using the typical application circuit (see Figure 8) unless otherwise noted. Typical values noted reflect the approximate parameter mean at T_A = 25°C under nominal conditions unless otherwise noted.

Characteristic	Symbol	Min	Typ	Max	Unit
CHARGE PUMP C$_{RES}$					
Charge Pump Voltage	V_{CRES}				V
$\quad V_{PWR}$ = KA_V_{PWR} = 14 V, I_{VDDH} = 200 mA, I_{CP} = 0 μA		12	–	15	
$\quad V_{PWR}$ = KA_V_{PWR} = 14 V, I_{VDDH} = 200 mA, I_{CP} = 10 μA		12	–	15	

DYNAMIC ELECTRICAL CHARACTERISTICS

Characteristics noted under conditions 9.0 V $\leq V_{PWR} \leq$ 16 V, -40°C $\leq T_J = T_A \leq$ 125°C using the typical application circuit (see Figure 8) unless otherwise noted. Typical values noted reflect the approximate parameter mean at T_A = 25°C under nominal conditions unless otherwise noted.

Characteristic	Symbol	Min	Typ	Max	Unit
BUCK REGULATOR V$_{DDH}$					
Switching Frequency (Note 14)	f_{SW}	–	750	–	kHz
Soft Start Duration (see Figure 2) V$_{PWR}$ = KA_V$_{PWR}$ = 6.0 V	t_{SS}	5.0	–	15	ms
CHARGE PUMP C$_{RES}$					
Charge Pump Current Ramp-Up Time V$_{PWR}$ = KA_V$_{PWR}$ = 14 V, C$_{RES}$ = 22 nF, V$_{CP}$ = 1.0 V to 11 V	t_{CRES}	1.0	–	20	ms
Charge Pump Ramp-Up Time V$_{PWR}$ = KA_V$_{PWR}$ = 7.0 V, C$_{RES}$ = 22 nF, V$_{CP}$ = 7.0 V to 10 V	t_{CRES}	1.0	–	10	ms
SENSOR SUPPLIES V$_{REF1}$, V$_{REF2}$					
V$_{REF}$ Overcurrent Detection Time (see Figure 3) V$_{REF}$ Load R$_L$ = 5.0 Ω to GND, V$_{DDH}$ = 5.1 V, V$_{PWR}$ = KA_V$_{PWR}$ = 10 V, EN = 5.0 V, SNSEN = 5.0 V	t_{Det}	0.5	–	2.0	μs
V$_{REF}$ Retry Timer Delay (see Figure 3) V$_{REF}$ Load R$_L$ = 5.0 Ω to GND, V$_{DDH}$ = 5.1 V, V$_{PWR}$ = KA_V$_{PWR}$ = 10 V, EN = 5.0 V, SNSEN = 5.0 V	t_{Ret}	5.0	–	20	ms
SUPERVISORY CIRCUITS					
PWROK Delay Time (Power-On Reset) (see Figure 4)	$t_{D(PWROK)}$	5.0	–	15	ms
VKAMOK Delay Time (see Figure 5)	$t_{D(VKAMOK)}$	10	–	30	ms
V$_{DDH}$ Power-Up Delay Time (see Figure 6)	$t_{D(VPWR)}$	1.0	–	10	ms
Fault-Off Timer Delay Time (see Figure 7)	t_{Fault}	1.0	–	10	ms

Notes

14. Guaranteed by design but not production tested.

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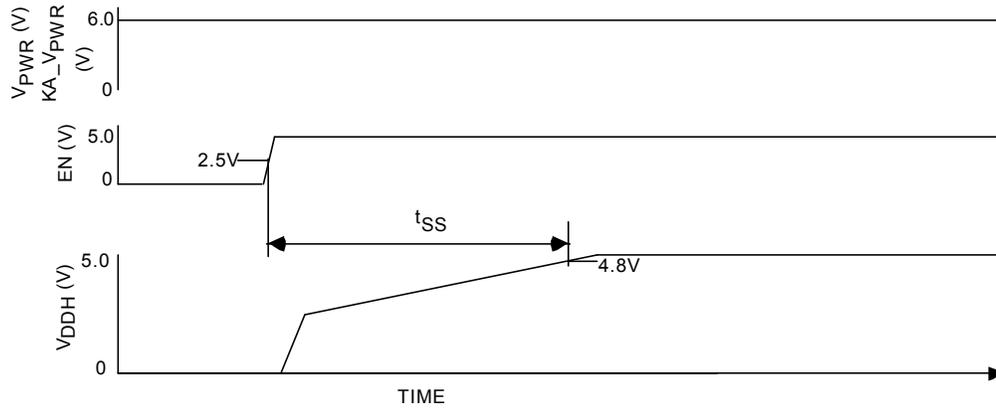
Timing Diagrams

Figure 2. Soft-Start Time
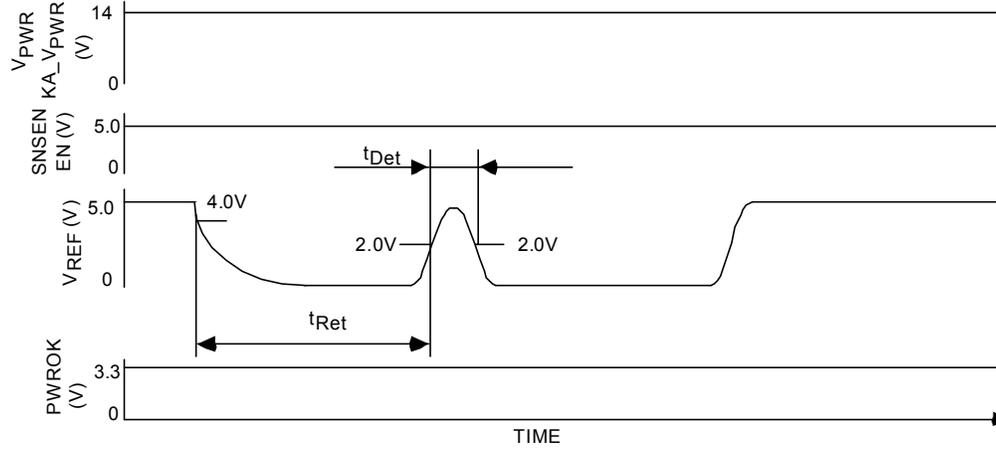
Figure 3. V$_{REF}$ Retry Timer
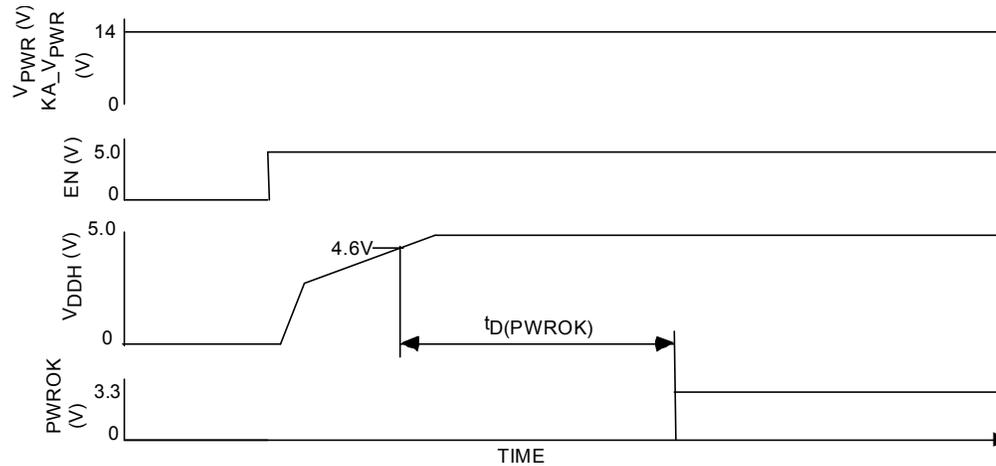
Figure 4. PWROK Delay Timer (Power-On Reset)

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Timing Diagrams (continued)
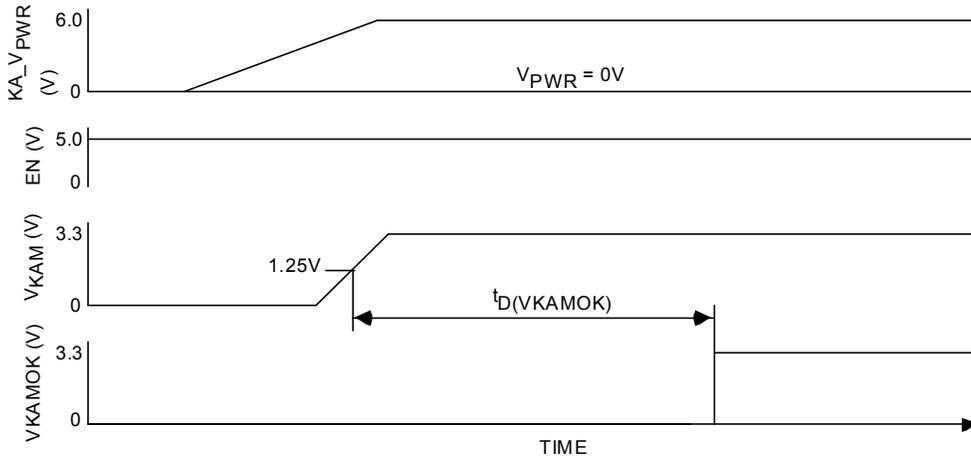
Figure 5. VKAMOK Delay Time
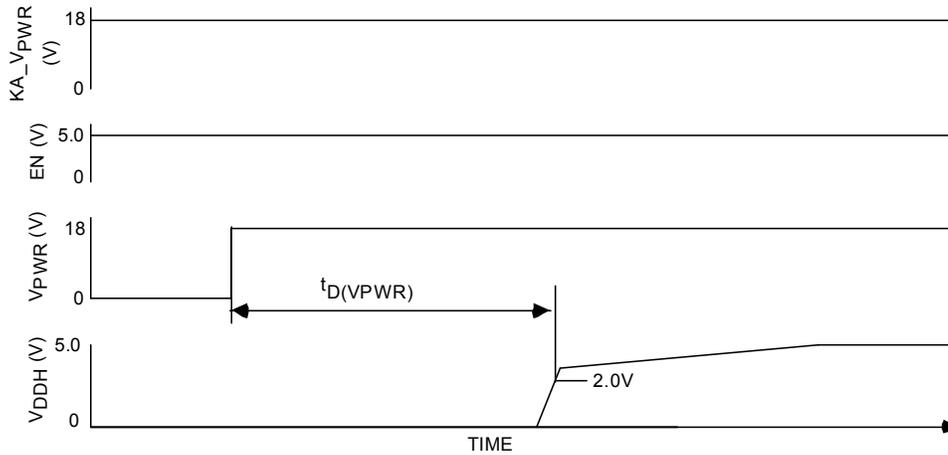
Figure 6. V$_{DDH}$ Power-Up Delay Time
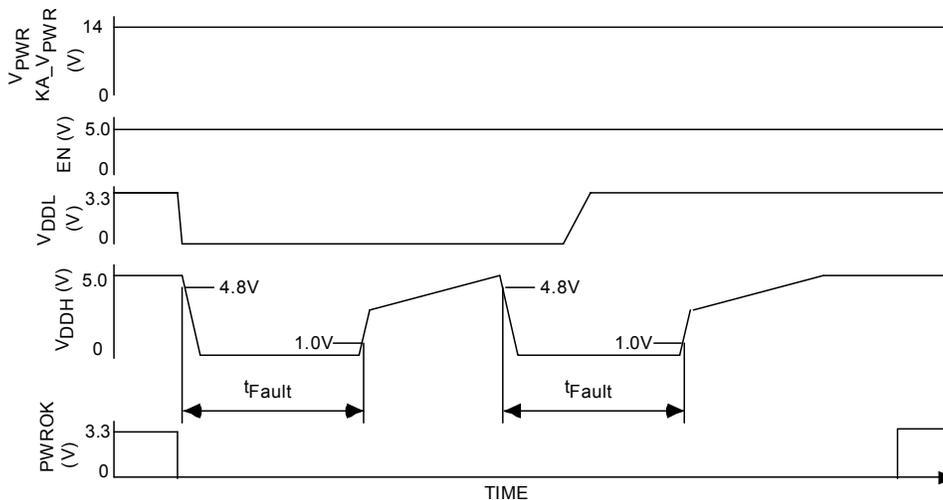
Figure 7. Fault-Off Timer Delay Time

MOTOROLA ANALOG INTEGRATED CIRCUIT DEVICE DATA

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SYSTEM/APPLICATION INFORMATION

INTRODUCTION

The 33997 multi-output power supply integrated circuit is capable of operating from 6.0 V up to 26.5 V with 40 V transient capability. It incorporates a step-down switching controller regulating directly to 5.0 V. The 3.3 V linear regulator uses an external pass transistor, thus reducing the power dissipation of the integrated circuit. The 33997 also provides a 3.3 V linear standby regulator and two 5.0 V sensor supply outputs protected by internal low-resistance LDMOS transistors against short-to-battery and short-to-ground.

FUNCTIONAL PIN DESCRIPTION

Switching Regulator V$_{DDH}$

The switching regulator is a high-frequency (750 kHz), conventional buck converter with integrated high-side p-channel power MOSFET. Its output voltage is regulated to provide 5.0 V with ±2% accuracy and it is intended to directly power the digital and analog circuits of the Electronic Control Module (ECM). The switching regulator output is rated for 1400 mA total output current. This current can be used by the linear regulator V$_{DDL}$ and sensor supplies V$_{REF1}$ and V$_{REF2}$. The 33997 switching controller utilizes "Sensorless Current Mode Control" to achieve good line rejection and stabilize the feedback loop. A soft-start feature is incorporated into the 33997. When the device is enabled, the switching regulator output voltage V$_{DDH}$ ramps up to about half of full scale and then takes 16 steps up to the nominal regulation voltage level (5.0 V nominal).

3.3 V Linear Regulator V$_{DDL}$

The 3.3 V linear post-regulator is powered from the 5.0 V switching regulator output (V$_{DDH}$). A discrete pass transistor is used to the power path for the V$_{DDL}$ regulator. This arrangement minimizes the power dissipation off the controller IC. The FBL pin is the feedback input of the regulator control loop and the DRVL pin the external NPN pass transistor base drive. Power up, power down, and fault management are coordinated with the 5.0 V switching regulator.

Sensor Supplies V$_{REF1}$ and V$_{REF2}$

The sensor supplies are implemented using a protected switch to the main 5.0 V (switching regulator) output. The 33997 integrated circuit provides two low-resistance LDMOS power MOSFETs connected to the switching regulator output (V$_{DDH}$). These switches have short-to-battery and short-to-ground protection integrated into the IC. When a severe fault conditions is detected, the affected sensor output is turned off and the sensor Retry Timer starts to time out. After the Retry Timer expires, the sensor supply tries to power up again. Sensor supplies V$_{REF}$ can be disabled by pulling the Sensor Enable SNSEN pin low (see Figure 7 for the V$_{REF}$ Retry Timer operation).

Notes: Severe fault conditions on the V$_{REF1}$ and V$_{REF2}$ outputs, like hard shorts to either ground or battery, may disrupt the operation of the main regulator V$_{DDH}$. Shorts to battery above 17 V are considered "double faults" and neither one of the V$_{REF}$ outputs is protected against such conditions.

Depending on the V$_{DDH}$ capacitor value and its ESR value, the severity of the short may disrupt the V$_{DDH}$ operation.

Keep-Alive (Standby) Regulator V$_{KAM}$

The Keep-Alive Regulator V$_{KAM}$ (keep-alive memory) is intended to provide power for "key off" functions such as nonvolatile SRAM, "KeyOff" timers and controls, KeySwitch monitor circuits, and perhaps a CAN/SCP monitor and wake-up function. It may also power other low-current circuits required during a "KeyOff" condition. The regulated voltage is nominally 3.3 V. A severe fault condition on the V$_{KAM}$ output is signaled by pulling the VKAMOK signal low.

V$_{KAM}$ Keep-Alive Operation (Standby, Power-Down Mode)

When the EN pin is pulled low, the power supply is forced into a low-current standby mode. In order to reduce current drawn by the V$_{PWR}$ and KA_V$_{PWR}$ pins, all power supply functions are disabled except for the V$_{KAM}$ and Enable (EN) pins. The latter pin is monitored for the "wake-up" signal. The switching transistor gate is actively disabled and the V$_{DDL}$ and V$_{DDH}$ pins are actively pulled low.

Power-Up Delay Timers

Two Power-Up Delay timers are integrated into the control section of the integrated circuit. One timer monitors the input voltage at the V$_{PWR}$ input pin (see Figure 3), and the other monitors the input voltage at the KA_V$_{PWR}$ input pin. In both cases, sufficient supply voltage must be present long enough for the timers to "time out" before the switching regulator can be enabled.

Fault-Off Timer

If the V$_{DDL}$ output voltage does not reach its valid range at the end of soft-start period, or if the V$_{DDH}$ or V$_{DDL}$ output voltage gets below its PWROK threshold level, the Fault-Off Timer shuts the switching regulator off until the timer "times out" and the switching regulator retries to power up again (see Figure 7 for Fault-Off Timer operation details).

Power-On Reset Timer

This timer starts to time out at the end of the soft-start period if the V_{DDH} and V_{DDL} outputs are in the valid regulation range. If the timer "times out", then the open-drain PWROK signal is released, indicating that "power is ON".

Supervisory Circuits PWROK and VKAMOK

The 33997 has two voltage monitoring open-drain outputs, the PWROK and the VKAMOK pins. PWROK is "active high". This output is pulled low when either of the regulator outputs (V_{DDH} or V_{DDL}) are below their regulation windows. If both regulator outputs are above their respective lower thresholds, and the Power-On Reset Timer has expired, the output driver is turned off and this pin is at high-impedance state (see Figure 6).

The VKAMOK signal indicates a severe fault condition on the keep-alive regulator output V_{KAM}. The V_{KAM} output voltage is compared to the internal bandgap reference voltage. When the V_{KAM} falls below the bandgap reference voltage level, the VKAMOK signal is pulled low.

APPLICATIONS
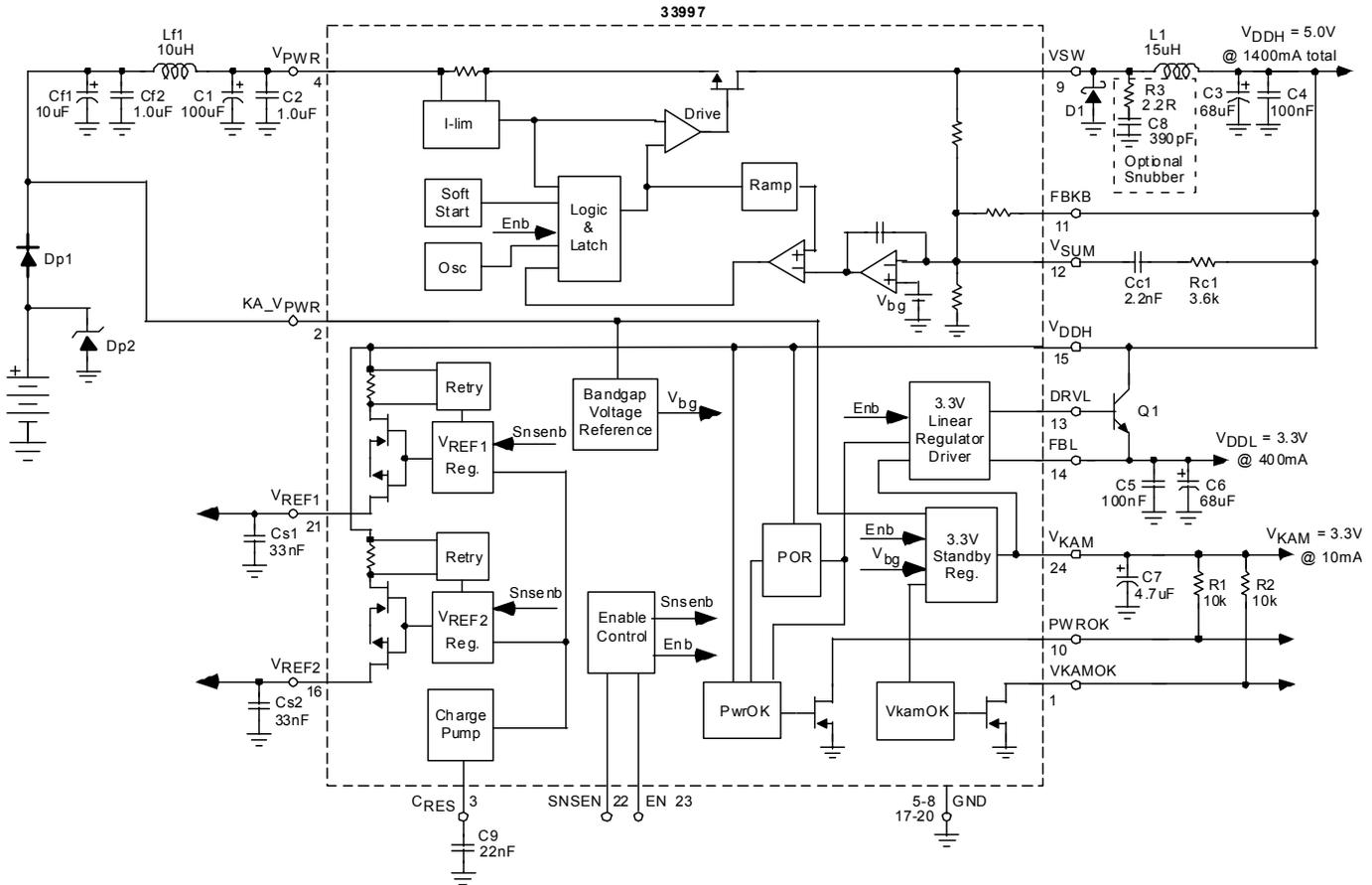
Note The V_{DDH} total output current is 1.4 A. This includes the current used by the linear regulator V_{DDL} and buffered outputs V_{REF1} and V_{REF2}.

Figure 8. 33997 Application Circuit Schematic Diagram

Table 1. Recommended Components

Designator	Value/Rating	Description/Part No.	Manufacturer (Note 16)
Cf1	10 µF/50 V	Aluminum Electrolytic/UUB1H100MNR	Nichicon
Cf2, C2	1.0 µF/50 V	Ceramic X7R/C1812C105K5RACTR	Kemet
C1	100 µF/50 V	Aluminum Electrolytic/UUH1V101MNR	Nichicon
C3 (Note 15)	68 µF/10 V	Tantalum/T494D686M010AS	Kemet
C6	68 µF/10 V	Tantalum/T494D686M010AS	Kemet
C7	4.7 µF/10 V	Tantalum/T494A475M010AS	Kemet
C4, C5	100 nF/16 V	Ceramic X7R	Any Manufacturer
C8 (Optional)	390 pF/50 V	Ceramic X7R	Any Manufacturer
C9	22 nF/25 V	Ceramic X7R	Any Manufacturer

Notes
15. It is possible to use ceramic capacitors in the switcher output, e.g. C3 = 2 x 22 µF/6.3 V X7R ceramic. In this case the compensation resistor has to be changed to Rc1 = 200 Ω to stabilize the switching regulator operation.
16. Motorola does not assume liability, endorse, or warrant components from external manufacturers that are referenced in circuit drawings or tables. While Motorola offers component recommendations in this configuration, it is the customer's responsibility to validate their application.

Designator	Value/Rating	Description/Part No.	Manufacturer (Note 17)
Cs1, Cs2	33 nF/25 V	Ceramic X7R	Any Manufacturer
Cc1	2.2 nF/16 V	Ceramic X7R	Any Manufacturer
R1, R2	10 kΩ	Resistor 0805, 5%	Any Manufacturer
R3 (Optional)	2.2 Ω	Resistor 0805, 5%	Any Manufacturer
Rc1	3.6 kΩ	Resistor 0805, 5%	Any Manufacturer
Lf1	10 µH	CDRH127-100M or SLF10145-100M2R5	Sumida TDK
L1	15 µH	CDRH127-150MC or SLF10145-150M2R2	Sumida TDK
Q1	1.0 A/20 V	Bipolar Transistor/BCP68T1	ON Semiconductor
D1	2.0 A/50 V	Schottky Diode/SS25	General Semiconductor
Dp1	3.0 A/200 V	Diode/MURS320	ON Semiconductor
Dp2	27 V	Transient Voltage Suppressor/SM5A27	General Semiconductor

Notes

17. Motorola does not assume liability, endorse, or warrant components from external manufacturers that are referenced in circuit drawings or tables. While Motorola offers component recommendations in this configuration, it is the customer's responsibility to validate their application.

PACKAGE DIMENSIONS

DW SUFFIX
24-LEAD SOIC WIDE BODY
PLASTIC PACKAGE
CASE 751E-04
ISSUE E
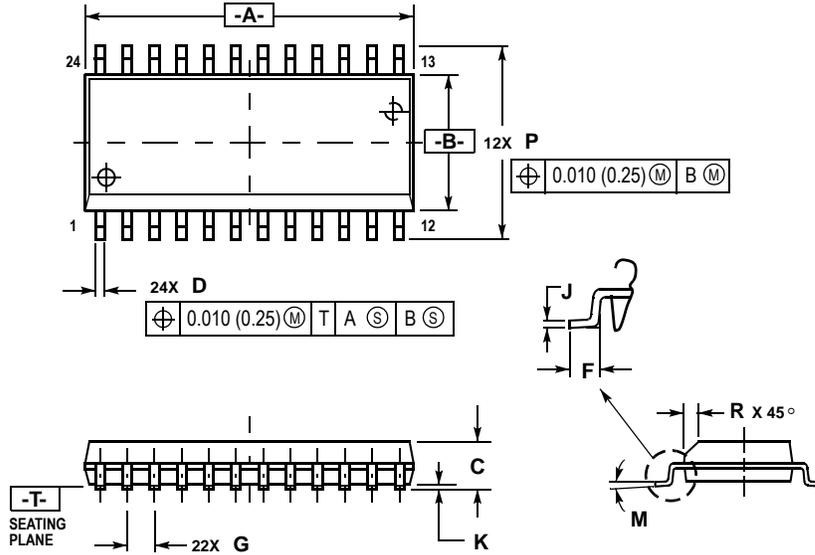
NOTES:
1. DIMENSIONING AND TOLERANCING PER ANSI Y14.5M, 1982.
2. CONTROLLING DIMENSION: MILLIMETER.
3. DIMENSIONS A AND B DO NOT INCLUDE MOLD PROTRUSION.
4. MAXIMUM MOLD PROTRUSION 0.15 (0.006) PER SIDE.
5. DIMENSION D DOES NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE DAMBAR PROTRUSION SHALL BE 0.13 (0.005) TOTAL IN EXCESS OF D DIMENSION AT MAXIMUM MATERIAL CONDITION.

0.010 (0.25) Ⓜ B Ⓜ

0.010 (0.25) Ⓜ T A Ⓢ B Ⓢ

R X 45°

DIM	MILLIMETERS		INCHES	
	MIN	MAX	MIN	MAX
A	15.25	15.54	0.601	0.612
B	7.40	7.60	0.292	0.299
C	2.35	2.65	0.093	0.104
D	0.35	0.49	0.014	0.019
F	0.41	0.90	0.016	0.035
G	1.27 BSC		0.050 BSC	
J	0.23	0.32	0.009	0.013
K	0.13	0.29	0.005	0.011
M	0°	8°	0°	8°
P	10.05	10.55	0.395	0.415
R	0.25	0.75	0.010	0.029

SEATING PLANE

Freescale Semiconductor, Inc.

NOTES

NOTES

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MC33997/D