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Contact us

Tel: +86-755-8981 8866 Fax: +86-755-8427 6832

Email & Skype: info@chipsmall.com Web: www.chipsmall.com

Address: A1208, Overseas Decoration Building, #122 Zhenhua RD., Futian, Shenzhen, China



TRIUNE PRODUCTS

Features

- Supports Qi® 1.2.2, AirFuel Inductive (PMA) and Resonant (A4WP) and proprietary wireless charging applications
- Power outputs up to 100W
- Support for single and multi-coil applications
- Support for half and full-bridge power sections
- Support for variable voltage, variable frequency and variable duty cycle architectures
- Integrated controller and flash for communications and control
- High precision data converters
- Precise control of bridge duty cycle and frequency
- Low external component count
- Product is lead-free, Halogen Free, RoHS / WEEE compliant

Description

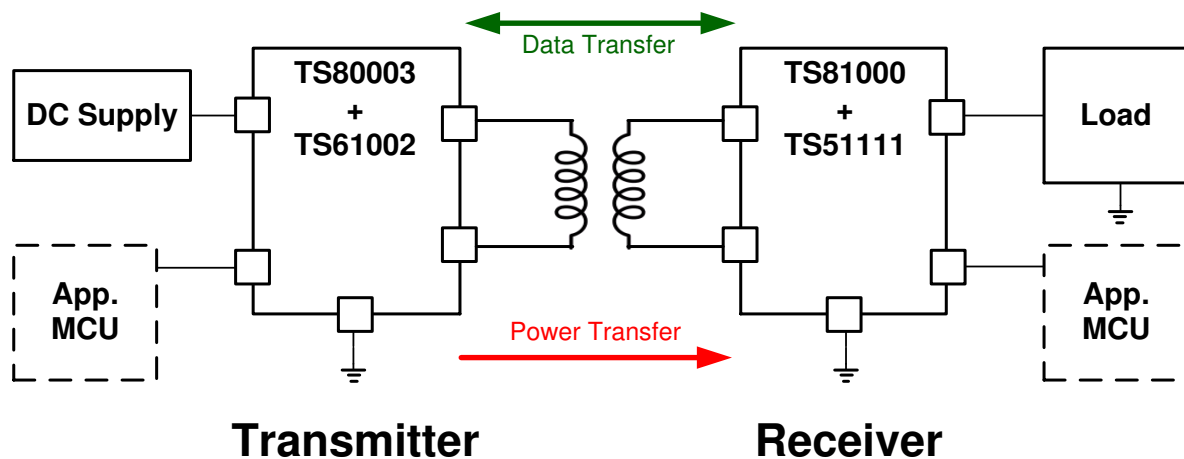
The TS80003 is a power transmitter communications and control unit for wireless charging applications. The TS80003 can support power outputs up to 100W, and supports Qi® compliant, PMA compliant, A4WP and proprietary applications. The TS80003 can be configured to drive single or multi-coil applications, in half and full-bridge systems.

The TS80003 performs the necessary decode of packets from the secondary side device and adjusts the control accordingly. An integrated PID filter provides the necessary compensation for the loop for high-precision control of duty cycle, frequency, and or bridge voltage.

Applications

- 5 / 12 / 19 / 24V single coil wireless power transmitters
- Multi-coil transmitters
- Power tool chargers
- Laptop chargers
- Wearable device chargers
- Medical applications

Typical Application Circuit



Pinout (Top View)

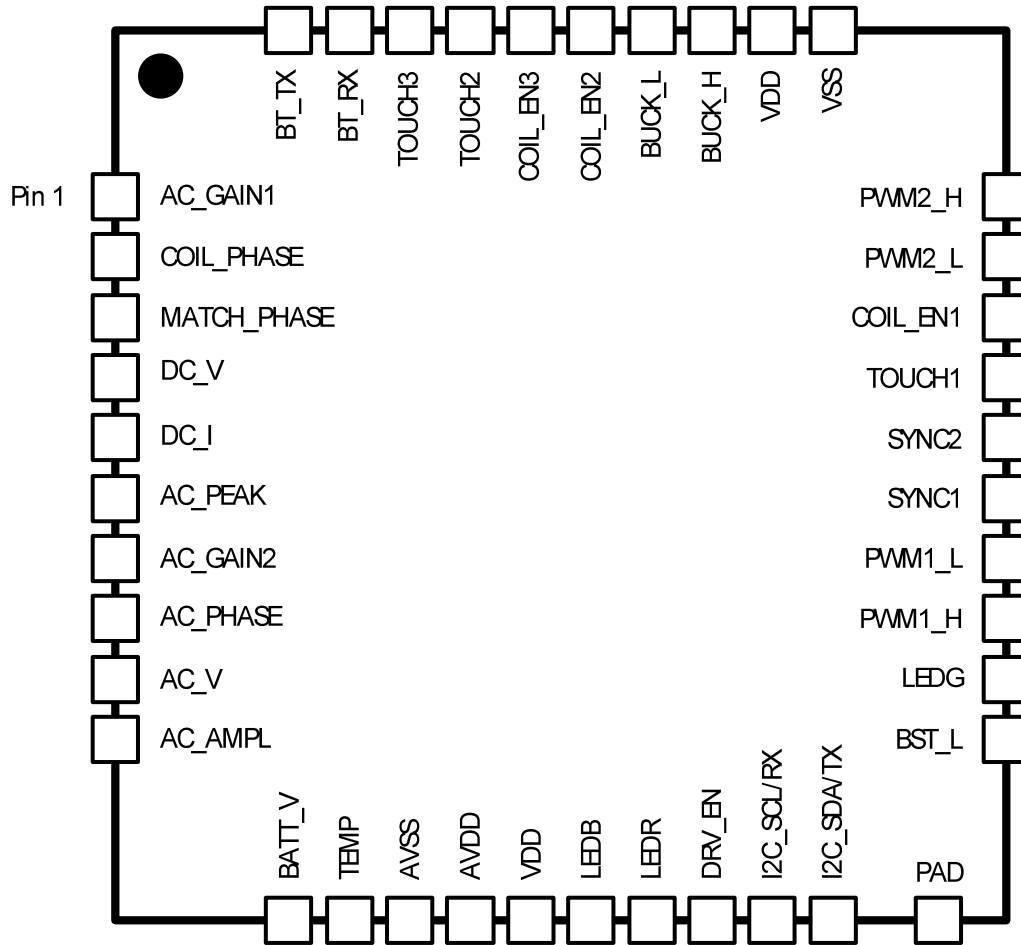


Figure 1. TS8003 Pin Configuration

Pin Description

Pin #	Pin Name	Pin Function	Description
1	AC_GAIN1	GPIO	Gain control
2	COIL_PHASE	Analog GPIO	Coil feedback
3	MATCH_PHASE	Analog GPIO	Coil feedback
4	DC_V	Analog GPIO	DC voltage measurement
5	DC_I	Analog GPIO	DC current measurement
6	AC_PEAK	Analog GPIO	Coil peak voltage measurement
7	AC_GAIN2	GPIO	Gain control
8	AC_PHASE	Analog GPIO	Coil voltage phase measurement
9	AC_V	Analog GPIO	AC coil voltage measurement
10	AC_AMPL	Analog GPIO	Coil voltage amplitude measurement
11	BATT_V	Analog GPIO	Input voltage measurement
12	TEMP	Analog GPIO	Temperature measurement
13	AVSS	Analog GND	Analog GND
14	AVDD	Analog power	Analog power supply
15	VDD	Input power	Input power supply
16	LEDB	High-current GPIO	LED Driver
17	LEDR	High-current GPIO	LED Driver
18	DRV_EN	Drive enable	FET driver enable
19	I2C_SCL/RX	I2C/UART	I2C clock or UART input
20	I2C_SDA/TX	I2C/UART	I2C data or UART output
21	BST_L	Reset	Reset
22	LEDG	High-current GPIO	LED Driver
23	PWM1_H	PWM	PWM1 high-side control
24	PWM1_L	PWM	PWM1 low-side control
25	SYNC1	GPIO	Sync signal for TS61002
26	SYNC2	GPIO	Sync signal for TS61002
27	TOUCH/BST_VSET	GPIO	Touch panel interface
28	COIL_EN1	GPIO	Coil selection for multi-coil system
29	PWM2_L	PWM	PWM2 low-side control
30	PWM2_H	PWM	PWM2 high-side control
31	VSS	Power GND	Power GND
32	VDD	Input power	Input power supply
33	BUCK_H	PWM	High-side control for Buck stage
34	BUCK_L	PWM	Low-side control for Buck stage
35	COIL_EN2	GPIO	Coil selection for multi-coil system
36	COIL_EN3	GPIO	Coil selection for multi-coil system
37	TOUCH2	GPIO	Touch panel interface
38	TOUCH3	GPIO	Touch panel interface

39	BT_RX/SWDIO	I2C/UART	I2C data or UART input
40	BT_TX/SWDCLK	I2C/UART	I2C clock or UART output
41	PAD	Thermal Pad	Thermal Pad

Functional Block Diagram

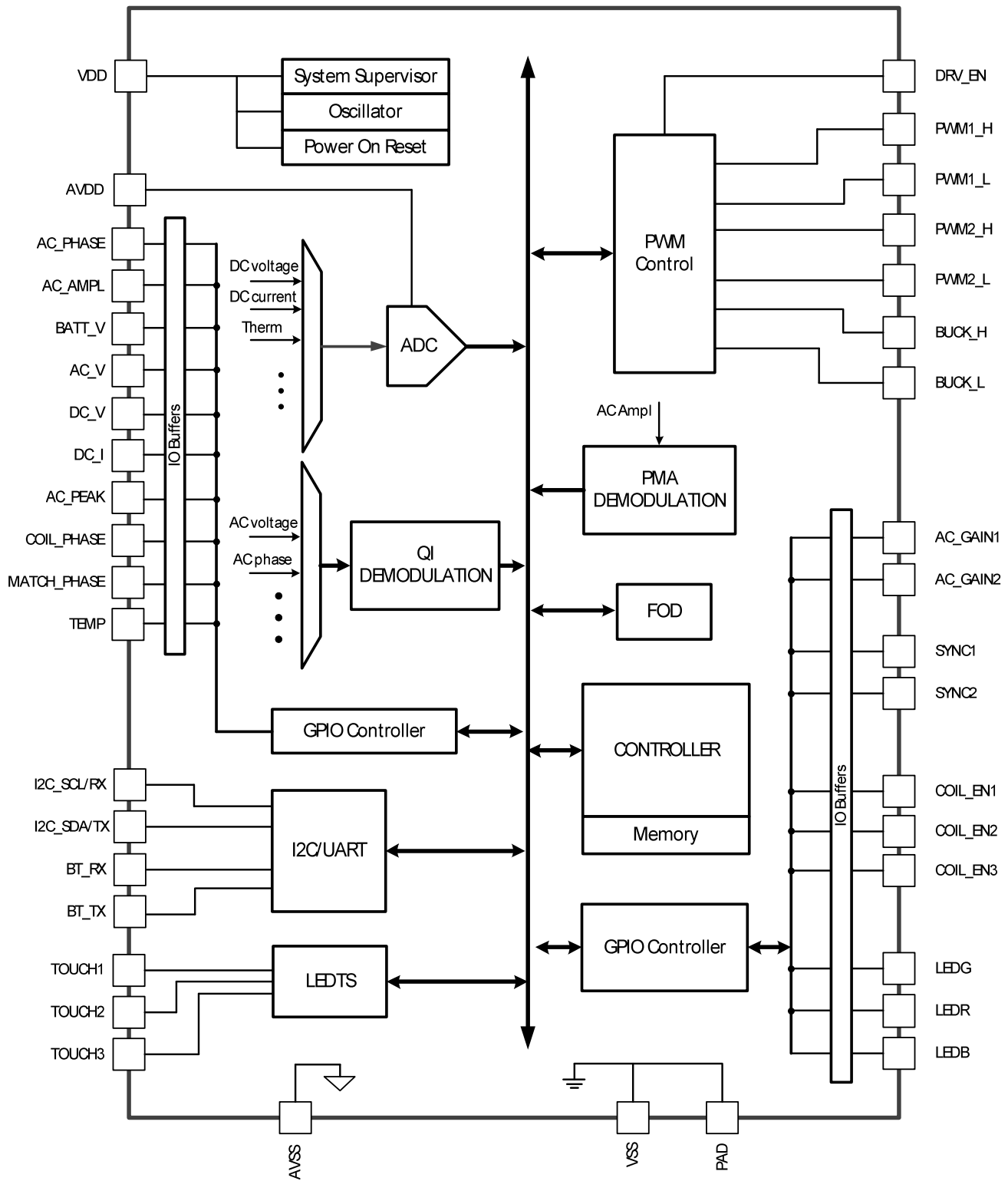


Figure 2. TS80003 Block Diagram

Specification

Absolute Maximum Ratings

Stresses above the values listed under “Absolute Maximum Ratings” may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these or any other conditions above those indicated in the operational sections of this specification is not implied. Exposure to absolute maximum rating conditions may affect device reliability.

Parameter	Min	Max	Unit	Note / Test Condition
VDD - VSS	-0.3	6.0	V	
Voltage on any pin	$V_{SS}-0.5$	$V_{DD}+0.5$ or max. 6 ⁽¹⁾	V	whichever is lower
Input current on any pin during overload condition	-10	10	mA	
Absolute sum of all input currents during overload condition	-50	50	mA	
Operating Junction Temperature Range, T_J	-40	115	°C	
Storage Temperature Range, T_{STG}	-40	125	°C	
ESD susceptibility according to Human Body Model (HBM)		2000	V	Confirming to EIA/JESD22-A114-B
ESD susceptibility according to Charged Device Model(CDM) pins		500	V	Confirming to JESD22-C101-C
Moisture sensitivity level		3		JEDEC J-STD-020D
IR reflow temperature		260	°C	Profile according to JEDEC J-STD-020D

Pin Reliability in Overload

When receiving signals from higher voltage devices, low-voltage devices experience overload currents and voltages that go beyond their own IO power supplies specification.

The follow table defines overload conditions that will not cause any negative reliability impact if all the following conditions are met:

- full operation life-time is not exceeded
- Operating Conditions are met for
 - pad supply levels (VDDP)
 - temperature

Overload Parameters

Symbol	Parameter	Min.	Typ.	Max.	Unit	Note / Test Condition
I_{OV}	Input current on any port pin during overload condition	-5	—	5	mA	
I_{OVS}	Absolute sum of all input circuit currents during overload condition	—	—	25	mA	

If a pin current is outside of the Operating Conditions but within the overload conditions, then the parameters of this pin as stated in the Operating Conditions can no longer be guaranteed. Operation is still possible in most cases but with relaxed parameters.

Note: An overload condition on one or more pins does not require a reset.

Note: A series resistor at the pin to limit the current to the maximum permitted overload current is sufficient to handle failure situations like short to battery.

Figure 3 shows the path of the input currents during overload via the ESD protection structures. The diodes against VDDP and ground are a simplified representation of these ESD protection structures.

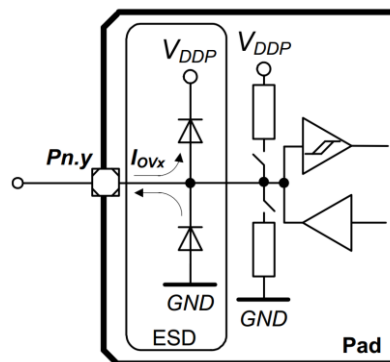


Figure 3. Input Overload Current via ESD structures

The following table lists input voltages that can be reached under overload conditions. Note that the absolute maximum input voltages as defined in the Absolute Maximum Ratings must not be exceeded during overload.

Parameter	$I_{OV} = 5 \text{ mA}, T_J = -40^\circ\text{C}$	$I_{OV} = 5 \text{ mA}, T_J = 115^\circ\text{C}$
PN-Junction Characteristics for positive overload	$V_{IN} = V_{DDP} + 0.5V$	$V_{IN} = V_{DDP} + 0.5V$
PN-Junction Characteristics for negative overload	$V_{IN} = V_{SS} - 0.5V$	$V_{IN} = V_{SS} - 0.5V$

Recommended Operating Conditions

The following operation conditions must not be exceeded in order to ensure correct operation and reliability of the TS80003. All parameters specified in the following tables refer to these operation conditions, unless noted otherwise.

Symbol	Parameter	Min.	Typ.	Max.	Unit	Note / Test Condition
T_A	Ambient Temperature	-40	—	105	°C	
V_{DDP}	Digital supply voltage	1.8	—	5.5	V	
C_{VDD}	Decoupling capacitor value		1	—	μF	
C_{AVDD}	Decoupling capacitor value	0.47	1	3.3	μF	
I_{SC}	Short circuit current of digital outputs	-5	—	5	mA	
ΣI_{SC}	Absolute sum of short circuit currents of the device	—	—	25	mA	

Detailed Description

Overview

The TS80003 wireless charge transmitter controller features all the functions necessary to implement a high-efficiency wireless charge transmitter solution. It is a new lower-cost version in comparison with the previous controller TS80000. This controller can be used in vary applications: single-coil/multi-coil configuration, wide power range (1W to 100W), wide input voltage range (5V to 24V), wide frequency range (typically 100kHz to 205kHz). The functions of TS80003 are summarized as:

- The TS80003 provides variable-frequency variable-duty-cycle variable-phase-angle half-bridge/full-bridge pulse width modulation (PWM) signals to MOSFET driver (TS61001/TS61002), so as to regulate the operation point of resonant tank and adjust the power/voltage of the receiver.
- TS80003 is also able to achieve signal demodulation and detection in compatible with Qi standard and PMA standard as well as A4WP specification.
- Besides over-temperature, over-voltage, over-current protection, TS80003 has foreign objective detection (FOD) function which can prevent damage of transmitter or receiver.
- TS80003 provides digital ping function to reduce quiescent power dissipation. The standby power loss is less than 300mW.
- TS80003 can be configured for single-coil (default) application or applications with multiple coil ($n \leq 3$) for higher power or larger misalignment.

In order to achieve the above functions, some auxiliary detection circuit, power supply and drive circuit are needed.

Coil current detection

The Power Receiver communicates to the Power Transmitter using backscatter modulation. For this purpose, the Power Receiver modulates the amount of power that it draws from the Power Signal. The Power

Transmitter detects this as a modulation of the current through and/or voltage across the Primary Cell. In other words, the Power Receiver and Power Transmitter use amplitude modulated Power Signal to provide a Power Receiver to Power Transmitter communications channel.

The Power Receiver shall modulate the amount of power that it draws from the Power Signal, such that the Primary Cell current and/or Primary Cell voltage assume two states, namely a HI state and a LO state. A state is characterized in that the amplitude is constant within a certain variation Δ for at least t_s ms. If the Power Receiver is properly aligned to the Primary Cell of a type A1 or MP-A1 Power Transmitter, and for all appropriate loads, at least one of the following three conditions shall apply:

- The difference of the amplitude of the Primary Cell current in the HI and LO state is at least 15 mA.
- The difference of the Primary Cell current in the HI and LO state is at least 15 mA. The Primary Cell current is measured at instants in time that correspond to one quarter of the cycle of the control signal driving the half-bridge inverter.
- The difference of the amplitude of the Primary Cell voltage in the HI and LO state is at least 200 mV.

The amplitude modulation of the power signal is shown in Figure 4 and the parameters are listed as below table.

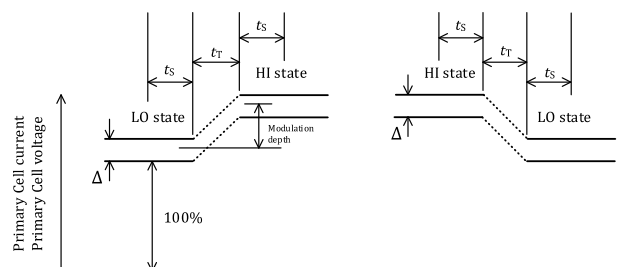


Figure 4. Amplitude modulation of the Power Signal

Parameter	Symbol	Value	Unit
Maximum transition time	t_T	100	μs
Minimum stable time	t_S	150	μs
Current amplitude variation	Δ	8	mA
Voltage amplitude variation	Δ	110	mV

The Power Receiver shall use a differential bi-phase encoding scheme to modulate data bits onto the Power Signal. For this purpose, the Power Receiver shall align each data bit to a full period t_{CLK} of an internal clock signal, such that the start of a data bit coincides with the rising edge of the clock signal. This internal clock signal shall have a frequency $f_{CLK} = 2 \pm 4\%$ kHz. A ripple on the Power Receiver's load yields a ripple on the Power Transmitter's current. As a result, such a ripple can lead to bit errors in the Power Transmitter. The number of bit errors can be particularly high if this ripple has a frequency that is close to the modulation frequency f_{CLK} . The Receiver shall encode a ONE bit using two transitions in the Power Signal, such that the first transition coincides with the rising edge of the clock signal and the second transition coincides with the falling edge of the clock signal. The Receiver shall encode a ZERO bit using a single transition in the Power Signal, which coincides with the rising edge of the clock signal. An example of a differential bi-phase encoding scheme is given in Figure 5.

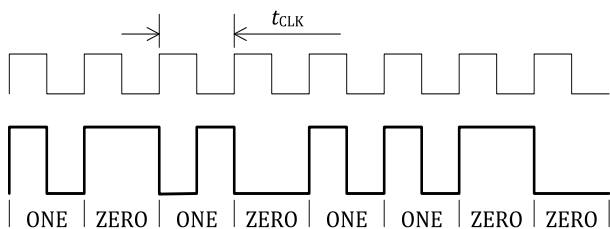


Figure 5. Example of a differential bi-phase encoding scheme

Coil current detection is necessary for QI demodulation. The message from receiver is carried with amplitude modulation (AM) from receiver coil to transmitter coil. The TS80003 samples the capacitor voltage in resonant tank and estimates the coil current. The coil current information is sent to a QI-DEMULATION unit, and the message packet is

obtained. Since the signal is amplitude modulation, the dc component is not necessary. A typical capacitor voltage detection circuit is shown in Figure 6. It acts as a band-pass filter. Only the frequency below 110kHz is removed, including the high DC voltage. Also, the high-frequency ($> 500\text{kHz}$) noise and harmonics are attenuated to make sure the sample accuracy. For different input voltage and resonant circuit, the detection circuit should be built with different parameters. Figure 4 shows an example for 19V input voltage with 5-20W output power. The resonant tank is 24uH inductor and 94nF capacitor.

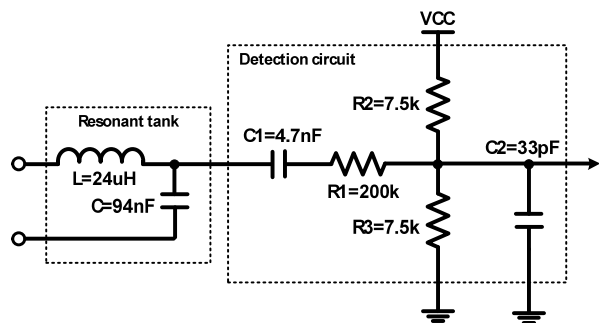


Figure 6. Coil current detection circuit for QI demodulation

Input voltage detection

The over-voltage threshold in TS80003 is 2.47V. By configuring with different voltage divider as shown in Figure 7, the maximum input voltage can be set. Also, another method is to configure the gain in TS80003 through UART communication interface. Please check interface section for details.

For example, if $R1=75\text{k}$ and $R2=10\text{k}$, the maximum input voltage is set to become 21V.

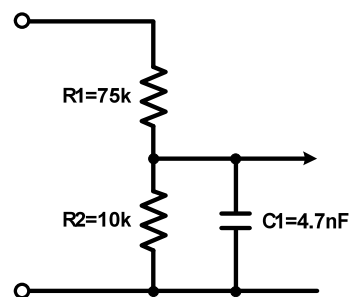


Figure 7. Input voltage detection circuit

Input current detection

The input current detection is for FOD function and over-current protection. For low-power application, it is enough to use sampling resistor and current detection amplifier. For high-power application, it is recommended to use Haul sensor to reduce power loss. The thermal co-efficient is a key parameter for selecting the components (sampling resistor, current amplifier or Haul sensor). Figure 8 shows a typical current measurement solution using current sensor amplifier TS94033. The sampling resistor can be connected to the positive side and the bias voltage should be less than 40V.

The gain of current detection can be set by choosing a different sampling resistor. Also, it is able to change the gain through UART communication with TS80003.

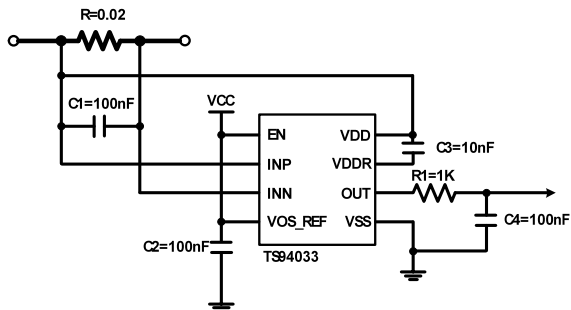


Figure 8. Input current detection circuit

Auxiliary power supply

The TS80003 is powered with 3V~5V. It requires a switching regulator or linear regulator to convert high input voltage to low voltage. An example of low-power switching regulator is shown in Figure 9. For 5V input application, the auxiliary power supply is not needed.

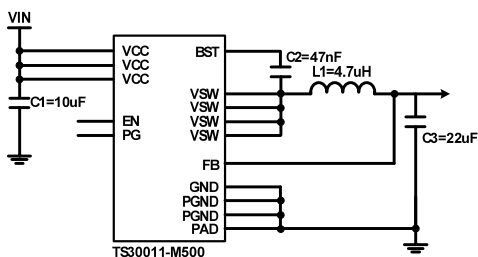


Figure 9. Auxiliary power supply for TS80003

AC amplitude voltage detection

An Air Fuel Inductive compliant Receiver uses a resistive or capacitive load modulation method for implementing the communication protocol between the Receiver and the Transmitter. These load changes on the Receiver coil are reflected on the Transmitter primary coil.

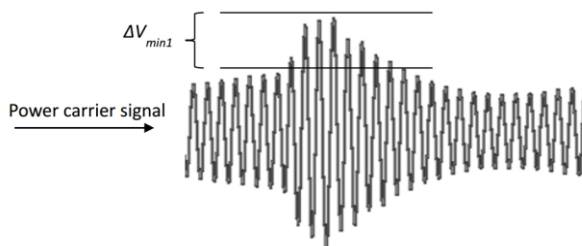


Figure 10. Transmitter – “Positive” Modulation Depth Illustration

The filtering is applied as a band-pass filter (BPF) with cutoff frequencies of 4kHz and 100kHz. The requirements will apply to amplitude noise level up to 10V and 15° respectively as long as the above conditions are met.

Spurious emissions from Transmitter device shall not exceed 0.1V on the frequency band of 200Hz-10kHz around the power carrier as measured on the primary coil (VLC).

The frequency of the peaks described above shall be interpreted by the Transmitter and classified to one of the Air Fuel Inductive communication protocol signals as described in the encoding scheme described in [N-1]. The signals shall be detected with a tolerance of $\Delta F\%_{min}$ percent on the signals designated frequency.

In order to make demodulation for PMA standard, it is required to detect the peak/amplitude current of the coil, which contains the PMA pulse signals from the receiver. A typical peak voltage detection circuit is shown in Figure 11. By changing the resistors, the gain of the peak voltage can be adjusted. For different resonant tank and input voltage, the parameters might be different to keep the voltage signal less than 3V.

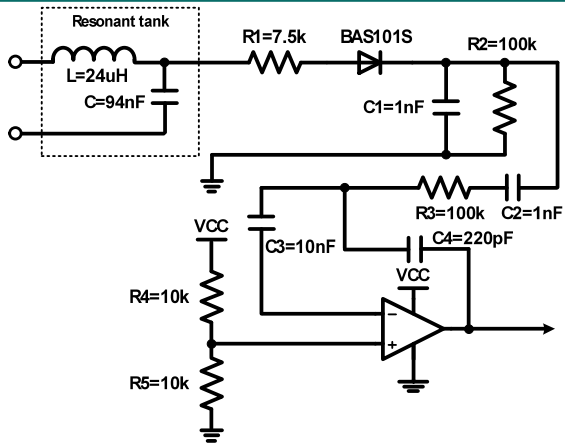


Figure 11. AC amplitude voltage detection circuit for PMA demodulation

Communication Interfaces

The Applications Processor can interrogate the TS80003 using the UART interface. The two interfaces are active at any time. Either one can be used to control, configure the TS80003, as well as read the status from the device.

I/O Pins

Pin 19 (I2C_SCL/RX) and Pin 20 (I2C_SDA/TX) are one UART interface. Pin 19 is receive line of TS80003 which should be connected to the transmission line of the application processor or PC/laptop. Pin 20 is transmission line of TS80003 which should be connected to the receive line of the application processor or PC/laptop.

Pin 39 (BT_RX) and Pin 40 (BT_TX) are one UART interface. Pin 19 is receive line of TS80003 which should be connected to the transmission line of the

application processor or PC/laptop. Pin 20 is transmission line of TS80003 which should be connected to the receive line of the application processor or PC/laptop.

UART Protocol

The TS80003 Wireless Power Transmitter Controller acts as a UART peripheral to allow communication with an application microcontroller. The packet start (8 bit) is **0xA5**. The Application MCU is a UART device and initiates every data transfer. The communication baud rate is 115200bits/s.

The TS80003 implements a set of registers available from the UART bus. It also implements a set of API functions that receive parameters and return values using the UART bus. Four transfer types are possible:

- Write Register
- Read Register
- Run API Function
- Read API Function Return Buffer

Write Register Operations

		Description
Start		Start of the UART transfer (0x7FA5 as 16-bit).
M→S	Write Command (8 bits)	Write command (0x01 as 8-bit)
M→S	Register <i>n</i> Address (8 bits)	Address of the first register.
M→S	Length of Registers (8 bits)	Length of Registers to be written
M→S	Register <i>n</i> Data (8 bits)	Write the first register.
M→S	Register <i>n+1</i> Data (8 bits)	Optionally write the following registers.
	...	
M→S	Register <i>n+k</i> Data (8 bits)	
M→S	CRC	Checksum from Start to Register <i>n+k</i> Data
Stop		Stop of the UART transfer (0xFF as 8-bit).

Read Register Operations

		Description
Start		Start of the UART transfer (0x7FA5 as 16-bit).
M→S	Read Command (8 bits)	Read command (0x00 as 8-bit)
M→S	Register n Address (8 bits)	Address of the first register.
M→S	Length of Registers (8 bits)	Length to be read
M→S	CRC	Checksum from Start to Length of Registers
Stop		Stop of the UART transfer (0xFF as 8-bit).
Start		Start of the UART transfer (0x7FA5 as 16-bit).
S→M	Read Command (8 bits)	Read command (0x00 as 8-bit)
S→M	Register n Address (8 bits)	Address of the first register.
S→M	Length of Registers (8 bits)	Length of Registers to be read
S→M	Register n Data (8 bits)	Read the first register.
S→M	Register $n+1$ Data (8 bits)	Optionally read the following registers.
	...	
S→M	Register $n+k$ Data (8 bits)	
S→M	CRC	Checksum from Start to Register $n+k$ Data
Stop		Stop of the UART transfer (0xFF as 8-bit).

Run API Function

		Description
Start		Start of the UART transfer (0x7FA5 as 16-bit).
M→S	Run API Function Command (8 bits)	Run API function command (0x02 as 8-bit)
M→S	API number (8 bits)	API number.
M→S	API input buffer length m (8 bits)	API input buffer length. Equal to 0 if no input buffer data is required by the API.
M→S	Input buffer data[0] (8 bits)	First byte of the input buffer (optional).
M→S	Input buffer data[1] (8 bits)	Second byte of the input buffer (optional).
	...	
M→S	Input buffer data[$m-1$] (8 bits)	Last byte of the input buffer (optional).
M→S	CRC	Checksum from Start to Input buffer data[$m-1$]
Stop		Stop of the UART transfer (0xFF as 8-bit) and execute the API function.

Read API Function Return Buffer

		Description
Start		Start of the UART transfer (0x7FA5 as 16-bit).
M→S	Read API Function Command (8 bits)	Read command (0x03 as 8-bit)
M→S	API number (8 bits)	Address of the first register.
M→S	CRC	Checksum from Start to API number
Stop		Stop of the UART transfer (0xFF as 8-bit).
Start		Start of the UART transfer (0x7FA5 as 16-bit).
S→M	Read API Function Command (8 bits)	Read API function command (0x03 as 8-bit)
S→M	API number (8 bits)	API number for the following return buffer.
S→M	API return buffer length n (8 bits)	API return buffer length.
S→M	Output buffer data[0] (8 bits)	Read the first byte in the output buffer.
S→M	Output buffer data[1] (8 bits)	Optionally read the following bytes.
	...	
S→M	Output buffer data[$n-1$] (8 bits)	Optionally read the last byte.
S→M	CRC	Checksum from Start to Output buffer data[$n-1$]
Stop		Stop of the UART transfer (0xFF as 8-bit).

Internal Registers

The information of the internal registers is listed in the table, including the address, the name, the type, the access mode and description. For more details about the registers, please check the TS80000/TS80003 Embedded Communication Guide on Semtech Website (www.semtech.com/wireless-charging).

Address	Name	Type	Access Mode (bits)	Description
General Registers				
0x00	BOOTFW_REV_L	R	8 / 16	Bootloader Firmware Revision (L)
0x01	BOOTFW_REV_H	R		Bootloader Firmware Revision (H)
0x02	FW_REV_L	R	8 / 16	Firmware Revision (L)
0x03	FW_REV_H	R		Firmware Revision (H)
0x04	MODE_L	R	8 / 16	Operating Mode (L)
0x05	MODE_H	R		Operating Mode (H)
0x06	RESET_L	R/W	8 / 16	Reset Register (L)
0x07	RESET_H	R/W		Reset Register (H)
0x08	STATUS0	R	8	Status0 Register
0x09	STATUS1	R	8	Status1 Register
0x0A	STATUS2	R	8	Status2 Register
0x0B	STATUS3	R	8	Status3 Register
0x0C	RESERVED			
Bootloader Mode				
0x0D	BLOCK_SIZE	R	8	Block Size
0x0E	FW_SIZE_L	R	8 / 16	Firmware Size (L)
0x0F	FW_SIZE_H	R		Firmware Size (H)
0x10	CONFIG_SIZE_L	R	8 / 16	Configuration Size (L)
0x11	CONFIG_SIZE_H	R		Configuration Size (H)
0x12	CALIBRATION_SIZE_L	R	8 / 16	Calibration Size (L)
0x13	CALIBRATION_SIZE_H	R		Calibration Size (H)
0x14	FW_FLAGS_L	R	8 / 16	Firmware Flags (L)
0x15	FW_FLAGS_H	R		Firmware Flags (H)
0x16-0x7F	RESERVED			
Transmitter Mode				
0x0D	CHANNEL_COUNT	R	8	Channel Count
0x0E	CHANNEL_SELECT	R/W	8	Channel Selection Register
0x0F	COIL_COUNT	R	8	Coil Count
0x10	FREQ_MIN_LIMIT_L	R/W	16	Limit for the Minimum Frequency (L)
0x11	FREQ_MIN_LIMIT_H	R/W		Limit for the Minimum Frequency (H)
0x12	FREQ_MAX_LIMIT_L	R/W	16	Limit for the Maximum Frequency (L)
0x13	FREQ_MAX_LIMIT_H	R/W		Limit for the Maximum Frequency (H)
0x14	DC_CURRENT_LIMIT_L	R/W	16	DC Current Limit (L)
0x15	DC_CURRENT_LIMIT_H	R/W		DC Current Limit (H)
0x16	AC_VOLTAGE_LIMIT_L	R/W	16	AC Voltage Limit (L)
0x17	AC_VOLTAGE_LIMIT_H	R/W		AC Voltage Limit (H)
0x18	TEMP_COIL_LIMIT_L	R/W	16	Coil Temperature Limit (L)
0x19	TEMP_COIL_LIMIT_H	R/W		Coil Temperature Limit (H)
0x1A	TEMP_DIE_LIMIT_L	R/W	16	Die Temperature Limit (L)
0x1B	TEMP_DIE_LIMIT_H	R/W		Die Temperature Limit (H)
0x1C	FAN_TEMP_MIN	R/W	8	Minimum Temperature for Fan Control
0x1D	FAN_TEMP_MAX	R/W	8	Maximum Temperature for Fan Control
0x1E	FAN_DTC_MIN	R/W	8	Minimum Duty Cycle for Fan Control
0x1F	FAN_DTC_MAX	R/W	8	Maximum Duty Cycle for Fan Control
0x20	SUPPORTED_STANDARDS	R/W	8	Supported Standards
0x21	MAX_POWER_WPC	R/W	8	Maximum Power in WPC Mode
0x22	MAX_POWER_PMA	R/W	8	Maximum Power in PMA Mode

0x23	MAX_POWER_A4WP	R/W	8	Maximum Power in A4WP Mode
0x24-0x3F	RESERVED			
0x40	ACTIVE_COIL	R	8	Active Coil
0x41	POWER_STATE_TX	R	8	Transmitter Power State
0x42	STANDARD	R	8	Wireless Power Standard
0x43	POWER_LEVEL	R	8	Power Level
0x44	FOD_TYPE	R	8	Foreign Object Detection Type
0x45	POWER_STATE_RX	R	8	Receiver Power State
0x46	PWM_FREQUENCY_L	R	16	PWM Frequency (L)
0x47	PWM_FREQUENCY_H	R		PWM Frequency (H)
0x48	PWM_DTC_L	R	16	PWM Duty Cycle (L)
0x49	PWM_DTC_H	R		PWM Duty Cycle (H)
0x4A	DC_VOLTAGE_L	R	16	Bridge DC Voltage (L)
0x4B	DC_VOLTAGE_H	R		Bridge DC Voltage (H)
0x4C	DC_CURRENT_L	R	16	Bridge DC Current (L)
0x4D	DC_CURRENT_H	R		Bridge DC Current (H)
0x4E	AC_VOLTAGE_L	R	16	Coil AC voltage (L)
0x4F	AC_VOLTAGE_H	R		Coil AC Voltage (H)
0x50	AC_CURRENT_L	R	16	Coil AC Current (L)
0x51	AC_CURRENT_H	R		Coil AC Current (H)
0x52	TEMP_COIL_L	R	16	Temperature at the Coil Thermistor (L)
0x53	TEMP_COIL_H	R		Temperature at the Coil Thermistor (H)
0x54	TEMP_DIE_L	R	16	Die Temperature (L)
0x55	TEMP_DIE_H	R		Die Temperature (H)
0x56	POWER_DC_IN_L	R	16	DC Power at the Bridge Input (L)
0x57	POWER_DC_IN_H	R		DC Power at the Bridge Input (H)
0x58	POWER_TX_L	R	16	TX Power into the Magnetic Field (L)
0x59	POWER_TX_H	R		TX Power into the Magnetic Field (H)
0x5A	POWER_RX_L	R	16	Received Power Reported by the RX (L)
0x5B	POWER_RX_H	R		Received Power Reported by the RX (H)
0x5C	BATT_CHARGE_LEVEL_RX	R	8	Receiver Battery Charge Level
0x5D	LED_STATE	R	8	LED State
0x5E	ERROR_L	R	16	Error Code and Parameter (L)
0x5F	ERROR_H	R		Error Code and Parameter (H)
0x60-0x6F	RESERVED			
0x70	CONTROL_POWER_L	R/W	16	Power Control Register (L)
0x71	CONTROL_POWER_H	R/W		Power Control Register (H)
0x72	CONTROL_DEBUG_L	R/W	16	Debug Control Register (L)
0x73	CONTROL_DEBUG_H	R/W		Debug Control Register (H)
0x74	DEBUG_MASK0	R/W	8	Debug Mask Register 0
0x75	DEBUG_MASK1	R/W	8	Debug Mask Register 1
0x76	DEBUG_MASK2	R/W	8	Debug Mask Register 2
0x77	DEBUG_MASK3	R/W	8	Debug Mask Register 3
0x78	INTERRUPT_MASK0	R/W	8	Interrupt Mask Register 0
0x79	INTERRUPT_MASK1	R/W	8	Interrupt Mask Register 1
0x7A	INTERRUPT_MASK2	R/W	8	Interrupt Mask Register 2
0x7B	INTERRUPT_MASK3	R/W	8	Interrupt Mask Register 3
0x7C-0x7F	RESERVED			

API functions

The API functions are listed in the table, which includes the API number, the name and the brief description. For more details and description about the functions, please check the TS80000/TS80003 Embedded Communication Guide on Semtech Website (www.semtech.com/wireless-charging).

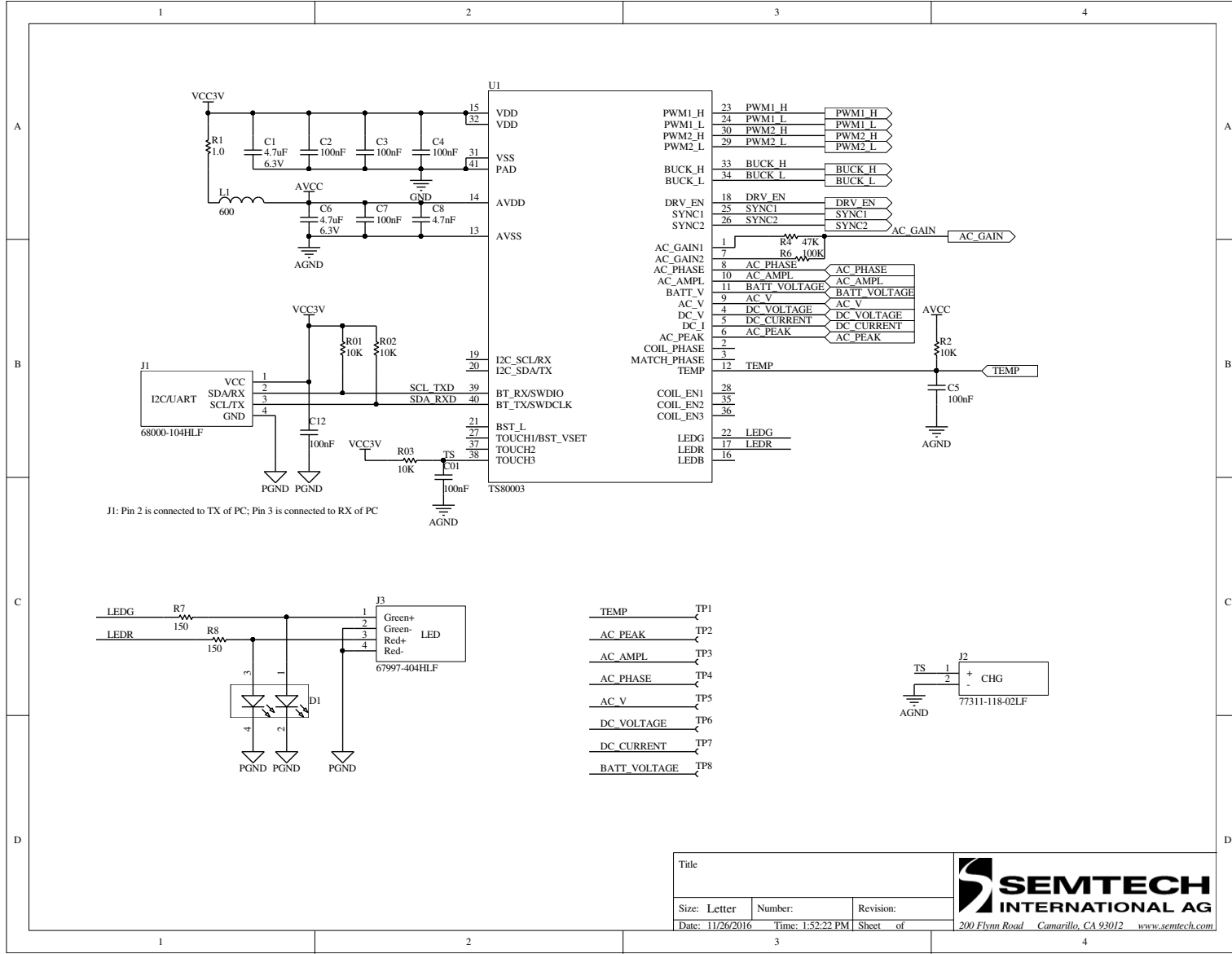
API Number	API Name	Description
0x80	BOOTLOADER_UNLOCK_FLASH	Allow changes to the FLASH memory
0x81	BOOTLOADER_WRITE_BLOCK	Write a page of the firmware into the FLASH memory
0x82	BOOTLOADER_CRC_CHECK	Check the CRC of the transmitter firmware
0x83	RESERVED	
0x84	BOOTLOADER_WRITE_CONFIGURATION	Write a page of the configuration block into the FLASH memory
0x85	BOOTLOADER_READ_CONFIGURATION	Read a page of the configuration block from the FLASH memory
0x86	BOOTLOADER_WRITE_CALIBRATION	Write a page of the calibration block into the FLASH memory
0x87	BOOTLOADER_READ_CALIBRATION	Read a page of the calibration block from the FLASH memory
0x88	BOOTLOADER_TRIM	Execute the trim procedure and store the result in FLASH memory. Used during production at Triune.
0x89	BOOTLOADER_READ_TRIM	Read the trim block from the FLASH memory. Used during production at Triune.
0x8A-0x8F	RESERVED	
0x90	WRITE_CONFIGURATION	Write to the TX channel configuration
0x91	READ_CONFIGURATION	Read from the TX channel configuration
0x92	READ_RX_CONFIG	Read the RX power contract parameters
0x93	READ_RX_ID	Read the RX ID
0x94	WRITE_TX_ID	Write the TX ID
0x95	READ_TX_ID	Read the TX ID
0x96	READ_DEBUG	Read the oldest debug block from the debug queue
0x97-0x9F	RESERVED	
0xA0	TEST_READ_MEASUREMENT	Read a measurement of one of the system signals
0xA1	TEST_CONFIGURE_BRIDGE	Configure the bridge to output a certain waveform
0xA2	TEST_CALIBRATE_FOD	Calibrate the FOD detection algorithm
0xA3-0xFE	RESERVED	
0xFF	API_ERROR	Value returned in the API field when a Read API Function Return Buffer command is issued and the API function called previously has generated an error.

API error codes

The API error codes are listed in the table, which provides the type of error and its corresponding reasons.

Error Code	Error Code Name	Description
0x00	ERROR_GENERIC	Generic error.
0x01	ERROR_OK	Operation succeeded. This is not indicating an error.
0x02	ERROR_INVALID_CRC	CRC error.
0x03	ERROR_FLASH_UNLOCK_FAILED	FLASH unlocking has failed.
0x04	ERROR_API_NOT_IMPLEMENTED	The API number is not implemented.
0x05	ERROR_API_DATA_OVERFLOW	The API input buffer has been filled with more data than its length.
0x06	ERROR_API_INVALID_PARAMETERS	At least one of the API parameters is invalid.
0x07	ERROR_FLASH_ERASE_FAILED	FLASH erase has failed.
0x08	ERROR_FLASH_PROGRAM_FAILED	FLASH programming has failed.
0x09	ERROR_API_DATA_NOT_READY	The API data is not available yet.
0x0A	ERROR_NOT_IN_TEST_MODE	The test mode is not enabled
0x0B	ERROR_BRIDGE_NOT_ACTIVE	The bridge is not active
0x0B-0xFF	RESERVED. Will be defined later.	

Application Schematic

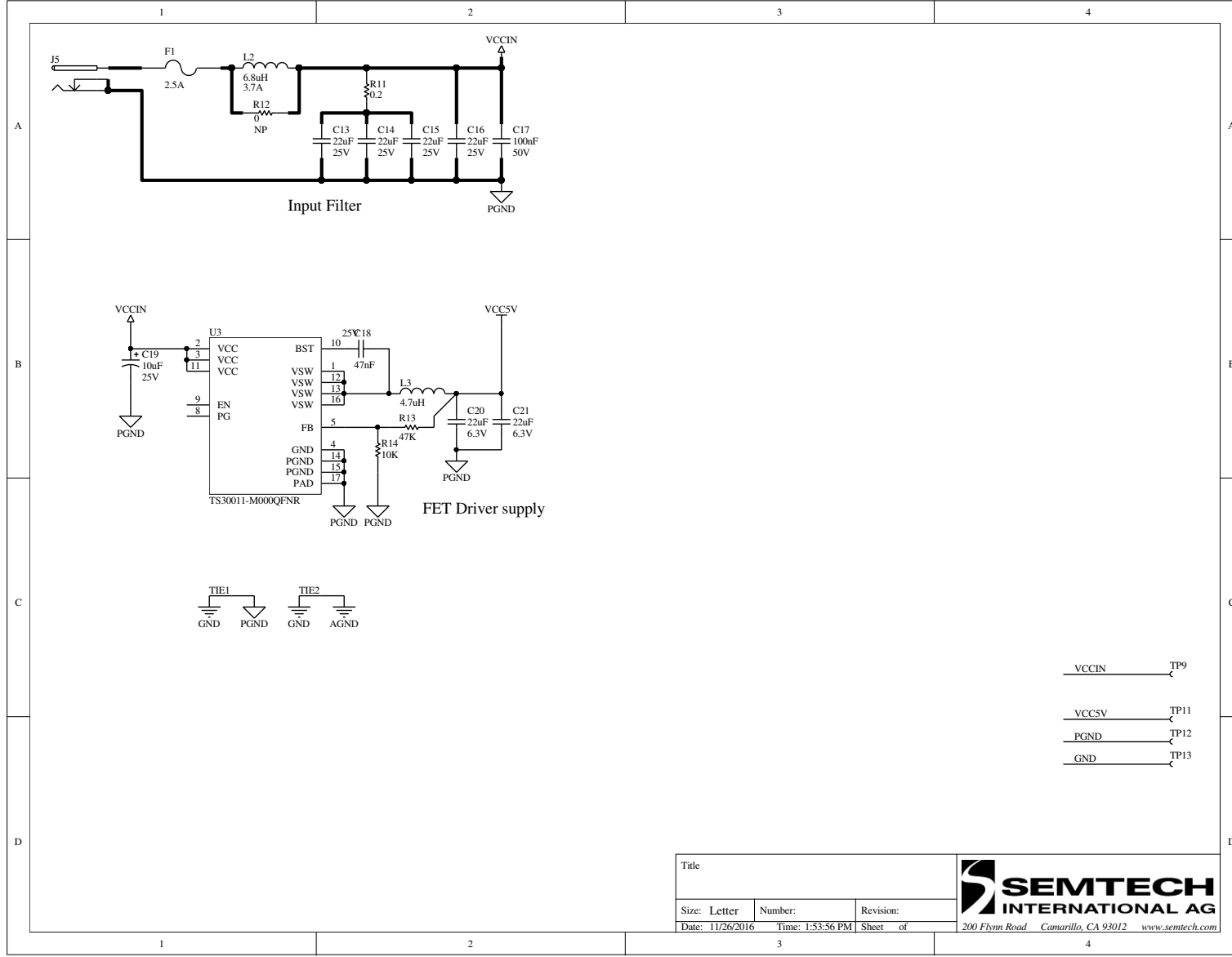


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Application Schematic (continued)

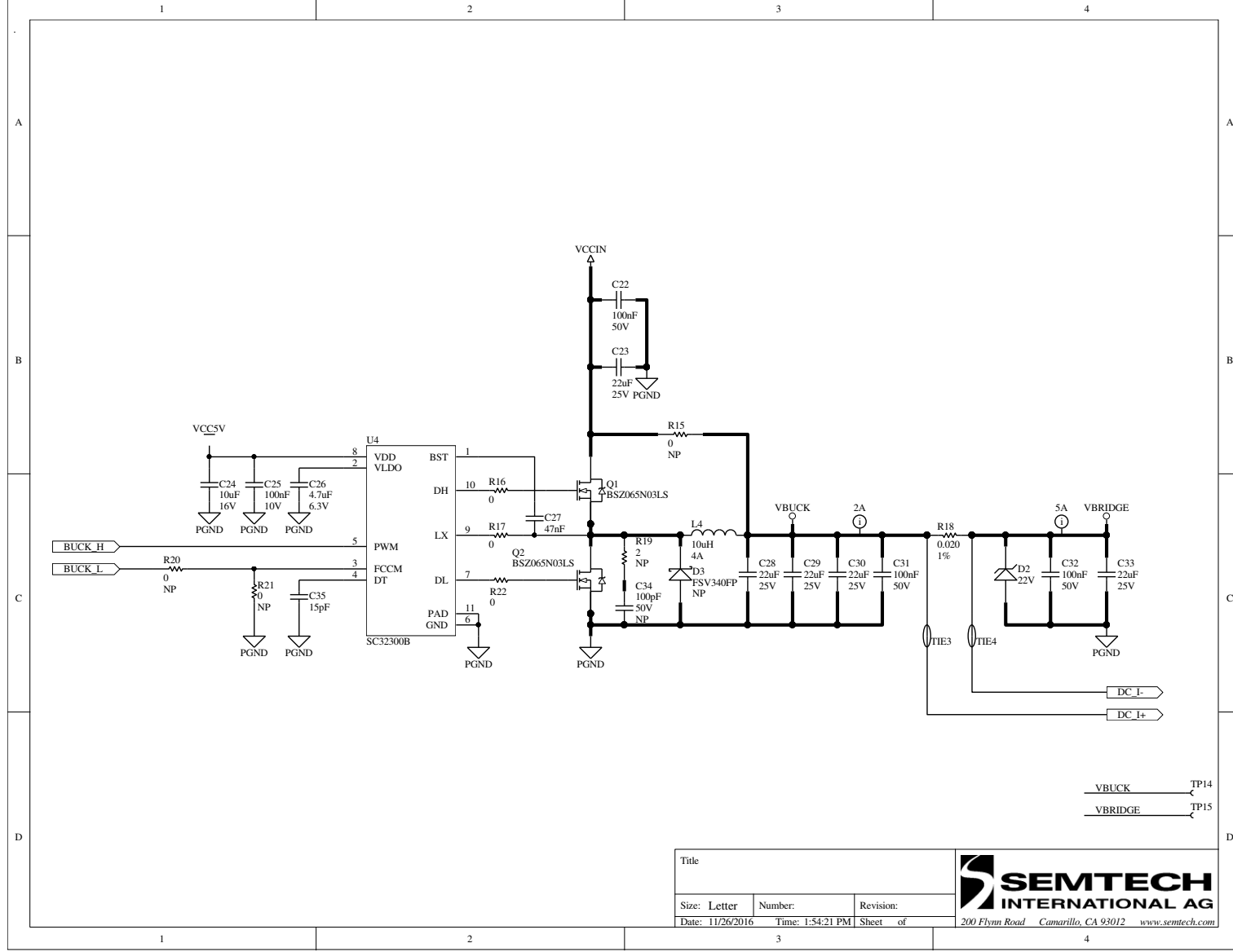


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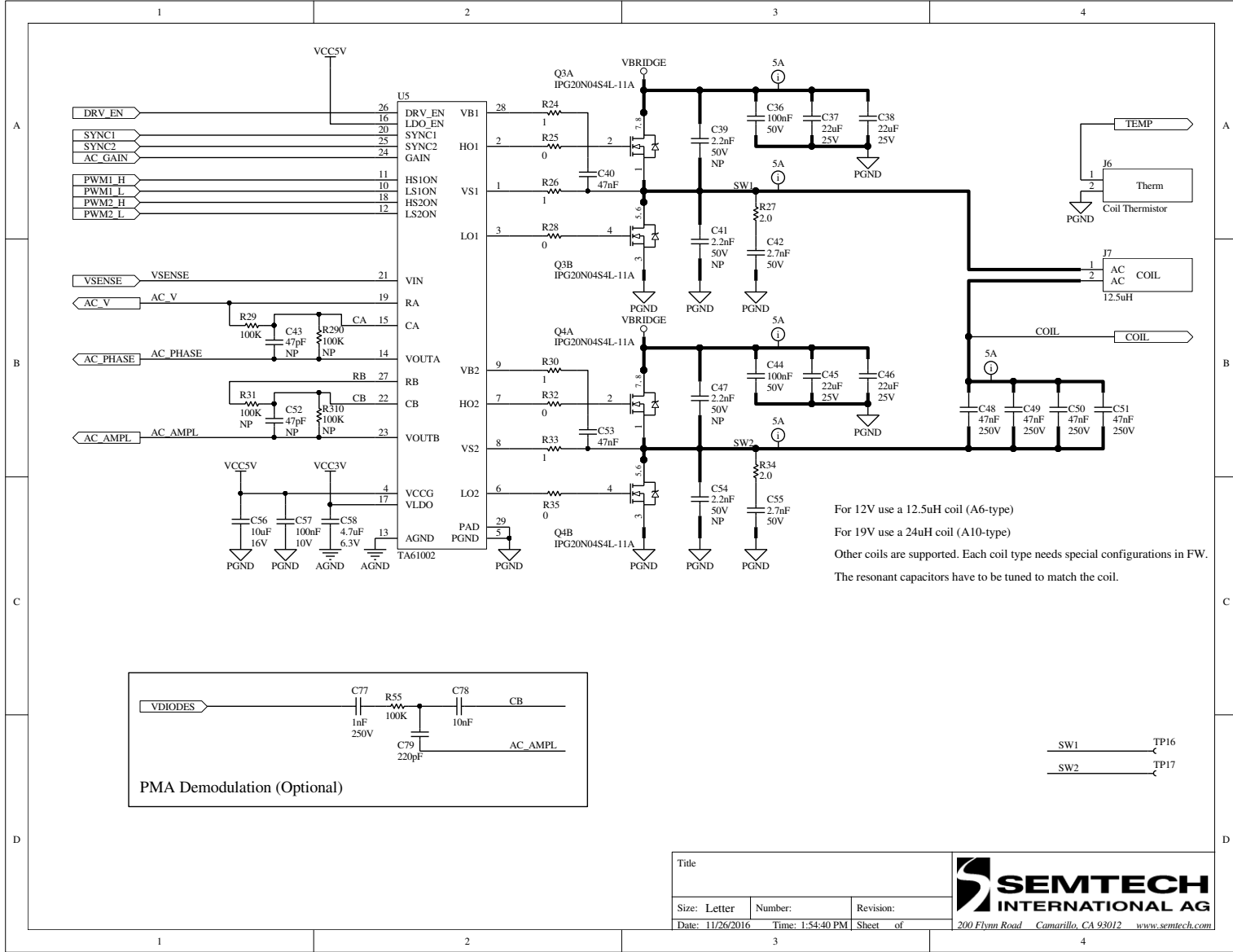
Application Schematic (continued)



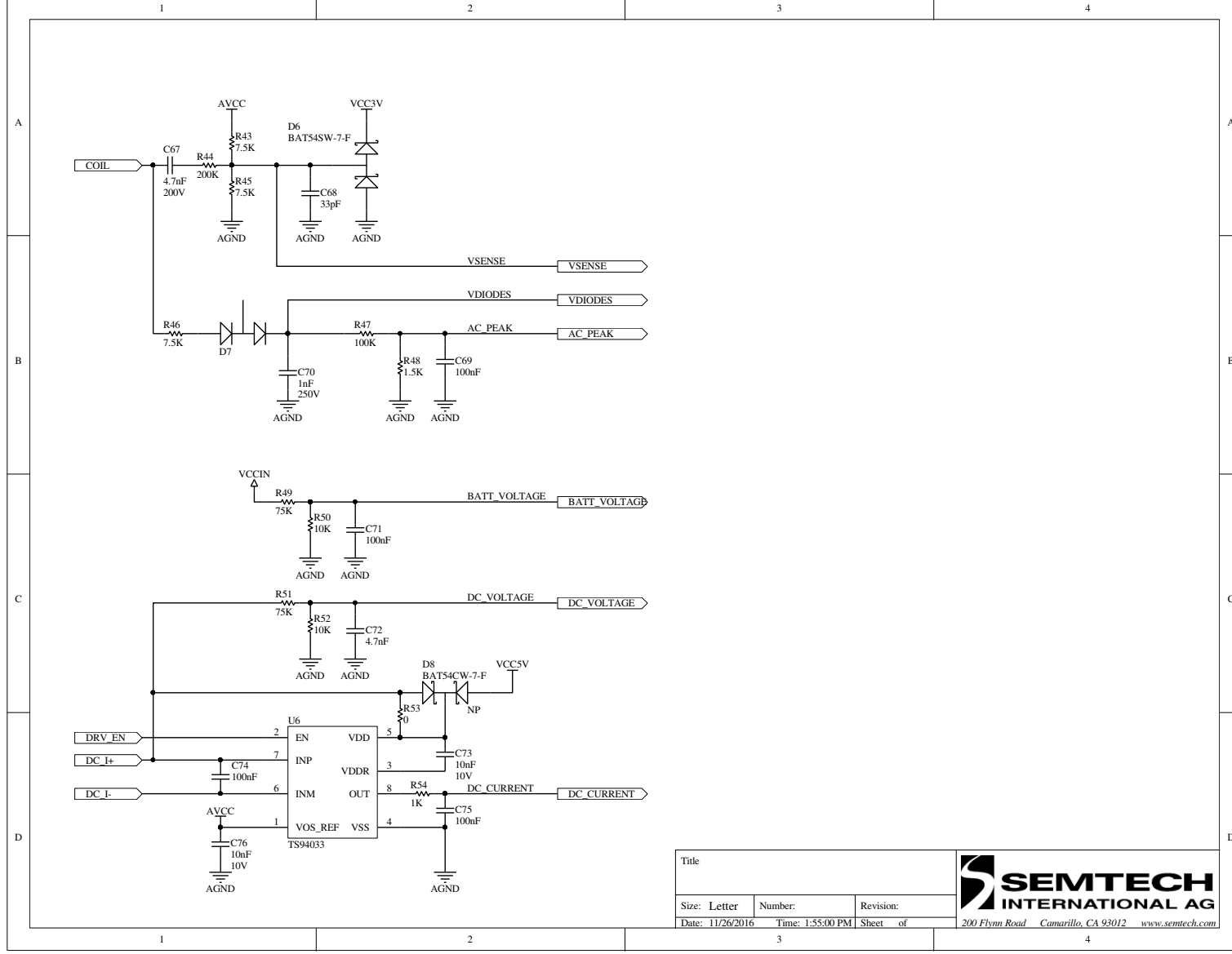
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Application Schematic (continued)



Application Schematic (continued)



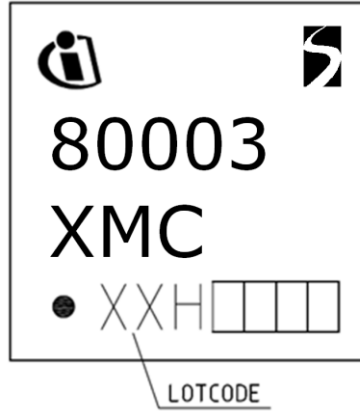
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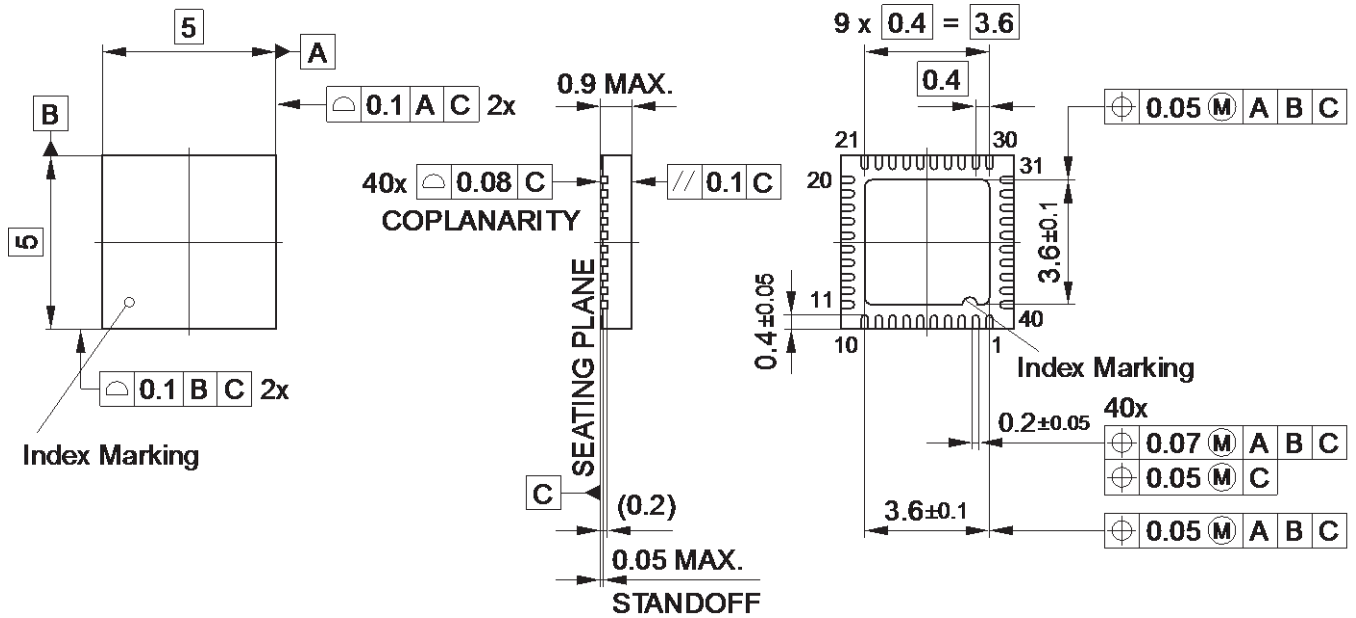
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Package Dimensions

TS80003 Device Marking



VQFN-40 5 X 5 mm, 0.4 mm pitch, package outline (dimensions in mm)



Recommended footprint (dimensions in mm)

