**Table 1. Terminal Functions**

TERMINAL		DESCRIPTION
NAME	NO.	
BUSL2	1	Meter-Bus
VB	2	Differential bus voltage after rectifier
STC	3	Support capacitor
RIDD	4	Current adjustment input
PF	5	Power fail output
SC	6	Sampling capacitor
TXI	7	Data output inverted
TX	8	Data output
BAT	9	Logic level adjust
VS	10	Switch for bus or battery supply output
VDD	11	Voltage regulator output
RX	12	Data input
RXI	13	Data input inverted
RIS	14	Adjust input for modulation current
GND	15	Ground
BUSL1	16	Meter-Bus

Functional Description

Data Transmission, Master to Slave

The mark level on the bus lines $V_{BUS} = \text{MARK}$ is defined by the difference of BUSL1 and BUSL2 at the slave. It depends on the distance from Master to Slave, which affects the voltage drop on the wire. To make the receiver independent, a dynamic reference level on the SC pin is used for the voltage comparator TC3 (see Figure 1).

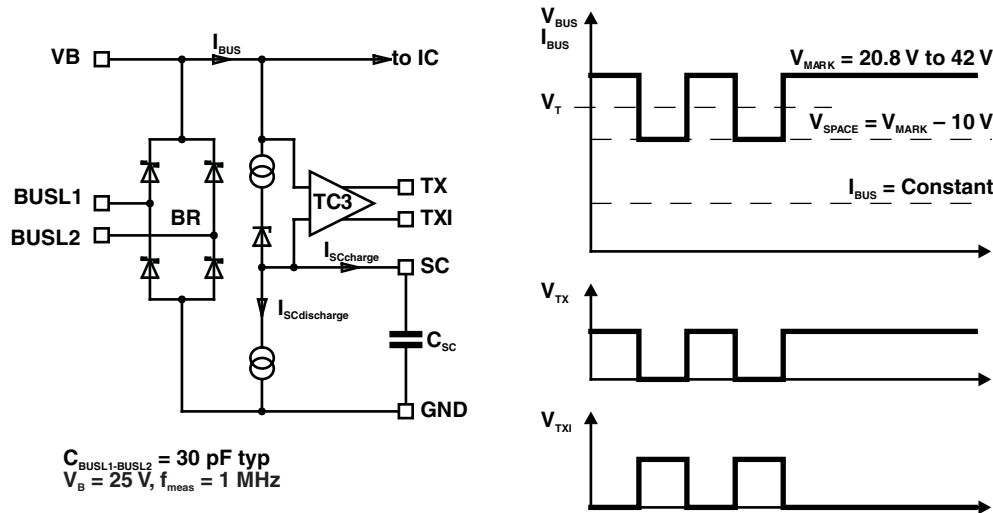


Figure 1. Data Transmission, Master to Slave

A capacitor (C_{SC}) at the SC pin is charged by a current ($I_{SCcharge}$) and is discharged with a current ($I_{SCdischarge}$) where:

$$I_{SCdischarge} = \frac{I_{SCcharge}}{40 \text{ (typ)}} \quad (1)$$

This ratio is necessary to run any kind of UART protocol independent of the data contents (for example, if an 11-bit UART protocol is transmitted with all data bits at 0 and only the stop bit at 1). There must be sufficient time to recharge the capacitor C_{SC} . The input level detector TC3 detects voltage modulations from the master ($V_{BUS} = \text{SPACE}$ or MARK conditions) and switches the inverted output TXI and the noninverted output TX.

Data Transmission, Slave to Master

The device uses current modulation to transmit information from the slave to the master while the bus voltage remains constant. The current source CS3 modulates the bus current and the master detects the modulation. The constant current source CS3 is controlled by the inverted input RXI or the noninverted input RX. The current source CS3 can be programmed by an external resistor R_{RIS} . The modulation supply current I_{MS} flows in addition to the current source CS3 during the modulation time.

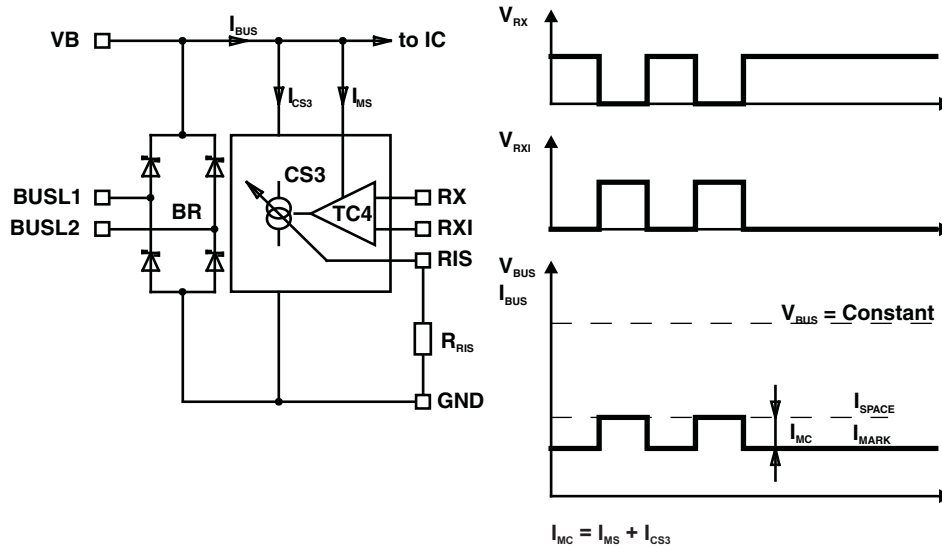


Figure 2. Data Transmission, Slave to Master

Because the TSS521 is configured for half-duplex only, the current modulation from RX or RXI is repeated concurrently as ECHO on the outputs TX and TXI. If the slave, as well as the master, is trying to send information on the lines, the added signals appear on the outputs TX and TXI, which indicates the data collision to the slave (see).

The bus topology requires a constant current consumption by each connected slave.

To calculate the value of the programming resistor R_{RIS} , use the formula shown in Figure 3.

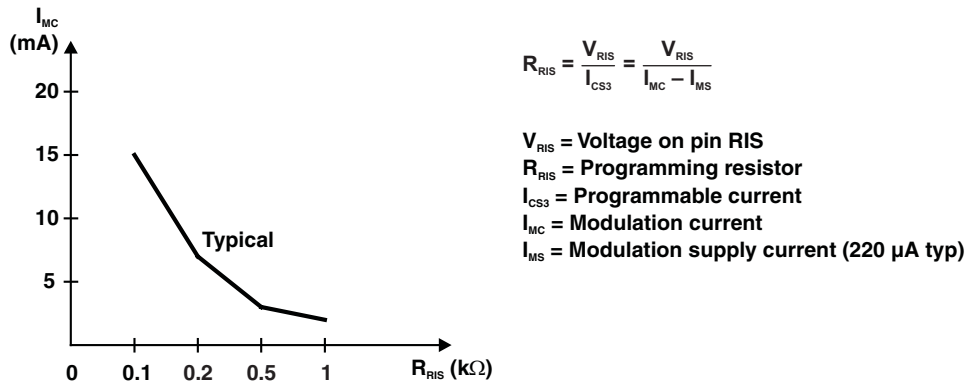


Figure 3. Calculate Programming Resistor R_{RIS}

Slave Supply, 3.3 V

The TSS521 has an internal 3.3-V voltage regulator. The output power of this voltage regulator is supplied by the storage capacitor C_{STC} at the STC pin. The storage capacitor C_{STC} at the STC pin is charged with constant current I_{STC_use} from the current source CS1. The maximum capacitor voltage is limited to REF1. The charge current I_{STC} has to be defined by an external resistor at pin RIDD.

The adjustment resistor R_{RIDD} can be calculated using [Equation 2](#).

$$R_{RID} = 25 \frac{V_{RIDD}}{I_{STC}} = 25 \frac{V_{RIDD}}{I_{STC_use} + I_{IC1}} \quad (2)$$

Where,

- I_{STC} = current from current source CS1
- I_{STC_use} = charge current for support capacitor
- I_{IC1} = internal current
- V_{RIDD} = voltage on pin RIDD
- R_{RIDD} = value of adjustment resistor

The voltage level of the storage capacitor C_{STC} is monitored with comparator TC1. Once the voltage V_{STC} reaches V_{VDD_on} , the switch S_{VDD} connects the stabilized voltage V_{VDD} to pin VDD. VDD is turned off if the voltage V_{STC} drops below the V_{VDD_off} level.

Voltage variations on the capacitor C_{STC} create bus current changes (see [Figure 4](#)).

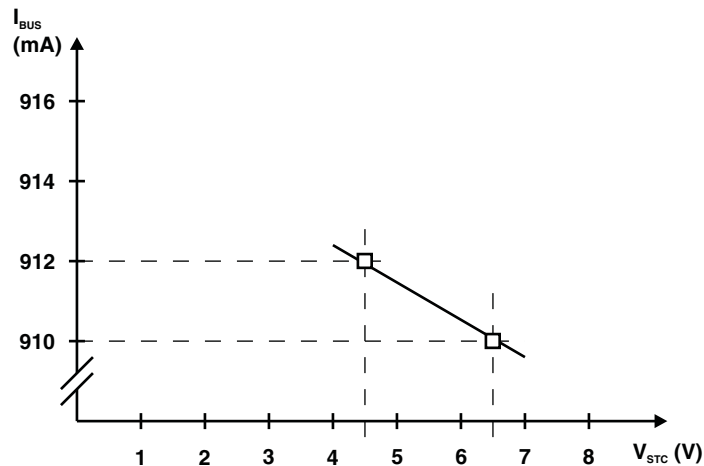


Figure 4. Single Mode Bus Load

At a bus fault the shut down time of VDD (t_{off}) in which data storage can be performed depends on the system current I_{VDD} and the value of capacitor C_{STC} . See [Figure 5](#), which shows a correlation between the shutdown of the bus voltage V_{BUS} and V_{DD_off} and t_{off} for dimensioning the capacitor.

The output VS is meant for slave systems that are driven by the bus energy, as well as from a battery should the bus line voltage fail. The switching of VS is synchronized with VDD and is controlled by the comparator TC1. An external transistor at the output VS allows switching from the Meter-Bus remote supply to battery.

Power On and Off

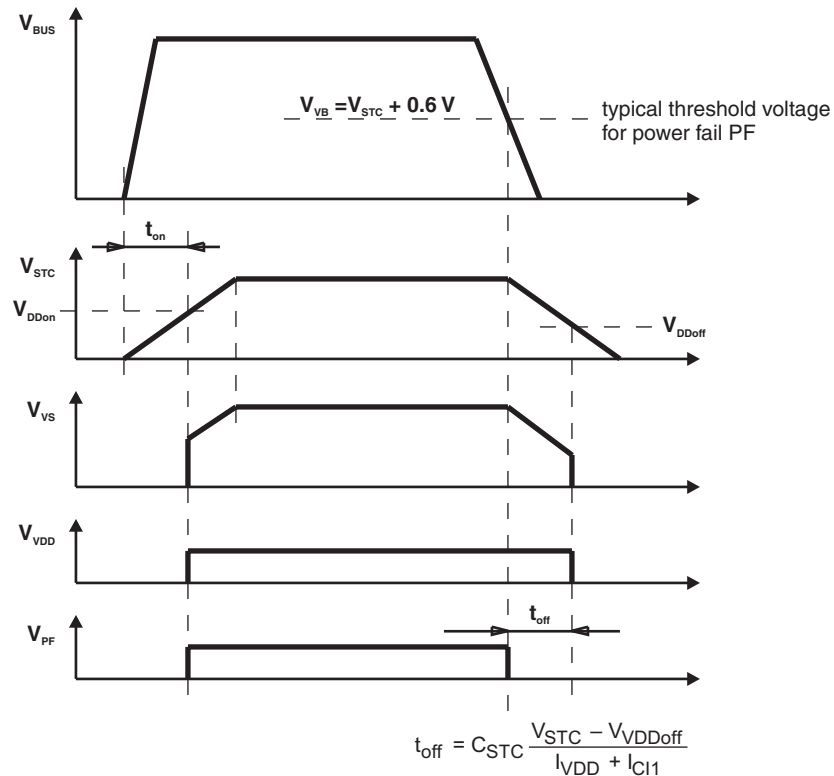


Figure 5. Power On/Off Timing

Power Fail Function

Because of the rectifier bridge BR at the input, BUSL1, and BUSL2, the TSS521 is polarity independent. The pin VB to ground (GND) delivers the bus voltage V_{VB} less the voltage drop over the rectifier BR. The voltage comparator TC2 monitors the bus voltage. If the voltage $V_{VB} > V_{STC} + 0.6\text{ V}$, then the output PF = 1. The output level PF = 0 (power fail) provides a warning of a critical voltage drop to the microcontroller to save the data immediately.

Absolute Maximum Ratings

over operating free-air temperature range (unless otherwise noted)

V_{MB}	Voltage, BUSL1 to BUSL2		± 50 V
V_I	Input voltage range	RX and RXI	-0.3 V to 5.5 V
		BAT	-0.3 V to 5.5 V
T_J	Operating junction temperature range		-25°C to 150°C
T_A	Operating free-air temperature range		-25°C to 85°C
T_{STG}	Storage temperature range		-65°C to 150°C
	Power derating factor, junction to ambient		8 mW/°C

Recommended Operating Conditions

 See note ⁽¹⁾. Typical values are specified at $V_{CC} = 3.3$ V and $T_A = 25^\circ\text{C}$ (unless otherwise noted)

		MIN	MAX	UNIT	
V_{MB}	Bus voltage, BUSL2 – BUSL1	Receiver	10.8	42	V
		Transmitter	12	42	
V_I	Input voltage	VB (receive mode)	9.3		V
		BAT ⁽²⁾	2.5	3.8	
R_{RIDD}	RIDD resistor	13	80	k Ω	
R_{RIS}	RIS resistor	100		Ω	
T_A	Operating free-air temperature	-25	85	°C	

(1) All voltage values are measured with respect to the GND terminal unless otherwise noted.

 (2) $V_{BAT(max)} \leq V_{STC} - 1$ V

Electrical Characteristics

 See note ⁽¹⁾. Over operating free-air temperature range (unless otherwise noted)

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
ΔV_{BR}	Voltage drop at rectifier BR $I_{BUS} = 3$ mA			1.5	V
ΔV_{CS1}	Voltage drop at current source CS1 $R_{RIDD} = 13$ k Ω			1.8	V
I_{BUS}	BUS current $V_{STC} = 6.5$ V, $I_{MC} = 0$ mA	$R_{RIDD} = 13$ k Ω		3	mA
		$R_{RIDD} = 30$ k Ω		1.5	
ΔI_{BUS}	BUS current accuracy $\Delta V_{BUS} = 10$ V, $I_{MC} = 0$ mA, $R_{RIDD} = 13$ k Ω to 30 k Ω			2	%
I_{CC}	Supply current $V_{STC} = 6.5$ V, $I_{MC} = 0$ mA, $V_{BAT} = 3.8$ V, $R_{RIDD} = 13$ k Ω ⁽²⁾			650	μ A
I_{CI1}	CI1 current $V_{STC} = 6.5$ V, $I_{MC} = 0$ mA, $V_{BAT} = 3.8$ V, $R_{RIDD} = 13$ k Ω , $V_{BUS} = 6.5$ V, RX/RXI = off ⁽²⁾			350	μ A
V_{VDD}	VDD voltage $-I_{VDD} = 1$ mA, $V_{STC} = 6.5$ V	3.1		3.4	V
R_{VDD}	VDD resistance $-I_{VDD} = 2$ to 8 mA, $V_{STC} = 4.5$ V			5	Ω
V_{STC}	STC voltage $V_{DD} = \text{on}$, $V_S = \text{on}$ $V_{DD} = \text{off}$, $V_S = \text{off}$ $I_{VDD} < I_{STC_use}$		5.6	6.4	V
			3.8	4.3	
			6.5	7.5	
I_{STC_use}	STC current $V_{STC} = 5$ V	$R_{RIDD} = 30$ k Ω	0.65	1.1	mA
		$R_{RIDD} = 13$ k Ω	1.85	2.4	
V_{RIDD}	RIDD voltage $R_{RIDD} = 30$ k Ω	1.23		1.33	V
V_{VS}	VS voltage $V_{DD} = \text{on}$, $I_{VS} = -5$ μ A	$V_{STC} - 0.4$		V_{STC}	V
R_{VS}	VS resistance $V_{DD} = \text{off}$	0.3		1	M Ω
V_{PF}	PF voltage $V_{STC} = 6.5$ V	$V_{VB} = V_{STC} + 0.8$ V, $I_{PF} = -100$ μ A	$V_{BAT} - 0.6$	V_{BAT}	V
		$V_{VB} = V_{STC} + 0.3$ V, $I_{PF} = 1$ μ A	0	0.6	
		$V_{VB} = V_{STC} + 0.3$ V, $I_{PF} = 5$ μ A	0	0.9	

(1) All voltage values are measured with respect to the GND terminal unless otherwise noted.

 (2) Inputs RX/RXI and outputs TX/TXI are open, $I_{CC} = I_{CI1} + I_{CI2}$

Electrical Characteristics (continued)

See note ⁽¹⁾. Over operating free-air temperature range (unless otherwise noted)

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
t_{on}	Turn-on time			3	s

Receiver Section Electrical Characteristics

See note ⁽¹⁾. Over operating free-air temperature range (unless otherwise noted)

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
V_T	See Figure 1	MARK – 8.2		MARK – 5.7	V
V_{SC}	SC voltage			V_{VB}	V
$I_{SCcharge}$	SC charge current	$V_{SC} = 24\text{ V}$, $V_{VB} = 36\text{ V}$		–40	μA
$I_{SCdischarge}$	SC discharge current	$V_{SC} = V_{VB} = 24\text{ V}$	0.3	$-0.033 \times I_{SCcharge}$	μA
V_{OH}	High-level output voltage (TX, TXI)	I_{TX} , $I_{TXI} = -100\ \mu\text{A}$ (see Figure 1)	$V_{BAT} - 0.6$	V_{BAT}	V
V_{OL}	Low-level output voltage (TX, TXI)	I_{TX} , $I_{TXI} = 100\ \mu\text{A}$	0	0.5	V
		$I_{TX} = 1.1\text{ mA}$	0	1.5	V
I_{TX} I_{TXI}	TX, TXI current	$V_{TX} = 7.5$, $V_{VB} = 12\text{ V}$, $V_{STC} = 6\text{ V}$, $V_{BAT} = 3.8\text{ V}$		16	μA

(1) All voltage values are measured with respect to the GND terminal unless otherwise noted.

Transmitter Section Electrical Characteristics

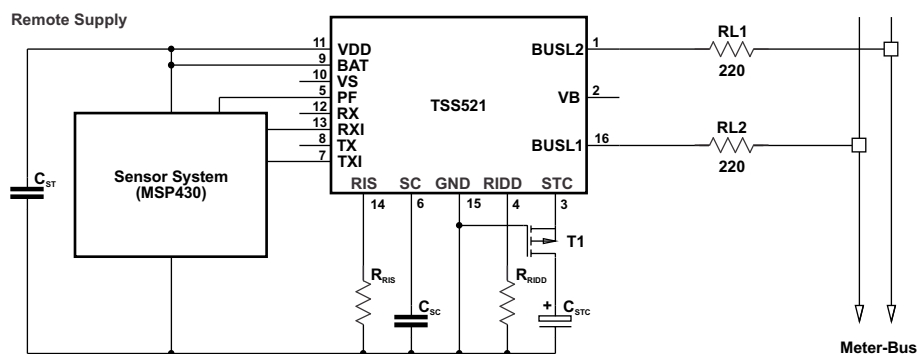
See note ⁽¹⁾. Over operating free-air temperature range (unless otherwise noted)

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
I_{MC}	MC voltage	$R_{RIS} = 100\ \Omega$	11.5	19.5	mA
V_{RIS}	RIS voltage	$R_{RIS} = 100\ \Omega$	1.4	1.7	V
		$R_{RIS} = 1000\ \Omega$	1.5	1.8	V
V_{IH}	High-level input voltage (RX, RXI)	See Figure 2 , see ⁽²⁾	$V_{BAT} - 0.8$	5.5	V
V_{IL}	Low-level input voltage (RX, RXI)	See Figure 2	0	0.8	V
I_{RX}	RX current	$V_{RX} = 0\text{ V}$, $V_{BAT} = 3\text{ V}$, $V_{STC} = 6.5\text{ V}$	–10	–40	μA
I_{RXI}	RXI current	$V_{RXI} = V_{BAT} = 3\text{ V}$, $V_{STC} = 6.5\text{ V}$	10	40	μA

(1) All voltage values are measured with respect to the GND terminal unless otherwise noted.

(2) $V_{IH}(\text{max}) = 5.5\text{ V}$ is valid only when $V_{STC} \geq 6.5\text{ V}$.

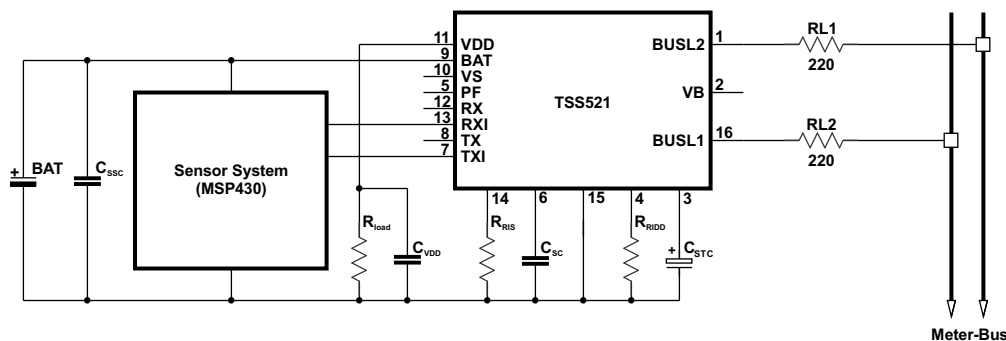
APPLICATION INFORMATION



$R_{RIDD} = 30\text{ k}\Omega$	$C_{STC} \leq 220\text{ }\mu\text{F}$	single load 1UL
$R_{RIDD} = 13\text{ k}\Omega$	$C_{STC} \leq 470\text{ }\mu\text{F}$	double load 2UL

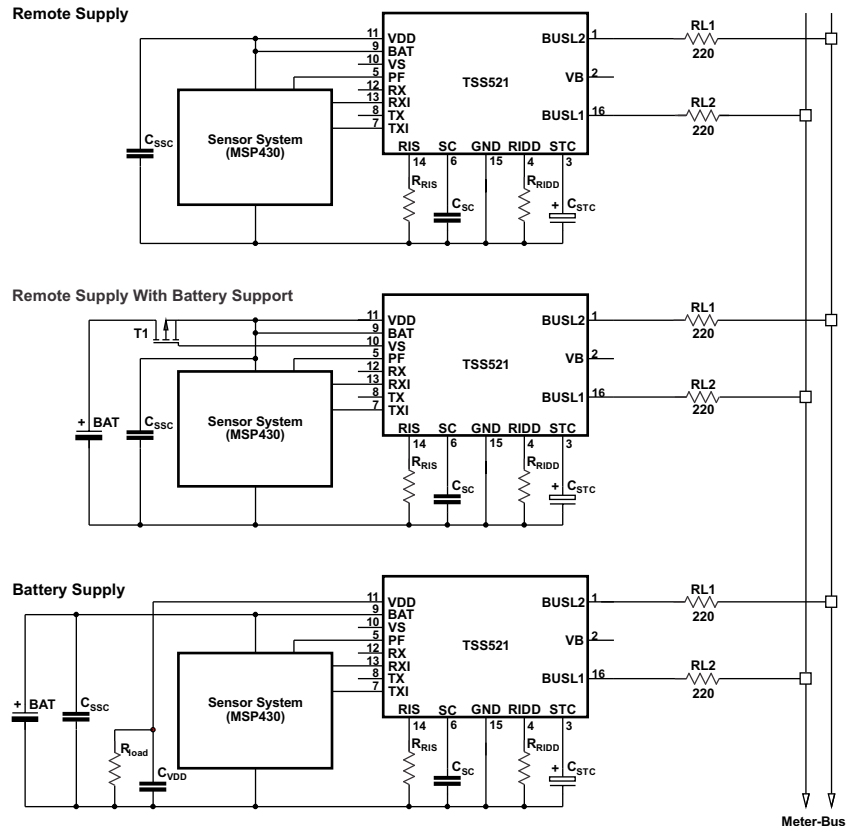
NOTE: Transistor T1 should be a BSS84.

Figure 6. Basic Application Circuit With Support Capacitor $C_{STC} > 50\text{ }\mu\text{F}$



- C_{SSC} = system stabilizing capacitor
- C_{STC} = support capacitor
- C_{SC} = sampling capacitor
- C_{VDD} = stabilizing capacitor (100 nF)
- $C_{STC} : C_{VDD} \geq 4:1$
- R_{RIDD} = slave=current adjustment resistor
- R_{RIS} = modulation-current resistor
- RL1, RL2 = protection resistors
- R_{LOAD} = discharge resistor (100 k Ω recommended)

Figure 7. Basic Application Circuit for Supply From Battery



NOTE: R_{DSon} of the transistor T1 (BSS84) at low battery voltage must be considered during application design.

Figure 8. Basic Applications for Different Supply Modes

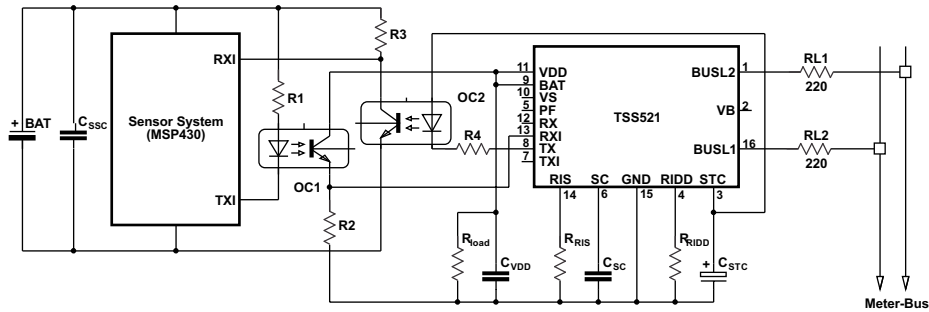


Figure 9. Basic Optocoupler Application

PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead finish/ Ball material (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
TSS521D	ACTIVE	SOIC	D	16	40	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-25 to 85	TSS521	Samples
TSS521DR	ACTIVE	SOIC	D	16	2500	RoHS & Green	NIPDAU	Level-1-260C-UNLIM	-25 to 85	TSS521	Samples

(1) The marketing status values are defined as follows:

ACTIVE: Product device recommended for new designs.

LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.

NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.

PREVIEW: Device has been announced but is not in production. Samples may or may not be available.

OBSOLETE: TI has discontinued the production of the device.

(2) **RoHS:** TI defines "RoHS" to mean semiconductor products that are compliant with the current EU RoHS requirements for all 10 RoHS substances, including the requirement that RoHS substance do not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, "RoHS" products are suitable for use in specified lead-free processes. TI may reference these types of products as "Pb-Free".

RoHS Exempt: TI defines "RoHS Exempt" to mean products that contain lead but are compliant with EU RoHS pursuant to a specific EU RoHS exemption.

Green: TI defines "Green" to mean the content of Chlorine (Cl) and Bromine (Br) based flame retardants meet JS709B low halogen requirements of <=1000ppm threshold. Antimony trioxide based flame retardants must also meet the <=1000ppm threshold requirement.

(3) MSL, Peak Temp. - The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

(6) Lead finish/Ball material - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

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TAPE AND REEL INFORMATION

QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE


*All dimensions are nominal

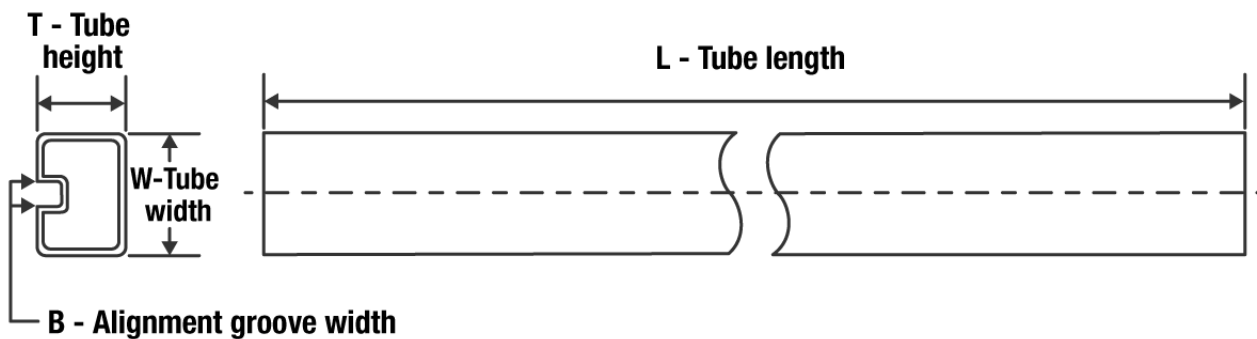
Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
TSS521DR	SOIC	D	16	2500	330.0	16.4	6.5	10.3	2.1	8.0	16.0	Q1

TAPE AND REEL BOX DIMENSIONS


*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
TSS521DR	SOIC	D	16	2500	350.0	350.0	43.0

TUBE

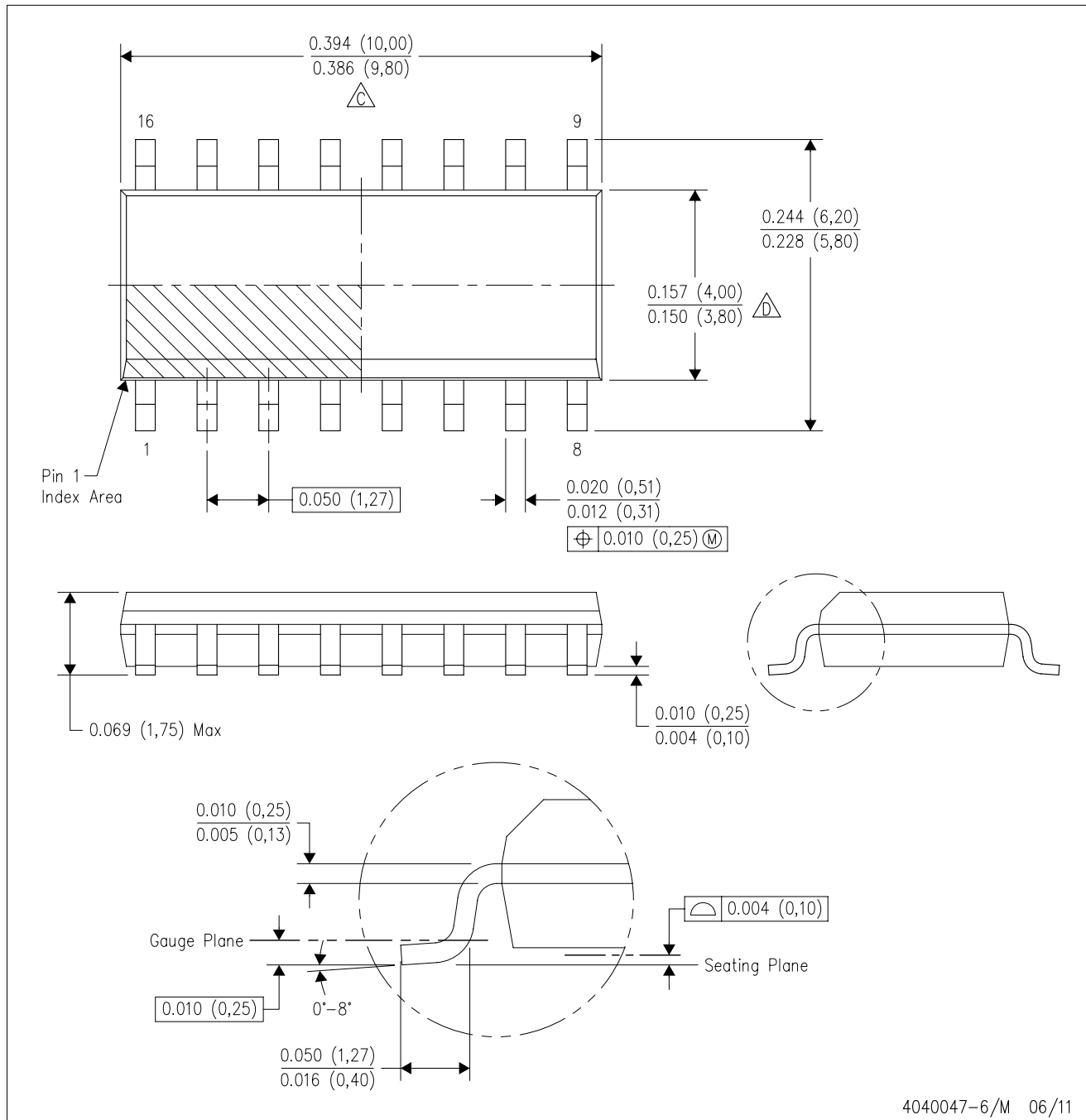


*All dimensions are nominal

Device	Package Name	Package Type	Pins	SPQ	L (mm)	W (mm)	T (μm)	B (mm)
TSS521D	D	SOIC	16	40	505.46	6.76	3810	4

D (R-PDSO-G16)

PLASTIC SMALL OUTLINE



- NOTES:
- A. All linear dimensions are in inches (millimeters).
 - B. This drawing is subject to change without notice.
 - C. Body length does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.006 (0,15) each side.
 - D. Body width does not include interlead flash. Interlead flash shall not exceed 0.017 (0,43) each side.
 - E. Reference JEDEC MS-012 variation AC.

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