ABSTRACT
As RS-232 continues to withstand the test of time and serial port evolution, standard RS-232 transceivers must evolve to meet current and new system level needs. Applications demand smaller form factor, faster speed, lower power, cost efficiency, robustness, reliability, and ease of use. Most of the current standard solutions (that is, TRS3232, TRS3243, and so forth) meet these needs. Higher speed and lower power come from reducing RS-232 voltage levels from ±12 V to ±5.4 V. Reduced voltage swings switch faster with less capacitive current demand. TRS3122E improves ease of use with internal voltage translation between logic and charge pump $V_{CC}$ level. Alternatively, TRS3122E can be powered with a single 1.8-V, 3.3-V, or 5-V supply. TRS3122E has a small package size, 1-Mb/s speed and IEC 61000-4-2 ESD protection, ±15 kV Air-Gap, and ±8 kV Contact.

This application note will go beyond what is in the datasheet and explain how key specs and features can improve the users system in order to aid the user in taking advantage of the key enhancements and features of this device. This application note will explain in detail:

- Extended Supply Operation: 1.8 V to 5.5 V
- Charge Pump Tripler Operation
- Auto-Powerdown-Plus
- Layout
- Key Design Care-Abouts

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1 Extended Supply Operation

The majority of RS-232 transceivers on the market are compatible with power supplies down to 3.3 V and have used charge pumps to boost and invert that voltage to RS-232 voltage levels that are compliant with the standard, (> ±5 V). For ages this has been sufficient, however, many systems are using processors with 1.8 V GPIOs. As shown in Figure 1, a level shifter was used to overcome this.

In order to interface with these low voltage GPIOs, many RS-232 suppliers have developed devices that have a logic supply pin (V_L) in addition to the main V_CC supply. This allows users to interface to an internal level translator that will shift the GPIO high level voltage (equal to V_L) to a voltage that is operable by the main chip and charge pump (that is, 1.8 V to 3.3 V). This is a great work around, however, this comes with the drawback of needing two supplies routed to your RS-232 transceiver.

RS-232 transceivers are peripheral devices that typically sit near the edge of the PCB along with other PHYs (that is, RS485, USB, Ethernet, and so forth). It may not be very efficient or reliable from a routing point of view to route both supplies all the way to your RS-232 device or to use an LDO or buck/boost converter to generate the 1.8 V or 3.3 V locally as needed. TRS3122E can operate from a single 1.8-V V_CC and generate compatible RS-232 driver voltage levels, eliminating the level of complexity that dual supplies add.

TRS3122E employs a tripler charge pump to generate RS-232 compatible driver voltages from a 1.8 V power source. Traditional standard RS-232 transceivers use regulated doublers, leading to the 3 V minimum V_CC requirements. An ideal unregulated doubler would yield driver voltages of ±3.6 V from a 1.8-V V_CC. This is enough to yield a solid 1 or 0 at the receiver that must properly decode ±3 V. However, the load from the receiver and cable capacitance switched at maximum data rate will cause the driver voltage to degrade, becoming much lower than ±3.6 V, due to switching losses. This is why a tripler is needed.
The TRS3122E device can operate using a single 1.8-V, 3-3V or 5-V supply. If single supply operation is desired, $V_{CC}$ and $V_L$ should be tied together, as shown in Figure 2. The TRS3122E device can also operate from dual supplies; $V_{CC}$ can be 1.8 V, 3.3 V, or 5 V and $V_L$ can be any voltage between 1.65 V and $V_{CC}$. There is no power up sequence requirement; either supply can power up first.

2 Tripler Charge Pump Operation

The charge pump doubler uses flying capacitor $C_1$ with $V_{CC}$ to charge the $V+$ pin storage capacitor. The charge pump tripler uses flying capacitors $C_1$ and $C_3$ with $V_{CC}$ to charge the $V+$ pin storage capacitor. Both doubler and tripler use flying capacitor $C_2$ to invert $V+$ pin voltage to charge the $V-$ pin storage capacitor. For 1.8-V and 3.3-V operation, nearly full boost is needed; therefore matching capacitors values (100 nF) can be used. Charge pump efficiency is highest when running close to full boost. For 5-V operation, minimal positive boost is needed, so capacitor $C_1$ is reduced and the other capacitors are increased. The charge pump voltage is regulated by only running pump cycles when the charge pump voltage at $V+$ or $V-$ is below target values. This method greatly improves efficiency with no load, cable unplugged and also improves efficiency at most loads. The regulation target is $\pm 5.4 \, V$ for doubler mode. In tripler mode, the regulation target is set to $\pm 2.65 \times V_{CC}$ to allow the highest output while maintaining high efficiency with all $V_{CC}$ from 1.65 V to 2 V.
If $V_{CC}$ is being operated between 3 V and 5.5 V, TRS3122E will operate as a doubler. If the third flying cap is present, it will be ignored. Operation between 2 V and 3 V is not recommended for $V_{CC}$ pin because of switching between doubler and tripler modes. $V_L$ can be any voltage from 1.65 V to $V_{CC}$. For example, $V_{CC} = 3.3$ V and $V_L = 2.5$ V is a valid operating condition.

4 Layout

For the best ESD performance connect the TRS3122E ground pin with the lowest possible resistance and inductance. This means short and wide metal to multiple vias placed close to the ground pin. The charge pump and $V_{CC}$ capacitors should also be close to the TRS3122E ground plane. RS-232 traces should be direct (connector to TRS3122E) without bends greater than 45 degrees and stubs should be avoided (to a test point for example).
5 Key Design Care-Abouts

- There are no pullup or pulldowns on logic inputs, so be sure to add resistors for any floating or disconnected logic inputs.
  - Do not leave digital inputs (DIN, FORCEOFF, FORCEON) unconnected or floating.
- Unused RIN, DOUT, ROUT, and INVALID pins can be left unconnected.
- Do not use a higher voltage on $V_L$ than $V_{CC}$; however, power up order does not matter.
- Supply current increases with data rate and cable capacitance.
- Ripple voltage on the DOUT line is normal. Increase capacitance of C2, C4, and C5 as needed to reduce ripple.
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