Application Report

SLCA001A – July 2016 – Revised July 2016

Designing With the TRS3122E

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.

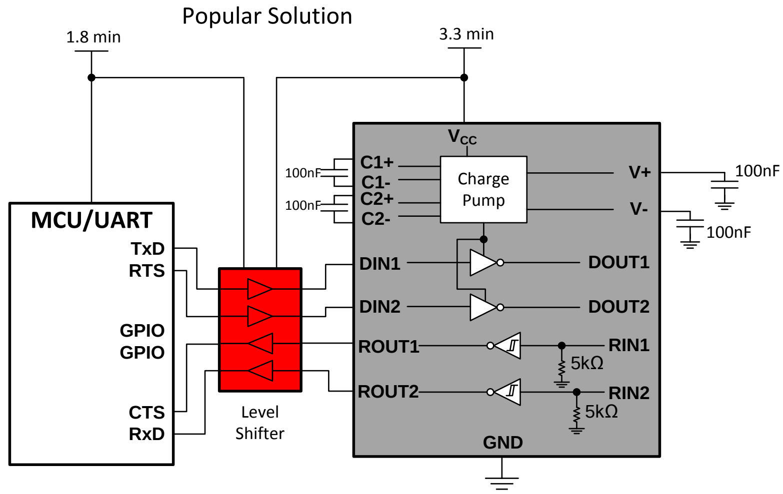

Figure 1. Previous Generation Solution

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.

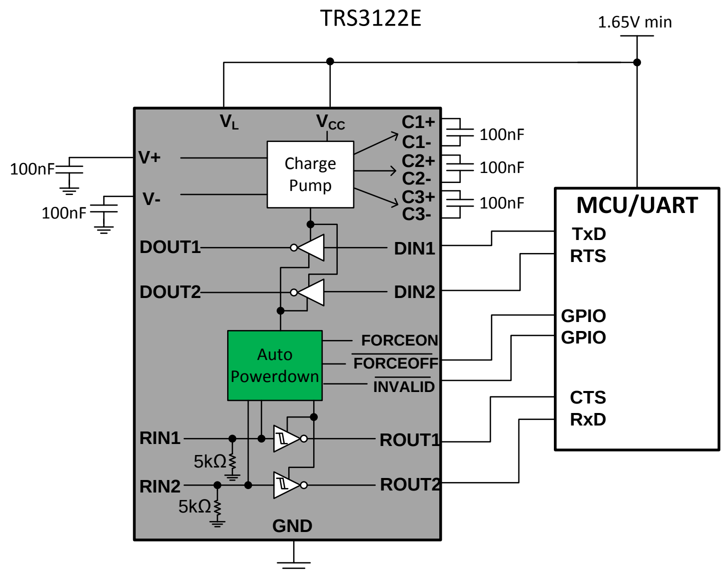

Figure 2. TRS3122E Diagram

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 C1 with V_{CC} to charge the V+ pin storage capacitor. The charge pump tripler uses flying capacitors C1 and C3 with V_{CC} to charge the V+ pin storage capacitor. Both doubler and tripler use flying capacitor C2 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 C1 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 ±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.

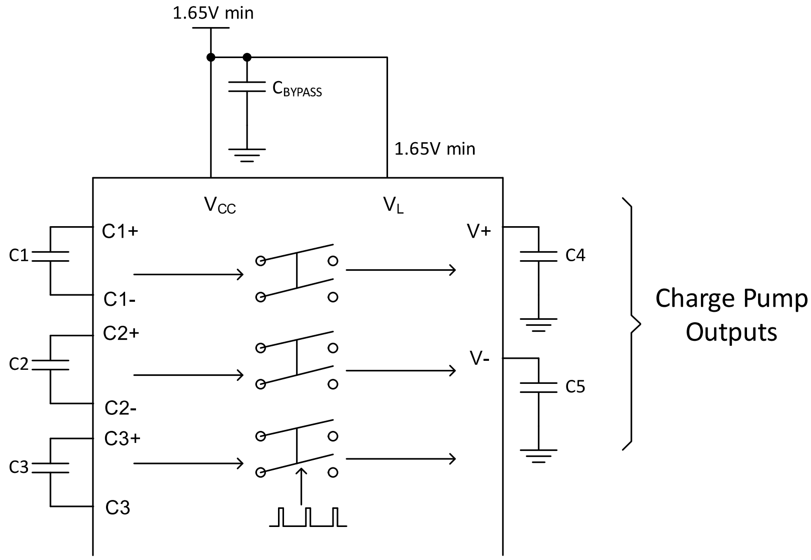

Figure 3. Charge Pump Regulator

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.

3 Auto-Powerdown-Plus

RS-232 transceivers in many systems may have long periods of idle time when no data is being sent or received. TRS3122E provides two options for power savings. The first option is to pull the $\overline{\text{FORCEOFF}}$ pin to ground; this will disable the receiver outputs and shut down the charge pump. Any DOUT that is high will immediately drop to zero. Any DOUT that is low will decay to zero with time based on line load and V- storage pin capacitance. This action protects against a mistaken start bit at the remote receiver. If FORCEON is low and $\overline{\text{FORCEOFF}}$ is high, the Auto-powerdown-plus feature will be active. Auto-powerdown-plus will turn off the drivers and leave the receivers on after detecting 30 seconds of inactivity at all receiver and driver inputs. Any activity at RIN or DIN will power the drivers back on and reset the inactivity timer. As a result, the system saves power without requiring any control.

Having both $\overline{\text{FORCEOFF}}$ and FORCEON high will keep both drivers and receivers on at all times.

The $\overline{\text{INVALID}}$ pin logic output goes low when all receiver inputs are less than ±0.3 V for more than 30 us. $\overline{\text{INVALID}}$ pin logic output goes high when any receiver input is greater than ±2.7 V. The INVALID output is not affected by $\overline{\text{FORCEOFF}}$ or FORCEON control inputs.

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).

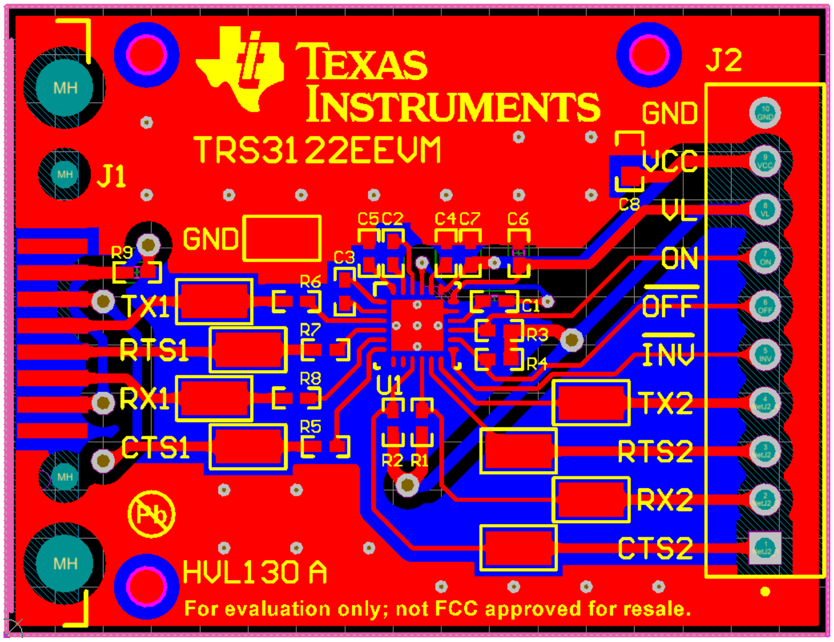

Figure 4. TRS3122E 2-Layer Metal Example Layout

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, $\overline{\text{FORCEOFF}}$, FORCEON) unconnected or floating.
- Unused RIN, DOUT, ROUT, and $\overline{\text{INVALID}}$ 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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