AN804

# Design Alternatives To The TC682 For Performing Inverting Voltage Doubler Functions

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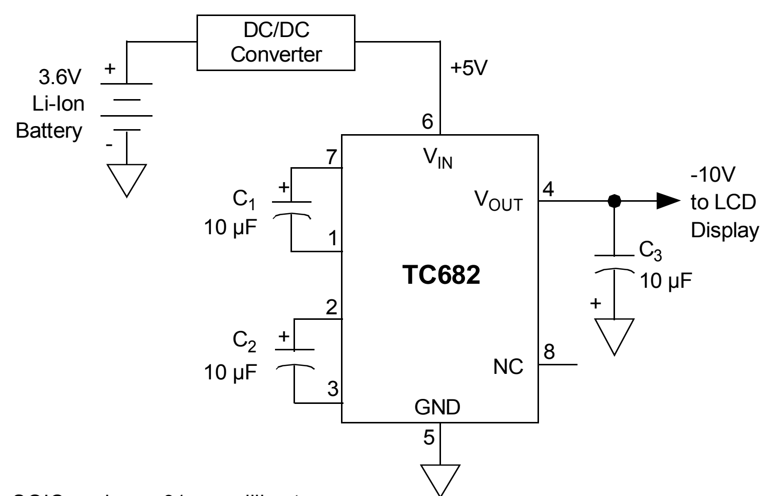
## INTRODUCTION

Creating a negative DC bias voltage from a positive DC supply often is required in battery-powered, portable, hand-held instruments that use a Liquid Crystal Display (LCD). Many LCDs require a relatively large negative bias (on the order of -10V). Since many portable systems (such as cellular subscriber units) often have a regulated +5V DC bias available, the critical design task involves converting this supply voltage to a negative DC bias for the LCD. This application note discusses the advantages and disadvantages of several alternatives for implementing the -10V bias required by the LCD.

## TRADITIONAL TC682 IMPLEMENTATION

Figure 1 shows a circuit implementation using Microchip Technology's TC682 to generate the -10V LCD bias from a regulated +5V input. Assuming that a single-cell Li-Ion battery (with a nominal terminal voltage of 3.6V) is powering the system, a regulating DC/DC boost converter is needed to generate the +5V regulated input supply to the TC682.

Although the TC682 requires only three external tantalum capacitors to generate the -10V bias, its package is a large 8-pin SOIC, which occupies approximately 31 square millimeters of circuit board space. The TC682 active supply current is typically 185 µA, with the internal charge pump switching frequency being 12 kHz. The TC682 has no shutdown features, so it always consumes power when the +5V input bias is active.




**Notes:**

1. Requires one 8-pin SOIC package, 31 sq. millimeters.
2. Requires three 10 µF tantalum capacitors.
3. TC682 supply current approximately 185 µA.
4. Charge pump switching frequency: 12 kHz.
5. No shutdown mode available.

***FIGURE 1:*** *TC682 Circuit Implementation.*

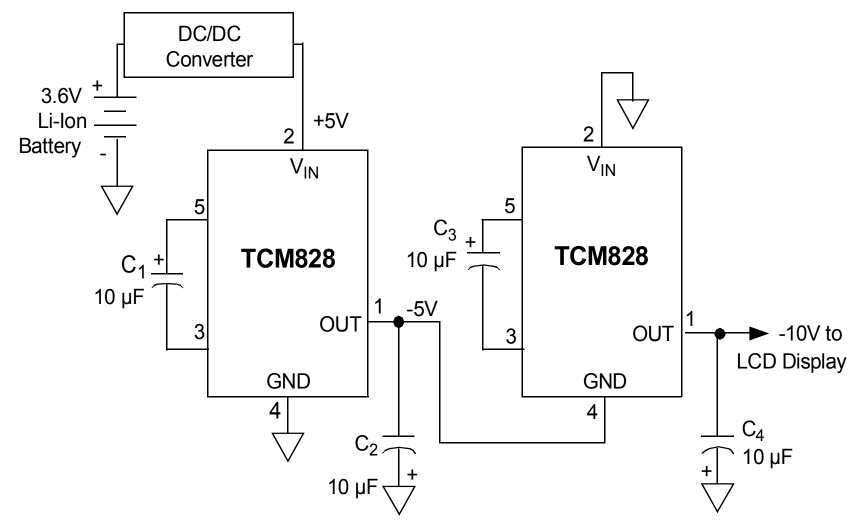
 

## DUAL TCM828 IMPLEMENTATION

Figure 2 shows a two-chip inverting doubler solution using Microchip's TCM828. Like the TC682 example, a regulating DC/DC boost converter is needed to provide the +5V regulated input voltage to the first TCM828, assuming the system is powered from a single-cell Li-Ion battery.

The second TCM828 is level-shifted (i.e., powered from ground and -5V) to generate the -10V LCD bias. Although this implementation requires four external tantalum capacitors, the total package size of the two TCM828s occupies only 18 square millimeters of board space, which is considerably less than the TC682 solution.

The dual-TCM828 approach consumes only 100 µA (again, considerably less than the TC682) and has the same internal charge pump switching frequency as the TC682 (i.e., 12 kHz). As in the TC682 example, the dual TCM828 solution has no shutdown feature.



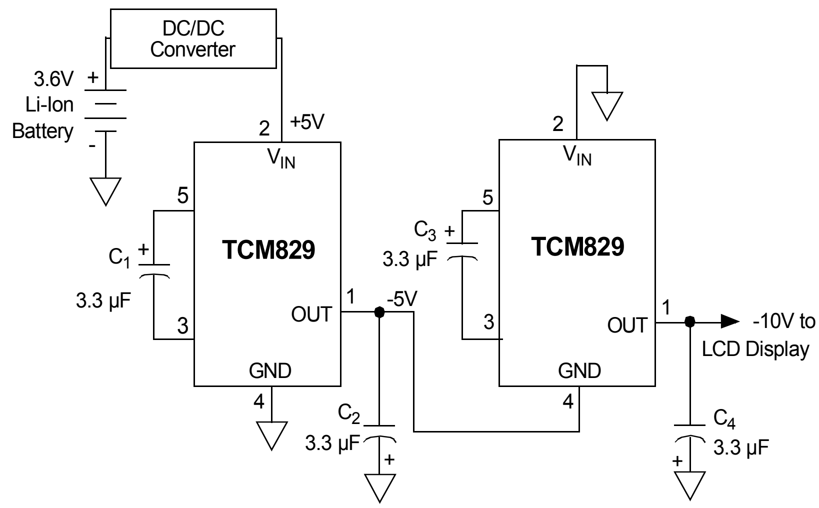

**Notes:**

1. Requires two SOT-23A-5 packages, 18 sq. millimeters total.
2. Requires four 10 µF tantalum capacitors.
3. Combined TCM828 supply current approximately 100 µA.
4. Charge pump switching frequency: 12 kHz.
5. No shutdown mode available.

***FIGURE 2:*** *Dual TCM828 implementation.*

## DUAL TCM829 IMPLEMENTATION

Figure 3 shows another two-chip inverting doubler solution using Microchip's TCM829. This implementation is almost identical to the dual TCM828 approach. The primary difference being that the two TC829s switch at a higher frequency (35 kHz) than the dual TCM828 or TC682. This allows the designer to use smaller external capacitors with the dual TCM829 solution at the expense of a higher supply current (230 µA) than the dual TCM828 approach. All other features of the dual TCM828 solution apply to the dual TCM829 solution.




**Notes:**

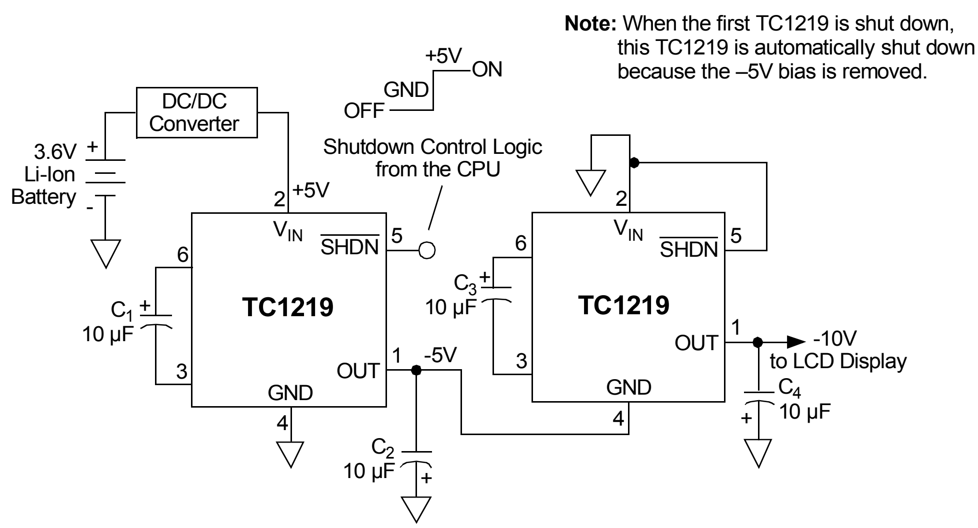
1. Requires two SOT-23A-5 packages, 18 sq. millimeters total.
2. Requires four 3.3 µF tantalum capacitors.
3. Combined TCM829 supply current approximately 230 µA.
4. Charge pump switching frequency: 35 kHz.
5. No shutdown mode available.

***FIGURE 3:*** *Dual TCM829 implementation.*

## DUAL TC1219 IMPLEMENTATION

A two-chip solution using Microchip's TC1219 is shown in Figure 4. This implementation is similar to the dual TCM828 approach with one key difference: the TC1219 has a shutdown feature that can power down the negative bias generator during low-power operating modes of the battery-powered instrumentation.

An example of this is the "sleep" mode of a Code Division Multiple Access (CDMA) cellular subscriber unit. By applying a low-level logic signal to the first TC1219, the second TC1219 will automatically be powered down because the -5V bias to its GND pin is eliminated. All other features of the dual TCM828 solution apply to the dual TC1219 approach, with the exception that the active supply current of the dual TC1219 solution (120 µA) is higher than the dual TCM828 solution (which can be negated by the shutdown feature of the TC1219).




**Notes:**

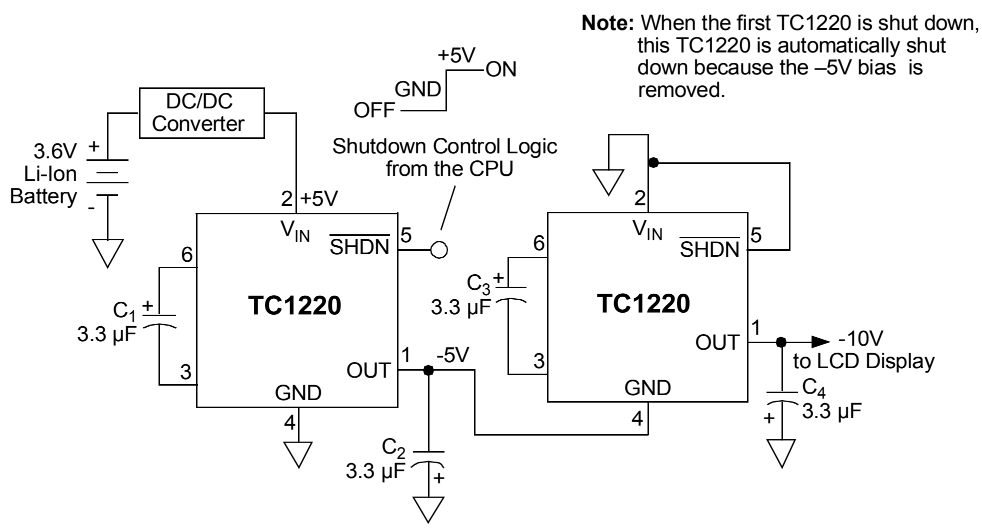
1. Requires two SOT-23A-6 packages, 18 sq. millimeters total.
2. Requires four 10 µF tantalum capacitors.
3. Combined TC1219 supply current approximately 120 µA.
4. Charge pump switching frequency: 12 kHz.
5. Total supply current in shutdown mode approximately 0.2 µA.

***FIGURE 4:*** *Dual TC1219 implementation.*

***** See the TC1142 data sheet (DS21360) for details.

## DUAL TC1220 IMPLEMENTATION

Figure 5 illustrates still another two-chip solution using Microchip's TC1220. This implementation is almost identical to the dual TC1219 approach, with the main difference being that the two TC1220s switch at a higher frequency (35 kHz) than the dual TC1219. This allows the designer to use smaller external capacitors with the dual TC1220 solution at the expense of a higher active supply current (230 µA) than the dual TC1219 approach. All other features of the dual TC1219 solution apply to the dual TC1220 approach.




**Notes:**

1. Requires two SOT-23A-6 packages, 18 sq. millimeters total.
2. Requires four 3.3 µF tantalum capacitors.
3. Combined TC1220 supply current approximately 230 µA.
4. Charge pump switching frequency: 35 kHz.
5. Total supply current in shutdown mode approximately 0.2 µA.

***FIGURE 5:*** *Dual TC1220 Implementation.*

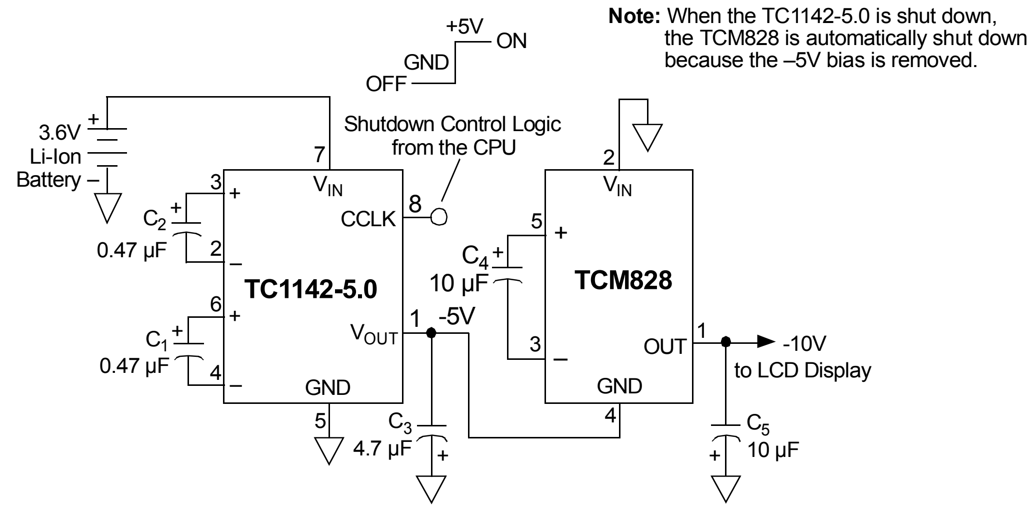
## TC1142/TCM828 IMPLEMENTATION

Figure 6 shows a two-chip inverter solution using Microchip's TC1142-5.0 and TCM828. The most important difference of this implementation, when compared to the previous solutions, is that the regulating DC/DC boost converter is no longer required.

The TC1142-5.0 is a regulating -2x boost/buck inverter that generates a -5V output from any positive DC bias ranging from 2.5V to 5.5V. This feature allows the TC1142-5.0 to connect directly to the single-cell Li-Ion battery without the need for a regulating +5V DC/DC converter.

The TC1142-5.0 also can be placed in a low power shutdown mode (with a logic-low on the CCLK input*****), which also will power down the TCM828 because the -5V bias to its GND pin is eliminated.

The TC1142-5.0 runs off an internal oscillator of 200 kHz, but this can be overridden by connecting an external oscillator to the CCLK input*. The solution requires less circuit board space than any of the previous solutions due to the DC/DC boost converter not being required. The total active supply current for this solution is approximately 250 µA.



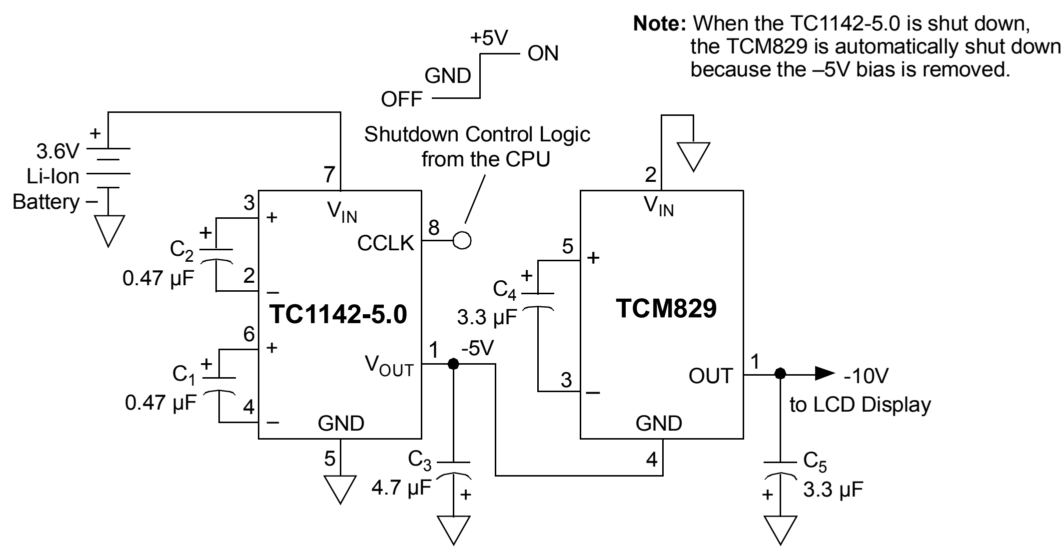

**Notes:**

1. Requires one SOT-23A-5 package and one 8-pin MSOP, 24.5 sq. millimeters total.
2. Requires two 10 µF, one 4.7 µF, and two 0.47 µF tantalum capacitors.
3. Total active supply current approximately 250 µA.
4. Charge pump switching frequency: 200 kHz for TC1142, 12 kHz for TCM828.
5. Shutdown mode available; total supply current in shutdown mode approximately 0.2 µA.
6. TC1142 provides regulated voltage output.
7. Unregulated input voltage (2.5V to 5.5V) allowed; can be powered directly off Li-Ion battery.

***FIGURE 6:*** *TC1142/TCM828 implementation.*

## TC1142/TCM829 IMPLEMENTATION

Figure 7 shows a two-chip inverter solution using Microchip's TC1142-5.0 and TCM829. This implementation is almost identical to the TC1142/TCM828 approach, with the only difference being that the TCM829 switches at a higher frequency (35 kHz) than the TCM828. This allows the designer to use smaller external capacitors on the TCM829. The total active supply current for this solution is approximately 315 µA.




**Notes:**

1. Requires one SOT-23A-5 package and one 8-pin MSOP, 24.5 sq. millimeters total.
2. Requires two 3.3 µF, one 4.7 µF, and two 0.47 µF tantalum capacitors.
3. Total active supply current approximately 315 µA.
4. Charge pump switching frequency: 200 kHz for TC1142, 35 kHz for TCM829.
5. Shutdown mode available; total supply current in shutdown mode approximately 0.2 µA.
6. TC1142 provides regulated voltage output.
7. Unregulated input voltage (2.5V to 5.5V) allowed; can be powered directly off Li-Ion battery.

***FIGURE 7:*** *TC1142/TCM829 implementation.*

## SUMMARY

There are many methods of implementing an inverting voltage doubler function using Microchip's power management ICs. Table 1 summarizes each approach and identifies the advantages and disadvantages of each.

Newer state-of-the-art components, such as the TCM828, TCM829, TC1219, TC1220 and TC1142, are providing designers of battery-powered instrumentation with greater circuit flexibility than the older traditional TC682 method of implementing a negative DC bias. Designers now can select the most optimal solution that best meets the technical criteria of their systems.

**TABLE 1: INVERTING DOUBLER TECHNICAL SUMMARY**

| Approach | IC Area (sq. mm) | # Caps | Active Supply Current (µA) | Switching Frequency (KHz) | Shutdown | Regulated Input Required | Primary Advantage(s) | Primary Disadvantage(s) |
|---|---|---|---|---|---|---|---|---|
| (1) TC682 | 32 | 3 | 185 | 12 | No | Yes | Component Count | No Shutdown/ Physical Area/ Supply Current/ Regulated Supply Required |
| (2) TCM828 | 18 | 4 | 100 | 12 | No | Yes | Supply Current | No Shutdown/ Regulated Supply Required |
| (2) TCM829 | 18 | 4 | 230 | 35 | No | Yes | Physical Area | No Shutdown/ Regulated Supply Required |
| (2) TC1219s | 18 | 4 | 120 | 12 | Yes | Yes | Supply Current/ Shutdown | Regulated Supply Required |
| (2) TC1220s | 18 | 4 | 230 | 35 | Yes | Yes | Physical Area/ Shutdown | Regulated Supply Required |
| (1) TC1142/ (1) TCM828 | 24.5 | 5 | 250 | 200/12 | Yes | No | Unregulated Input Allowed/ Shutdown | Active Supply Current |
| (1) TC1142/ (1) TCM829 | 24.5 | 5 | 315 | 200/35 | Yes | No | Unregulated Input Allowed/ Shutdown | Active Supply Current |

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