

1. INTRODUCTION

This specification describes the requirements for application of the Touch Control Technology (TCT) microcontroller line of products. Patent number US 5,760,715 (June 2, 1998) applies to these products. Subject part numbers are listed in Table 1.

The TCT microcontroller detects a touch condition on various numbers of keys per Table 1. The TCT microcontroller detects a touch presence directly on a conductive keypad or through dielectric material. The dielectric can be of various materials and thicknesses. The sensors under the dielectric are conductive plates. TCT controllers can be used in a wide variety of touch control applications such as:

- Touch panel keypads
- Membrane keypad replacement
- Tactile switch replacement
- Appliance Controls

The TCT microcontrollers are ready for operation without any calibration or other preliminary actions by the user. Typically only one sensitivity adjustment is required during keypad design and development; depending on the particular assembly design.

Tyco encourages customers to contact the Tyco TCT Design Centre with any questions and for customer circuit design consultation. Please send email messages to: tct@tycoelectronics.com
Inquiries are free of charge.

Part Number	Package	Maximum Number of Keys	Output Format	Notes
1710094-1	SOIC-20	10	Binary or 2x5 Matrix	See dwg.1710094
1710094-2	SOIC-20	10	Binary or 2x5 Matrix	Rated for 105°C
1710084-1	SOIC-20	15	Binary or 3x5 Matrix	See dwg.1710084
1710084-2	SOIC-20	15	Binary or 3x5 Matrix	Rated for 105°C
1710098-1	TQFP-32	24	Binary or 4x6 Matrix	See dwg.1710098
1710098-2	TQFP-32	24	Binary or 4x6 Matrix	Rated for 105°C
1710095-1	TQFP-32	36	Binary or 6x6 Matrix	See dwg.1710095
1710095-2	TQFP-32	36	Binary or 6x6 Matrix	Rated for 105°C
1710085-1	TQFP-32	56	Binary or 7x8 Matrix	See dwg.1710085
1710085-2	TQFP-32	56	Binary or 7x8 Matrix	Rated for 105°C

Table 1: TCT Microcontroller Part Numbers

Note: All parts are JEDEC standard compliant

2. REFERENCE MATERIAL

2.1 Revision Summary

This paragraph is reserved for a revision summary of changes and additions made to this specification. The following changes were made for this revision.

Rev F per EC LCD0-0069-04

- Section additions

2.2 Engineering Drawings

Tyco Customer drawings are available for part numbers listed in Table 1 and can be obtained from the Tyco service network. The information contained in Customer drawings takes priority if there is a conflict with this specification or with any other technical documentation supplied by Tyco Electronics.

2.3 Specifications

Tyco Product Specifications provide performance and test information. The Product Specification for this product is 108-47010, Touch Control Technology (TCT) Microcontrollers.

3. REQUIREMENTS

The following sections contain information and instructions required for the application of the subject product.

3.1 Input Requirements

The applicable sensor elements are connected to customer-supplied circuitry as shown in Figure 1 thru Figure 5. If a reduced matrix is used, the TCT microcontroller must be connected as follows:

If an entire row is removed, do not connect corresponding pin ROWx.

If an entire column is removed, connect corresponding pin COLx to circuit ground GND.

Using incomplete rows and/or columns is also possible.

Regardless of the specific matrix used, the generating output binary or matrix code will always be as shown in the binary output table (Table 4). The supply DC voltages are +5V and +24V, isolated or not depending on the application.

Touch control technology uses Earth ground as a touch signal conductive media. Consequently, the TCT keypad cannot use earth-ground as a reference ground for its own DC power supply. A short circuit condition will exist for the TCT keypad touch signal if an isolated power supply is not used (see section 3.8 for isolating circuit recommendations).

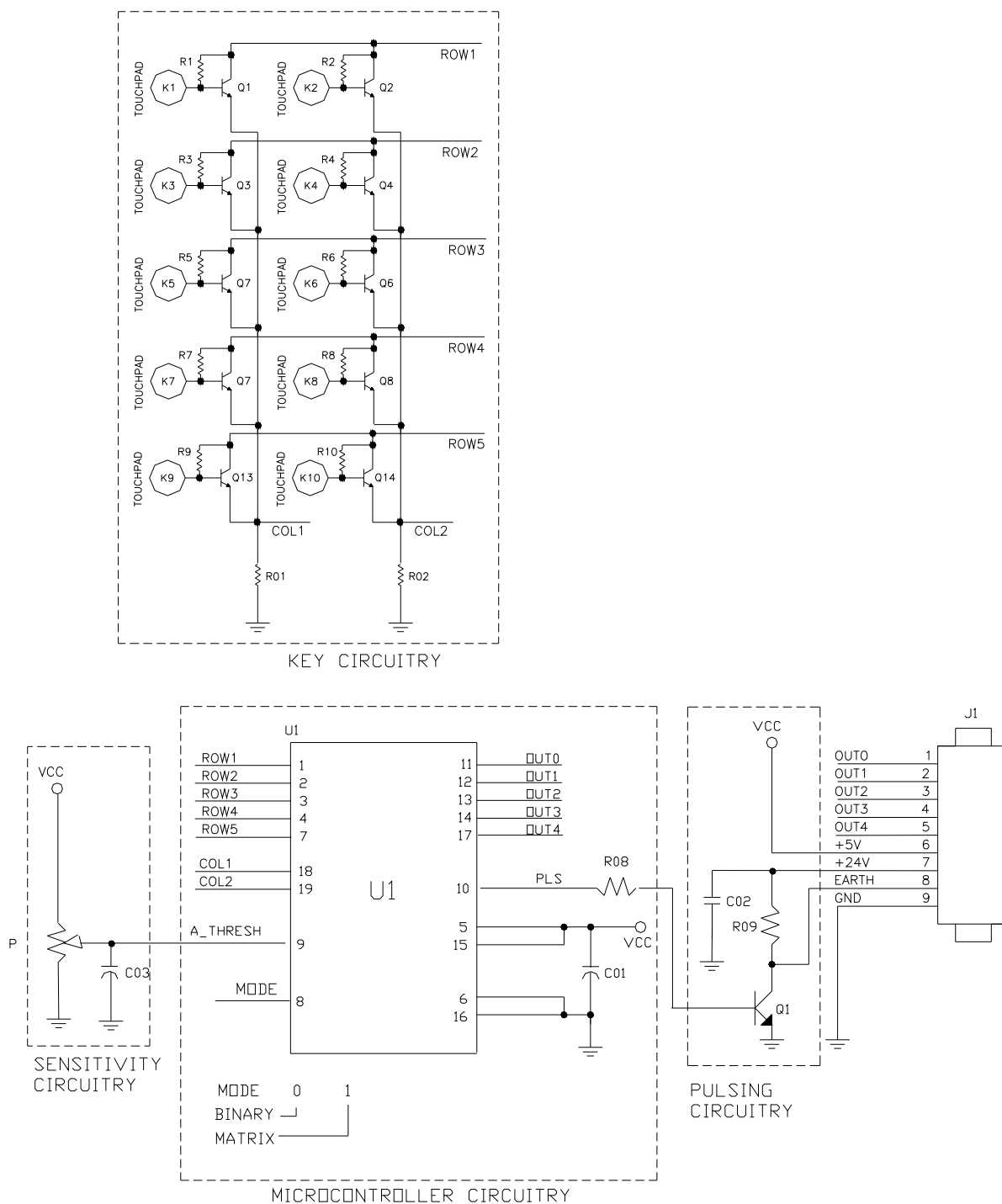
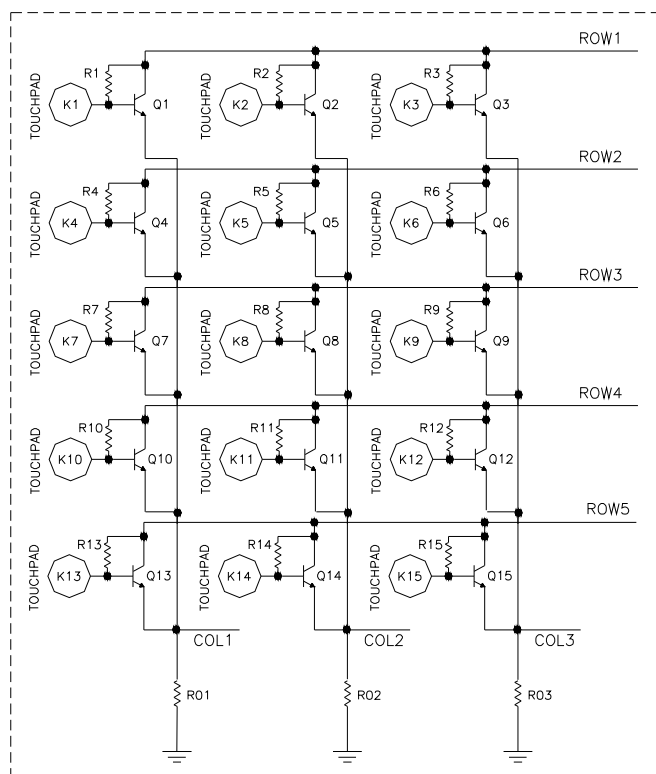


Figure 1: Typical Application Circuit for part 1710094-1 & -2



KEY CIRCUITRY

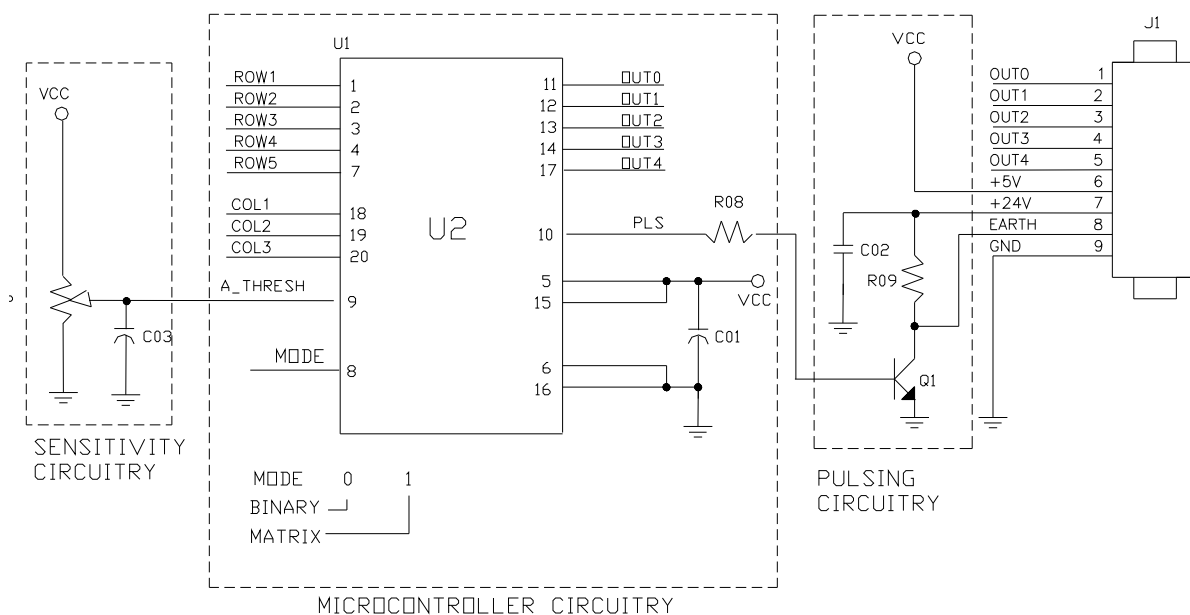


Figure 2: Typical Application Circuit for part 1710084-1 & -2

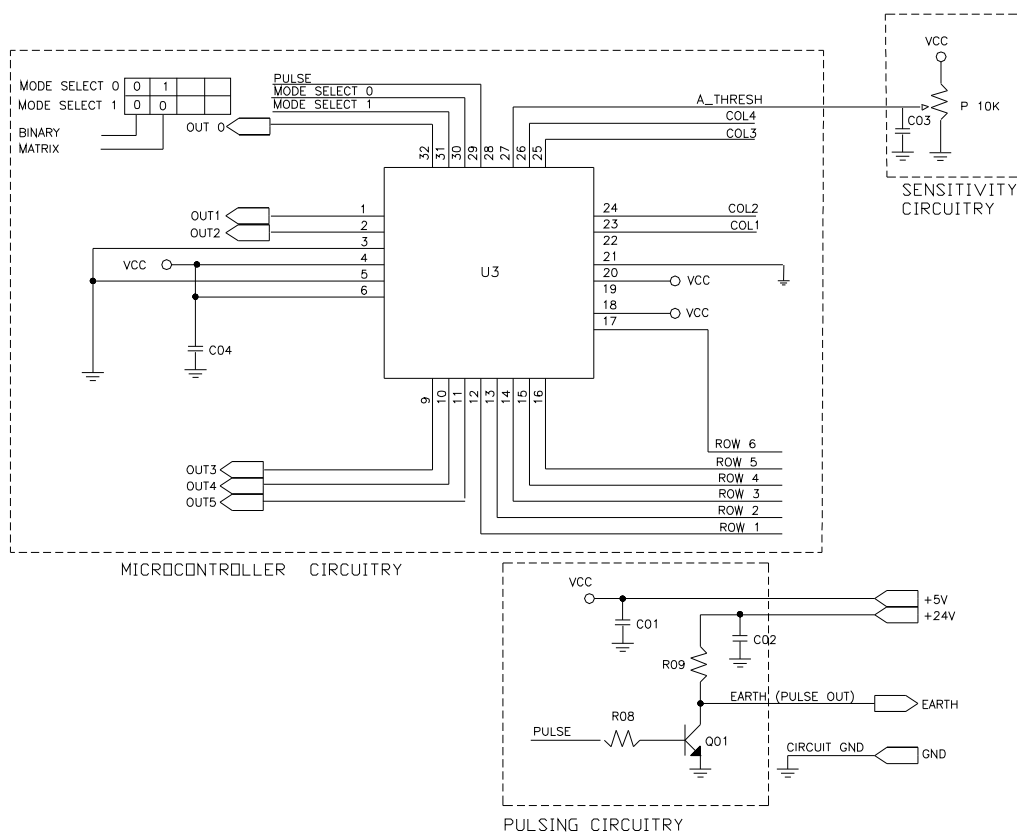
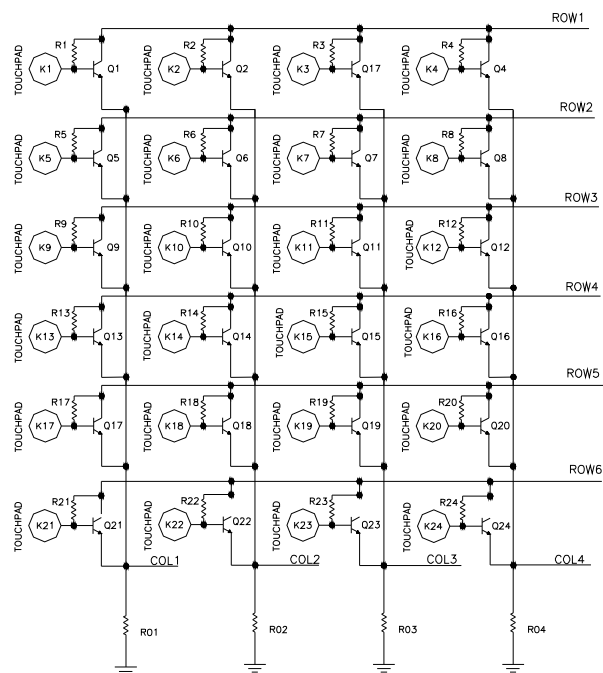


Figure 3: Typical Application Circuit for part 1710098-1 & -2

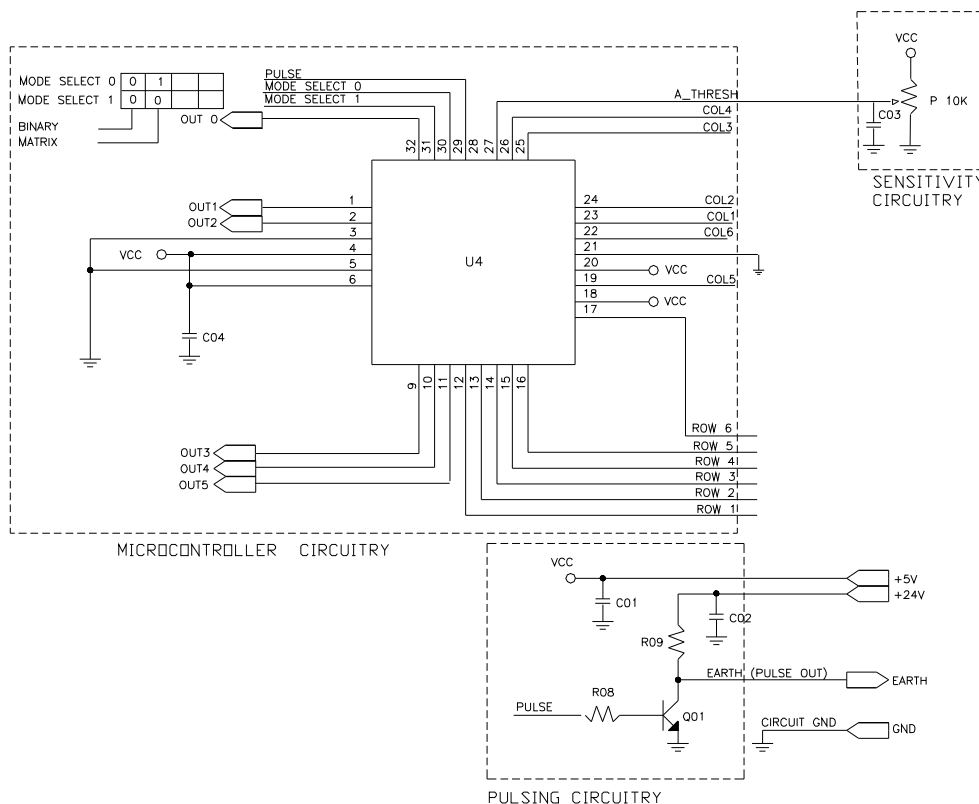
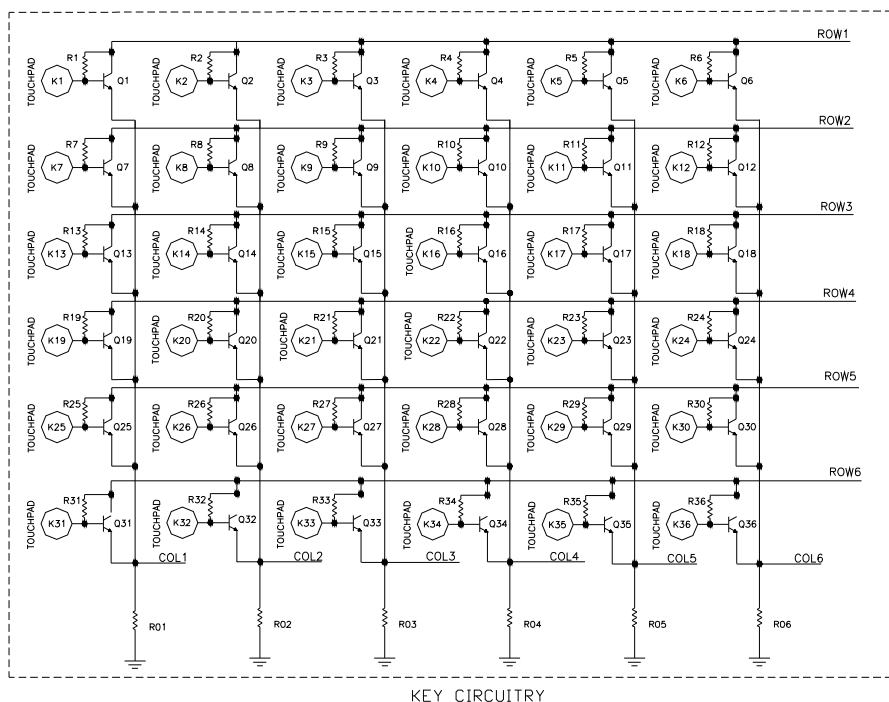
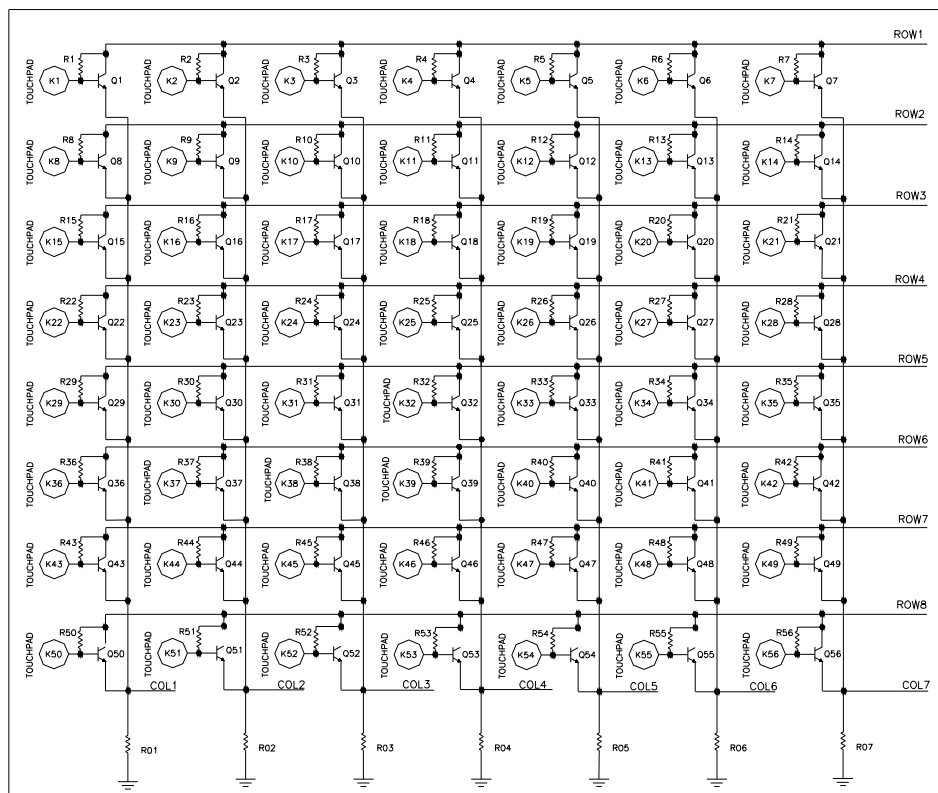


Figure 4: Typical Application Circuit for part 1710095-1 & -2



KEY CIRCUITRY

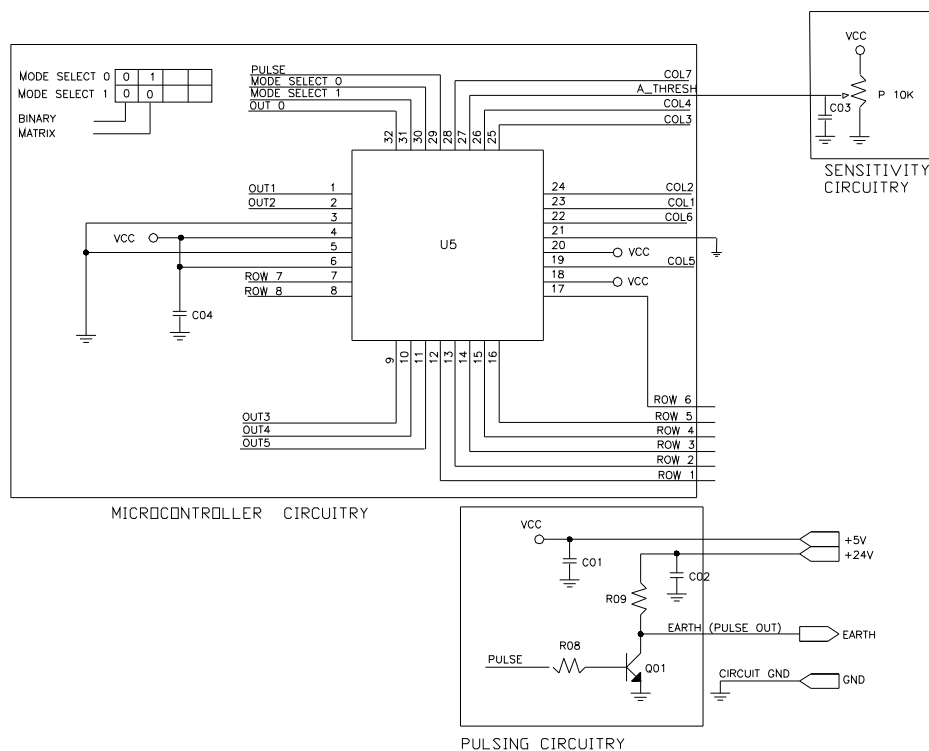


Figure 5: Typical Application Circuit for part 1710085-1 & -2

COMPONENT DESCRIPTION *	PCB DESIGNATOR	QUANTITY				
		10 Key	15 Key	24 Key	36 Key	56 Key
TRANSISTOR, MMBT 3904** Off transient delay time less than 0.5 micro-seconds.	Q1 to Q56 & Q01	11	16	25	37	57
SENSITIVITY POTENTIOMETER 10K 5 TURNS	P	1	1	1	1	1
CAPACITOR, 0.1Uf, 50V, SMT 1206	C01 to C04	3	3	4	4	4
RESISTOR, 10K, 1/8W, SMT 1206	R09	1	1	1	1	1
RESISTOR, 4.75K, 1%, SMT 1206	R01 to R08	3	4	5	7	8
RESISTOR, 5.6M, 1%, SMT 1206	R1 to R56	10	15	24	36	56
TCT Microcontroller	U1 to U5	1	1	1	1	1

Table 2: Component List

* - Deviation from recommended components may cause product malfunction. Please contact the Tyco TCT Design Centre for component consultation and recommendations. Send email messages to: tct@tycoelectronics.com

** - Transistors from Fairchild Semiconductor and ST Electronics have been used successfully with Tyco TCT.

3.2 Pin Description

GND:	Circuit Ground 0V
VCC:	Supply voltage +5Vdc
COL1-COL7:	Matrix keys columns (Input)
ROW1-ROW8:	Matrix keys rows (Output)
OUT1-OUT6:	Outputs
A_THRESH:	Analogue Threshold sensitivity adjustment (Input)
MODE SELECT x:	Output mode select
PLS:	Pulse Output

3.3 Electrical Description

- A. Hi-performance, 8 bit microcontroller.
- B. Internal On-chip RESET and CLOCK generator.
- C. Binary or matrix output interface.

Symbol	Parameter	Min	Typ	Max
VOH	Output High Voltage	4.2V		-
VOL	Output Low Voltage	-	-	0.6V
ICC	Supply current	-	20 to 25mA	-

Table 3: General Electrical Specifications

3.4 Mechanical Description

Package dimensions are shown on the applicable Customer drawing. Refer to Table 1

3.5 Output Information

The microcontroller can output binary or matrix coded signals depending on the Mode pin connection. If the microcontroller's A_Thresh pin is connected to Vcc the output will be matrix coded and if the A_Thresh pin is grounded, the output signals will be binary coded.

3.5.1 Binary output

The TCT microcontroller output represents the following key touch states: no touch, touch and error (more than one key at the same time). In the case of a normal touch, the TCT microcontroller will output the binary code of the touched key. In the case of no touch or error, the output is "0". The output chart for 56 key matrix configurations is shown below in Table 4. The output for fewer numbers of keys is identical up to maximum number of keys for that TCT version.

For particular applications where the host circuit DC voltage must be Earth grounded the use of a DC- DC converter and opto-couplers is needed to achieve touch signal isolation (see section 3.8 for isolating circuit recommendations).

KEY	OUTPUT					
	5	4	3	2	1	0
1	0	0	0	0	0	1
2	0	0	0	0	1	0
3	0	0	0	0	1	1
4	0	0	0	1	0	0
5	0	0	0	1	0	1
6	0	0	0	1	1	0
7	0	0	0	1	1	1
8	0	0	1	0	0	0
9	0	0	1	0	0	1
10	0	0	1	0	1	0
11	0	0	1	0	1	1
12	0	0	1	1	0	0
13	0	0	1	1	0	1
14	0	0	1	1	1	0
15	0	0	1	1	1	1
16	0	1	0	0	0	0
17	0	1	0	0	0	1
18	0	1	0	0	1	0
19	0	1	0	0	1	1
20	0	1	0	1	0	0
21	0	1	0	1	0	1
22	0	1	0	1	1	0
23	0	1	0	1	1	1
24	0	1	1	0	0	0
25	0	1	1	0	0	1
26	0	1	1	0	1	0
27	0	1	1	0	1	1
29	0	1	1	1	0	1
30	0	1	1	1	1	0

KEY	OUTPUT					
	5	4	3	2	1	0
31	0	1	1	1	1	1
32	1	0	0	0	0	0
33	1	0	0	0	0	1
34	1	0	0	0	1	0
35	1	0	0	0	1	1
36	1	0	0	1	0	0
37	1	0	0	1	0	1
38	1	0	0	1	1	0
39	1	0	0	1	1	1
40	1	0	1	0	0	0
41	1	0	1	0	0	1
42	1	0	1	0	1	0
43	1	0	1	0	1	1
44	1	0	1	1	0	0
45	1	0	1	1	0	1
46	1	0	1	1	1	0
47	1	0	1	1	1	1
48	1	1	0	0	0	0
49	1	1	0	0	0	1
50	1	1	0	0	1	0
51	1	1	0	0	1	1
52	1	1	0	1	0	0
53	1	1	0	1	0	1
54	1	1	0	1	1	0
55	1	1	0	1	1	1
56	1	1	1	0	0	0
ERR	1	1	1	1	1	1
No Key	0	0	0	0	0	0

Table 4: Binary Output

3.5.2 Matrix Output

The TCT microcontroller matrix output represents the following key touch states: no touch, touch and error (more than one key touched simultaneously). Matrix signals are used with analogue MUX (HCF-4051 type) for direct membrane keypad replacement. During the touch condition, the TCT microcontroller will output the matrix code needed to emulate the membrane code. In the case of no touch or error, no output will be generated. The output chart for 10, 15, 24, 36 and 56 keys matrix configurations are shown below in Table 5, 6, 7, 8 and 9

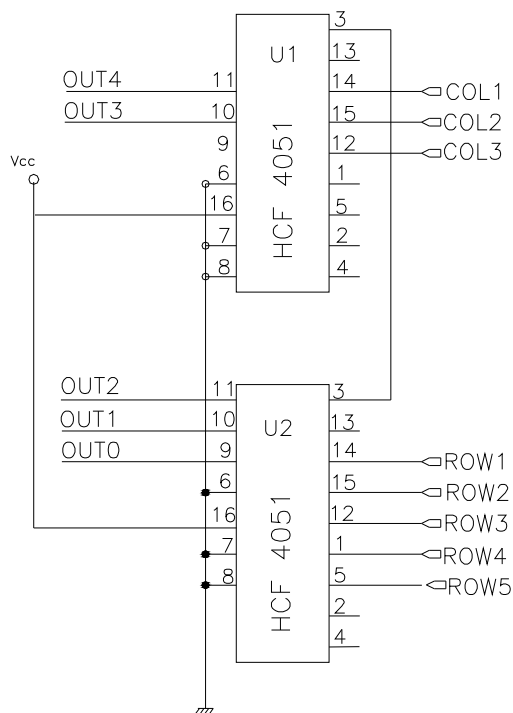


Figure 6: 10 and 15 Key Matrix Output

For particular applications the use of opto-couplers is needed to achieve isolation (see section 3.8 for isolating circuit recommendations).

3.5.3 Customized Output

Output configurations other than binary or matrix are also available. Serial protocols, for example, can be easily implemented. Please contact the Tyco TCT Design Centre for custom output configurations. Send email messages to: tct@tycoelectronics.com

KEY	OUTPUT				
	4	3	2	1	0
1	1	0	1	0	0
2	0	1	1	0	0
3	1	0	0	1	0
4	0	1	0	1	0
5	1	0	1	1	0

KEY	OUTPUT				
	4	3	2	1	0
6	0	1	1	1	0
7	1	0	0	0	1
8	0	1	0	0	1
9	1	0	1	0	1
10	0	1	1	0	1
NO KEY	0	0	0	0	0

Table 5: 10 Key Matrix Output

KEY	OUTPUT				
	4	3	2	1	0
1	1	0	1	0	0
2	0	1	1	0	0
3	1	1	1	0	0
4	1	0	0	1	0
5	0	1	0	1	0
6	1	1	0	1	0
7	1	0	1	1	0
8	0	1	1	1	0

KEY	OUTPUT				
	4	3	2	1	0
9	1	1	1	1	0
10	1	0	0	0	1
11	0	1	0	0	1
12	1	1	0	0	1
13	1	0	1	0	1
14	0	1	1	0	1
15	1	1	1	0	1
NO KEY	0	0	0	0	0

Table 6: 15 Key Matrix Output

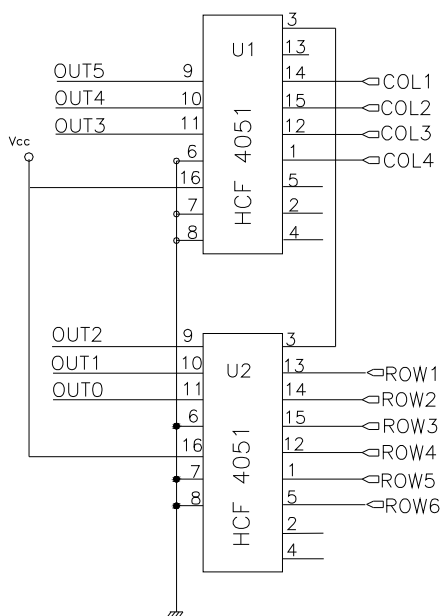


Figure 7: 24 Key Matrix Output

KEY	OUTPUT					
	5	4	3	2	1	0
1	0	0	1	0	0	0
2	0	1	0	0	0	0
3	0	1	1	0	0	0
4	1	0	0	0	0	0
5	0	0	1	0	0	1
6	0	1	0	0	0	1
7	0	1	1	0	0	1
8	1	0	0	0	0	1
9	0	0	1	0	1	0
10	0	1	0	0	1	0
11	0	1	1	0	1	0
12	1	0	0	0	1	0

KEY	OUTPUT					
	5	4	3	2	1	0
13	0	0	1	0	1	1
14	0	1	0	0	1	1
15	0	1	1	0	1	1
16	1	0	0	0	1	1
17	0	0	1	1	0	0
18	0	1	0	1	0	0
19	0	1	1	1	0	0
20	1	0	0	1	0	0
21	0	0	1	1	0	1
22	0	1	0	1	0	1
23	0	1	1	1	0	1
24	1	0	0	1	0	1
NO KEY	0	0	0	0	0	0

Table 7: 24 Key Matrix Output

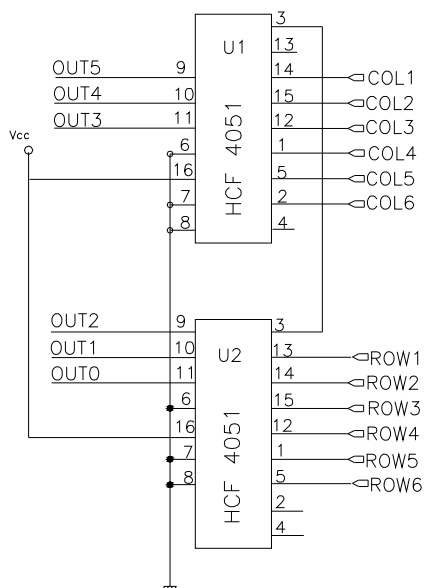


Figure 8: 36 Key Matrix Output

KEY	OUTPUT					
	5	4	3	2	1	0
1	0	0	1	0	0	0
2	0	1	0	0	0	0
3	0	1	1	0	0	0
4	1	0	0	0	0	0
5	1	0	1	0	0	0
6	1	1	0	0	0	0
7	0	0	1	0	0	1
8	0	1	0	0	0	1
9	0	1	1	0	0	1
10	1	0	0	0	0	1
11	1	0	1	0	0	1
12	1	1	0	0	0	1
13	0	0	1	0	1	0
14	0	1	0	0	1	0
15	0	1	1	0	1	0
16	1	0	0	0	1	0
17	1	0	1	0	1	0
18	1	1	0	0	1	0

KEY	OUTPUT					
	5	4	3	2	1	0
19	0	0	1	0	1	1
20	0	1	0	0	1	1
21	0	1	1	0	1	1
22	1	0	0	0	1	1
23	1	0	1	0	1	1
24	1	1	0	0	1	1
25	0	0	1	1	0	0
26	0	1	0	1	0	0
27	0	1	1	1	0	0
28	1	0	0	1	0	0
29	1	0	1	1	0	0
30	1	1	0	1	0	0
31	0	0	1	1	0	1
32	0	1	0	1	0	1
33	0	1	1	1	0	1
34	1	0	0	1	0	1
35	1	0	1	1	0	1
36	1	1	0	1	0	1
NO KEY	0	0	0	0	0	0

Table 8: 36 Key Matrix Output

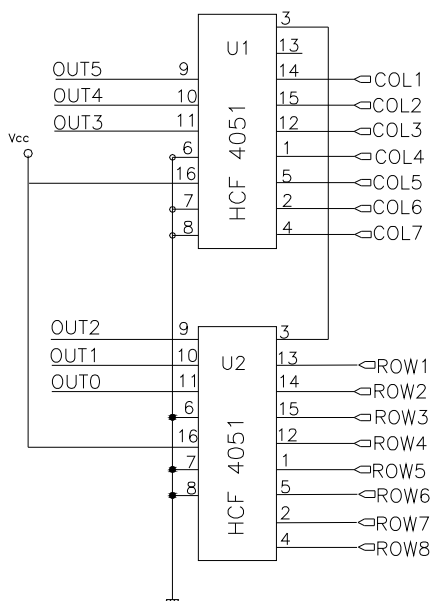


Figure 9: 56 Key Matrix Output

KEY	OUTPUT					
	5	4	3	2	1	0
1	0	0	1	0	0	0
2	0	1	0	0	0	0
3	0	1	1	0	0	0
4	1	0	0	0	0	0
5	1	0	1	0	0	0
6	1	1	0	0	0	0
7	1	1	1	0	0	0
8	0	0	1	0	0	1
9	0	1	0	0	0	1
10	0	1	1	0	0	1
11	1	0	0	0	0	1
12	1	0	1	0	0	1
13	1	1	0	0	0	1
14	1	1	1	0	0	1
15	0	0	1	0	1	0
16	0	1	0	0	1	0
17	0	1	1	0	1	0
18	1	0	0	0	1	0
19	1	0	1	0	1	0
20	1	1	0	0	1	0
21	1	1	1	0	1	0
22	0	0	1	0	1	1
23	0	1	0	0	1	1
24	0	1	1	0	1	1
25	1	0	0	0	1	1
26	1	0	1	0	1	1
27	1	1	0	0	1	1
28	1	1	1	0	1	1
29	0	0	1	1	0	0
30	0	1	0	1	0	0

KEY	OUTPUT					
	5	4	3	2	1	0
31	0	1	1	1	0	0
32	1	0	0	1	0	0
33	1	0	1	1	0	0
34	1	1	0	1	0	0
35	1	1	1	1	0	0
36	0	0	1	1	0	1
37	0	1	0	1	0	1
38	0	1	1	1	0	1
39	1	0	0	1	0	1
40	1	0	1	1	0	1
41	1	1	0	1	0	1
42	1	1	1	1	0	1
43	0	0	1	1	1	0
44	0	1	0	1	1	0
45	0	1	1	1	1	0
46	1	0	0	1	1	0
47	1	0	1	1	1	0
48	1	1	0	1	1	0
49	1	1	1	1	1	0
50	0	0	1	1	1	1
51	0	1	0	1	1	1
52	0	1	1	1	1	1
53	1	0	0	1	1	1
54	1	0	1	1	1	1
55	1	1	0	1	1	1
56	1	1	1	1	1	1
NO KEY	0	0	0	0	0	0

Table 9: 56 Key Matrix Output

3.6 Sensitivity Configuration

The overall touch sensitivity can be adjustable or fixed. Typically, sensitivity is adjusted during keypad design until the desired sensitivity is reached. A fixed sensitivity is then used in the final design.

Sensitivity adjustment is achieved by providing a DC voltage on the A_THRESH pin between 0.1V to 3.8V DC. Other factors, such as sensing element geometry and touch surface design, will also affect key sensitivity. See Figure 10 for adjustable or fixed sensitivity information.

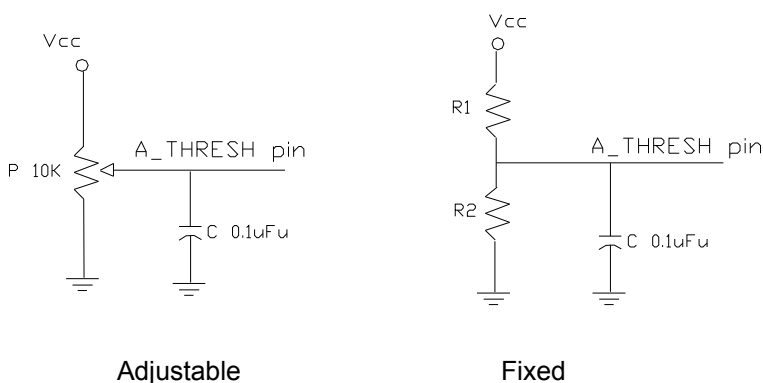


Figure 10: Sensitivity Configuration

3.7 Printed Circuit Design Requirements

TCT circuitry can be implemented on a variety of substrates. Rigid boards such as FR-4 and CEM-1 are typically used as well as flexible substrates such as polyester films.

In general, specification IPC 6012, Qualification and Performance Specification for Rigid Printed Boards, is to be followed.

The following rules and guidelines contained in the following sections should be used when designing circuit boards using Touch Control Technology.

3.7.1 Key Circuitry

The circuit board will typically have two or more layers. The top layer contains only the sensing elements and the grounding shield for the Analog Signal (AS) traces. A standard Printed Circuit Board (PCB) thickness of 1.6mm (0.062 in.) is recommended but not required. Single sided PCBs have been used successfully however care must be taken to ensure the PCB is not exposed to ground fields.

3.7.2 Microcontroller Circuitry

AS trace routing should be designed to maintain the analog signal integrity between key sensors and the TCT microcontroller.

AS trace width should be 0.6mm (0.025 in.) or less and the trace spacing should be 0.3mm (0.012 in.) or more. AS traces should exist only under the top ground plane shield. AS traces should not run parallel to clock or digital signal traces. Digital and AS traces should be designed for maximum separation. AS traces should also be separated from the pulse circuit to the greatest extent possible.

3.7.3 Key Circuitry

Key sensing element sizes usually range from 6mm (0.25 in.) to 13mm (0.5 in.) in diameter. The key is typically solid copper with a centered via to the transistor base. Typical spacing between keypad and surrounding ground shield is 2mm (0.075 in.). It is recommended that the ground plane shield surround the sensing element to minimize key sensitivity on the non-key side of the PCB. See Figure 11 for details.

Sensing elements should be shielded as much as possible to avoid cross talk with the pulse-generating transistor.

3.7.4 Pulsing Circuitry

Decoupling capacitors must be located as close as possible to active circuitry. Place a 0.1 uF decoupling capacitor near each Vcc pin. Place a 0.1 uF capacitor close to the pulse load resistor.

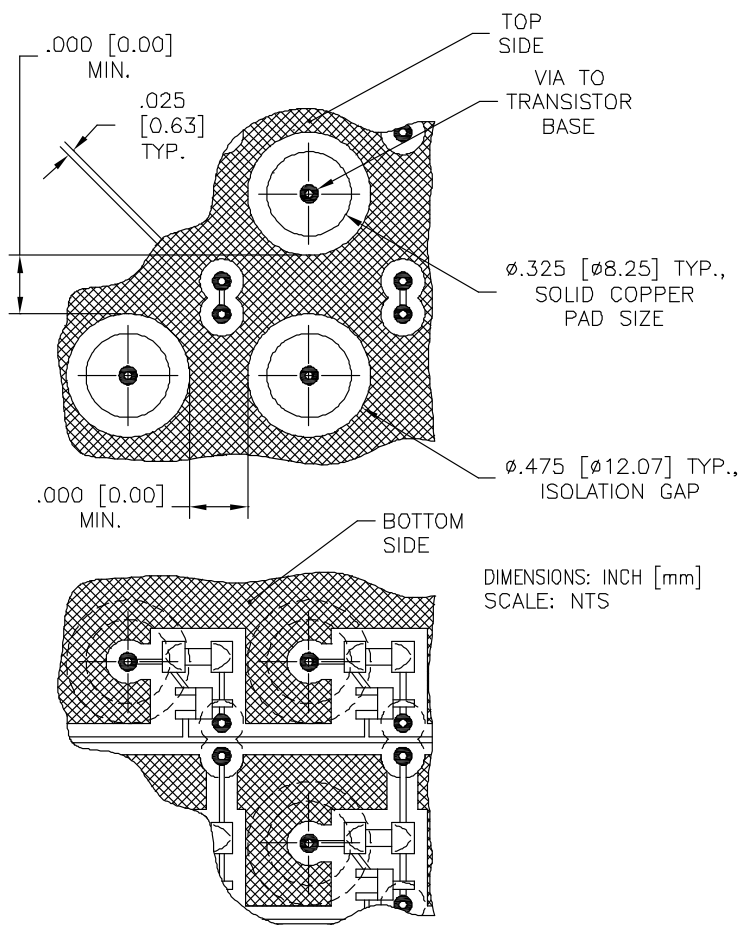


Figure 11: Key pad geometry example

3.8 Isolation Circuitry for TCT keypads

Touch Control Technology uses earth-ground as a touch signal conductive media. Consequently, the TCT keypad cannot use earth-ground as a reference ground for its own DC power supply. A short circuit condition will exist for the TCT keypad touch signal if an isolated power supply is not used.

If the DC power supply is earth-grounded, chassis connected, or both, then the TCT keypad must have both DC and AC isolation:

- DC isolation is defined as having no galvanic connections between the keypad's DC power supply and the remaining electronic circuit. DC isolation requires isolation resistance greater than 100Kohms. DC isolation can be checked with a simple Ohmmeter.
- AC isolation should be checked using a capacitance meter. AC isolation requires capacitance values less than 100pF.

Either of the following two techniques can be used to achieve an isolated power supply:

1. A separate power transformer (max 2VA)
2. A DC-DC converter that does not exhibit capacitance between primary and secondary.

At the keypad output, the use of phototransistors is recommended to achieve isolation.

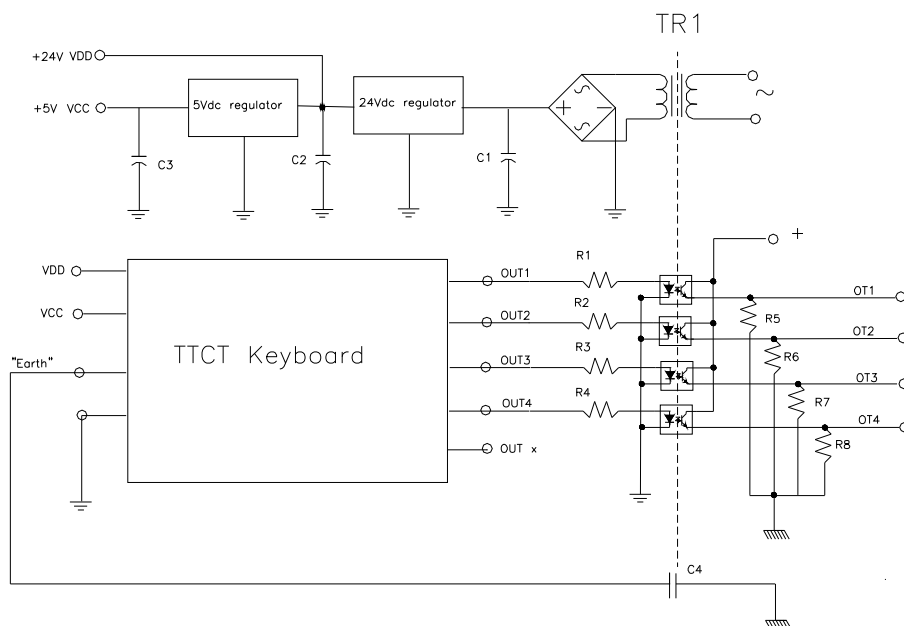


Figure 12: Isolation Circuit using a transformer

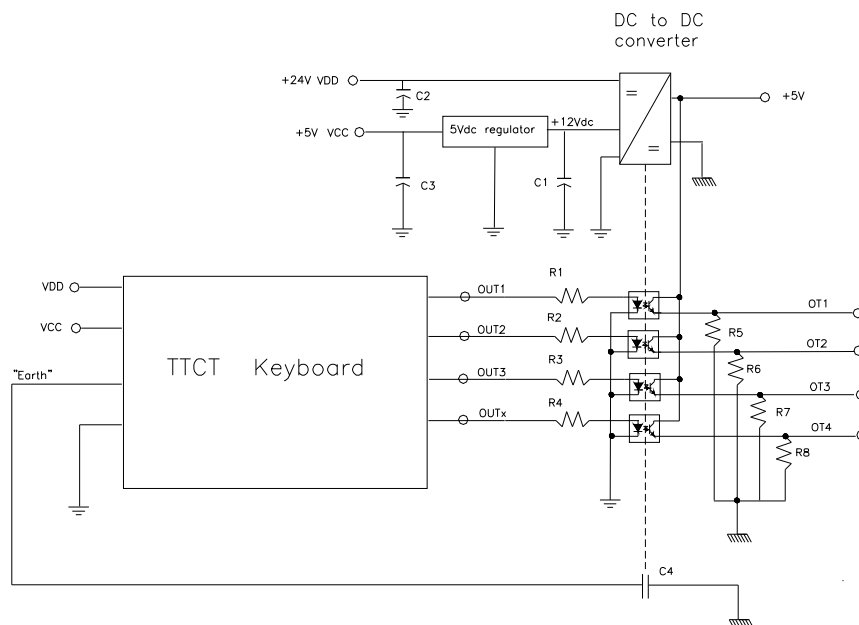


Figure 13: Isolation circuit using a DC to DC Converter

4. QUALIFICATION

The product described in this specification are tested per Tyco Product Specification 108-47010.

5. TOOLING

Special tooling is not required for this line of products.