Exhibit 4.

3.2 Block diagram

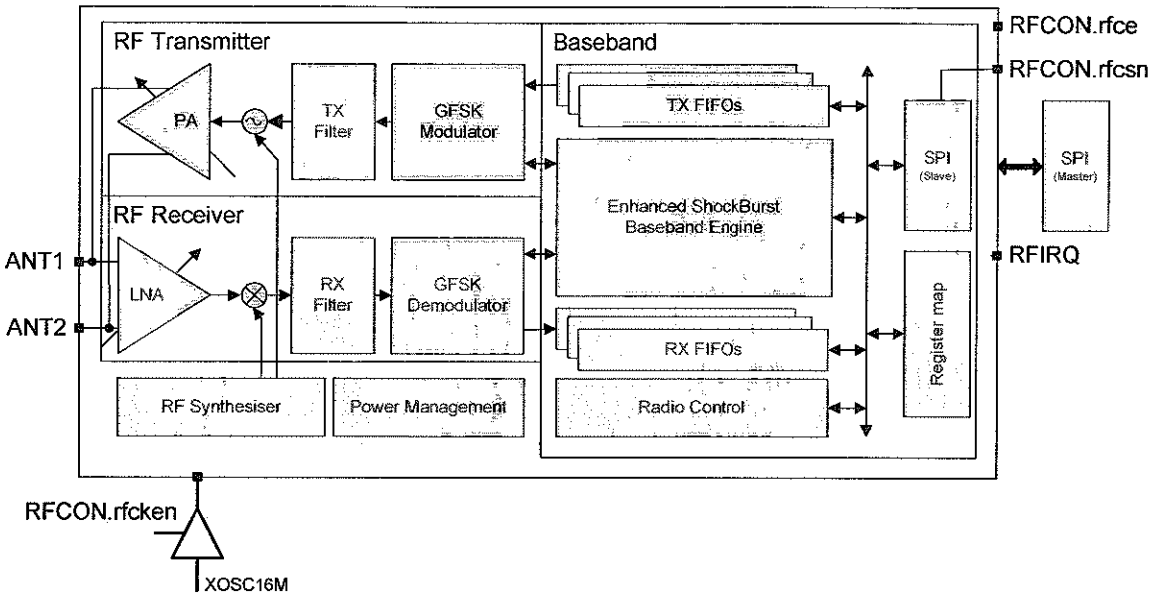


Figure 5. RF transceiver block diagram

3.3 Functional description

This section describes the different operating modes of the RF transceiver and the parameters used to control it.

The RF transceiver module has a built-in state machine that controls the transitions between the different operating modes. The state machine is controlled by SFR register `RFCON` and RF transceiver register `CONFIG`, see section 3.5 for details.

3.3.1 Operational Modes

You can configure the RF transceiver to power down, standby, RX and TX mode. This section describes these modes in detail.

3.3.1.1 State diagram

The state diagram (Figure 6.) shows the operating modes of the RF transceiver and how they function. At the end of the reset sequence the RF transceiver enters Power Down mode. When the RF transceiver enters Power Down mode the MCU can still control the module through the SPI and the `rfcsn` bit in the `RFCON` register.

There are three types of distinct states highlighted in the state diagram:

- **Recommended operating mode:** is a recommended state used during normal operation.
- **Possible operating mode:** is a possible operating state, but is not used during normal operation.
- **Transition state:** is a time limited state used during start up of the oscillator and settling of the PLL.

13 On-chip oscillators

The nRF24LE1 contains two high frequency oscillators and two low frequency oscillators. The primary high frequency clock source is a 16 MHz crystal oscillator. There is also a fast starting 16 MHz RC oscillator, which is used primarily to provide the system with a high frequency clock while it is waiting for the crystal oscillator to start up. The low frequency clock can be supplied by either a 32.768 kHz crystal oscillator or a 32.768 kHz RC oscillator. External 16 MHz and 32.768 kHz clocks may also be used instead of the on-chip oscillators. See section 11.3.1 on page 110 for control of the clock sources.

13.1 Features

- Low-power amplitude regulated 16 MHz crystal oscillator
- Fast starting 16 MHz RC oscillator with ±5% frequency accuracy
- Ultra low-power amplitude regulated 32.768 kHz crystal oscillator
- Ultra low-power 32.768 kHz RC oscillator with ±10% frequency accuracy

13.2 Block diagrams

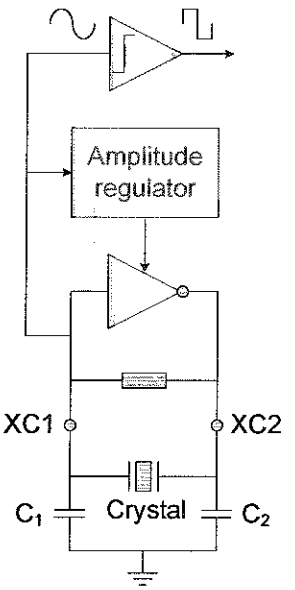


Figure 54. Block diagram of 16 MHz crystal oscillator

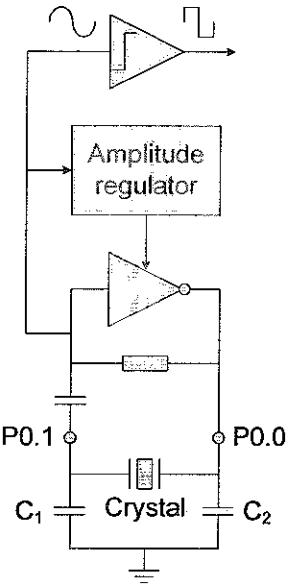


Figure 55. Block diagram of 32.768 kHz crystal oscillator

13.3 Functional description

13.3.1 16 MHz crystal oscillator

The 16 MHz crystal oscillator (XOSC16M) is designed to be used with an AT-cut quartz crystal in parallel resonant mode. To achieve correct oscillation frequency it is very important that the load capacitance matches the specification in the crystal datasheet. The load capacitance is the total capacitance seen by the crystal across its terminals:

$$C_{LOAD} = \frac{C_1' \cdot C_2'}{C_1' + C_2'}$$

$$C_1' = C_1 + C_{PCB1} + C_{PIN}$$

$$C_2' = C_2 + C_{PCB2} + C_{PIN}$$

C1 and C2 are ceramic SMD capacitors connected between each crystal terminal and VSS, CPCB1 and CPCB2 are stray capacitances on the PCB, while CPIN is the input capacitance on the `XC1` and `XC2` pins of the nRF24LE1 (typically 1pF). C1 and C2 should be of the same value, or as close as possible.

To ensure a functional radio link the frequency accuracy must be ±60 ppm or better. The initial tolerance of the crystal, drift over temperature, aging and frequency pulling due to incorrect load capacitance must all be taken into account. For reliable operation the crystal load capacitance, shunt capacitance, equivalent series resistance (ESR) and drive level must comply with the specifications in Table 114. on page 182. It is recommended to use a crystal with lower than maximum ESR if the load capacitance and/or shunt capacitance is high. This will give faster start-up and lower current consumption.

The start-up time is typically about 1 ms for a crystal with 9 pF load capacitance and an ESR specification

of 60 Ω max. This value is valid for crystals in a 3.2×2.5 mm can. If you use the smallest crystal cans (like 2.0×2.5 mm), pay particular attention to the startup time of the crystal. These crystals have a longer startup than crystals in larger cans. To make sure the startup time is <1.5 ms use a crystal for load capacitance of 6pF. A low load capacitance will reduce both startup time and current consumption. For more details regarding how to measure the startup of a specific crystal, please see the nAN24-13 application note.

The crystal oscillator is normally running only when the system is in active or standby mode. It is possible to keep it on in register retention mode as well, by writing a '1' to bit 7 in the CLKCTRL register (see Table 57. on page 105). This is recommended if the system is expected to wake up again in less than 5 ms. The reason is that the additional current drawn during start-up makes it more power-efficient to let the oscillator run for a few extra milliseconds than to restart it.

13.3.2 16 MHz RC oscillator

The 16 MHz RC oscillator (RCOSC16M) is used primarily to provide a high speed clock while the crystal oscillator is starting up. It starts in just a few microseconds, and has a frequency accuracy of ±5%.

By default, the 16 MHz RC and crystal oscillators are started simultaneously. The RC oscillator supplies the clock until the crystal oscillator has stabilized. The system then makes an automatic switch to the crystal oscillator clock, and turns off the RC oscillator to save power. Bit 3 in the CLKCTRL register can be polled to check which oscillator is currently supplying the high speed clock.

The system can be configured to start only one of the two 16 MHz oscillators. Write bit 4 and 5 in the CLKCTRL register to choose the desired behavior. Note that the RF Transceiver cannot be used while the high frequency clock is sourced by the RC oscillator. The ADC may also have reduced performance.

13.3.3 External 16 MHz clock

The nRF24LE1 may be used with an external 16 MHz clock applied to the XC1 pin. Write a '1' to bit 6 in the CLKCTRL register if the external clock is a rail-to-rail digital signal (This is for test and application development involving no radio link, only. Bit 6 must be cleared in normal operation.) The input signal may also be analog, coming from e.g. the crystal oscillator of a microcontroller. In this case the crystal oscillator on the nRF24LE1 must also be enabled, since it is used to convert the analog input into a digital clock signal. CLKCTRL[6] must be '0', and CLKCTRL[5:4] must be '10' to enable the oscillator. An input amplitude of 0.8V peak-to-peak or higher is recommended to achieve low current consumption and a good signal-to-noise ratio. The DC level is not important as long as the applied signal never rises above VDD or drops below VSS. The XC1 pin will load the microcontrollers crystal with approximately 1pF in addition to PCB routing. XC2 shall not be connected.

Note: A frequency accuracy of ±60 ppm or better is required to get a functional radio link.

13.3.4 32.768 kHz crystal oscillator

The 32.768 kHz crystal oscillator (XOSC32K) is operational in all system modes except deep sleep and memory retention, timer off. It is enabled by writing '000' to CLKLFCTRL[2:0].

A crystal must be connected between port pins P0.0 and P0.1, which are automatically configured as crystal pins when the oscillator is enabled. To achieve correct oscillation frequency it is important that the load capacitance matches the specification in the crystal datasheet. The load capacitance is the total capacitance seen by the crystal across its terminals:

$$C_{LOAD} = \frac{C_1^{'} \cdot C_2^{'}}{C_1^{'} + C_2^{'}}$$

$$C_1^{'} = C_1 + C_{PCB1} + C_{PIN}$$

$$C_2^{'} = C_2 + C_{PCB2} + C_{PIN}$$

C_1 and C_2 are ceramic SMD capacitors connected between each crystal terminal and VSS, C_{PCB1} and C_{PCB2} are stray capacitances on the PCB, while C_{PIN} is the input capacitance on the P0.0 and P0.1 pins of the nRF24LE1 (typically 3pF when configured as crystal pins). C_1 and C_2 should be of the same value, or as close as possible. The oscillator uses an amplitude regulated design similar to the 16 MHz crystal oscillator. For reliable operation the crystal load capacitance, shunt capacitance, equivalent series resistance (ESR) and drive level must comply with the specifications in Table 114. on page 182. It is recommended to use a crystal with lower than maximum ESR if the load capacitance and/or shunt capacitance is high. This will give faster start-up and lower current consumption.

The start-up time is typically less than 0.5s for a crystal with 9pF load capacitance, 1pF shunt capacitance and an ESR of 50kΩ. Bit 6 in the CLKLFCTRL register can be polled to check if the oscillator is ready for use.

13.3.5 32.768 kHz RC oscillator

The low frequency clock may be generated by a 32.768 kHz RC oscillator (RCOSC32K) instead of the crystal oscillator, if a frequency accuracy of ±10% is sufficient. This saves the cost of a crystal, and also frees up P0.0 and P0.1 for other applications. The 32.768 kHz RC oscillator is enabled by writing '001' to CLKLFCTRL[2:0]. It typically starts in less than 0.5ms. Bit 6 in the CLKLFCTRL register can be polled to check if the oscillator is ready for use.

13.3.6 Synthesized 32.768 kHz clock

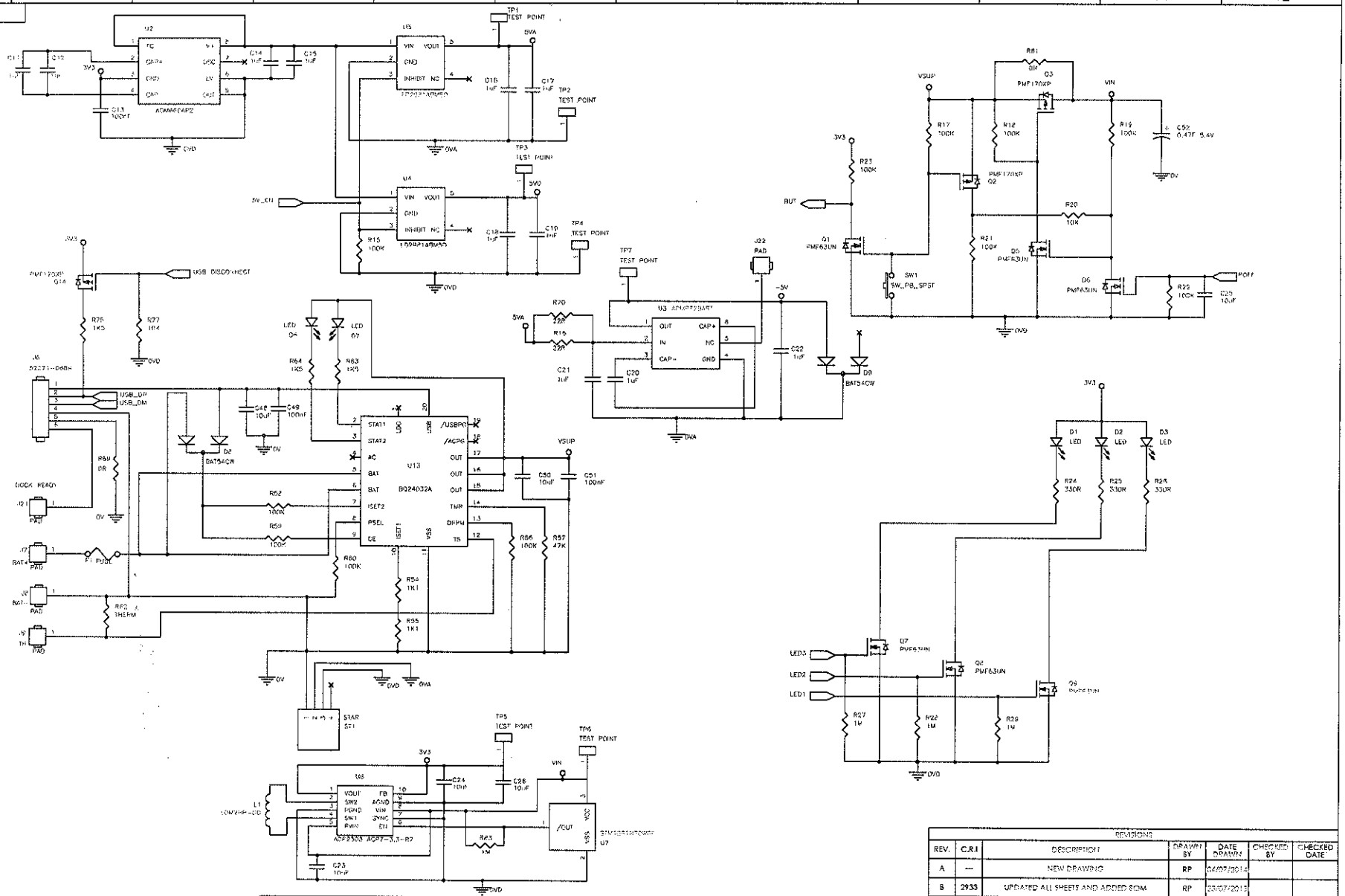
The low frequency clock can also be synthesized from the 16 MHz crystal oscillator clock. Write '010' to CLKLFCTRL[2:0] to select this option. The synthesized clock will only be available in system modes where the 16 MHz crystal oscillator is active. (This will be possible in the operational modes "Register retention," "Standby," and "Active.")

13.3.7 External 32.768 kHz clock

The nRF24LE1 may be used with an external 32.768 kHz clock applied to the P0.1 port pin. Write '100' to CLKLFCTRL[2:0] if the external clock is a rail-to-rail digital signal, or '011' if it is an analog signal coming from e.g. the crystal oscillator of a microcontroller. An analog input signal must have an amplitude of 0.2V peak-to-peak or higher. The DC level is not important as long as the applied signal never rises above VDD or drops below VSS. The P0.1 port pin will load the microcontrollers crystal with approximately 3pF in addition to PCB routing.

Exhibit 5

C 101-452



REVISIONS						
REV.	C.R.I	DESCRIPTION	DRAWN BY	DATE DRAWN	CHECKED BY	CHECKED DATE
A	---	NEW DRAWING	RP	04/07/2014		
B	2933	UPDATED ALL SHEETS AND ADDED BOM	RP	23/07/2014		
C	2950	UPDATED ALL SHEETS	RP	28/11/2014		
D	2959	UPDATED SHEETS 1, 5, 6 AND 8	HS	10/04/2014		
E	2992	UPDATED BOM	DR	21/05/2014		

crane

SCALE 1:1

THIRD ANGLE PROJECTION

MATERIAL XXXX

FINISH XXXX

TOLERANCES UNLESS STATED
X, ±0,5 ANGLES ±0,5°
,X ±0,2
,XX ±0,1
THREADS TO BS3643 COARSE 6H/6g FIT
DIMENSIONS IN MILLIMETRES UNLESS OTHERWISE STATED

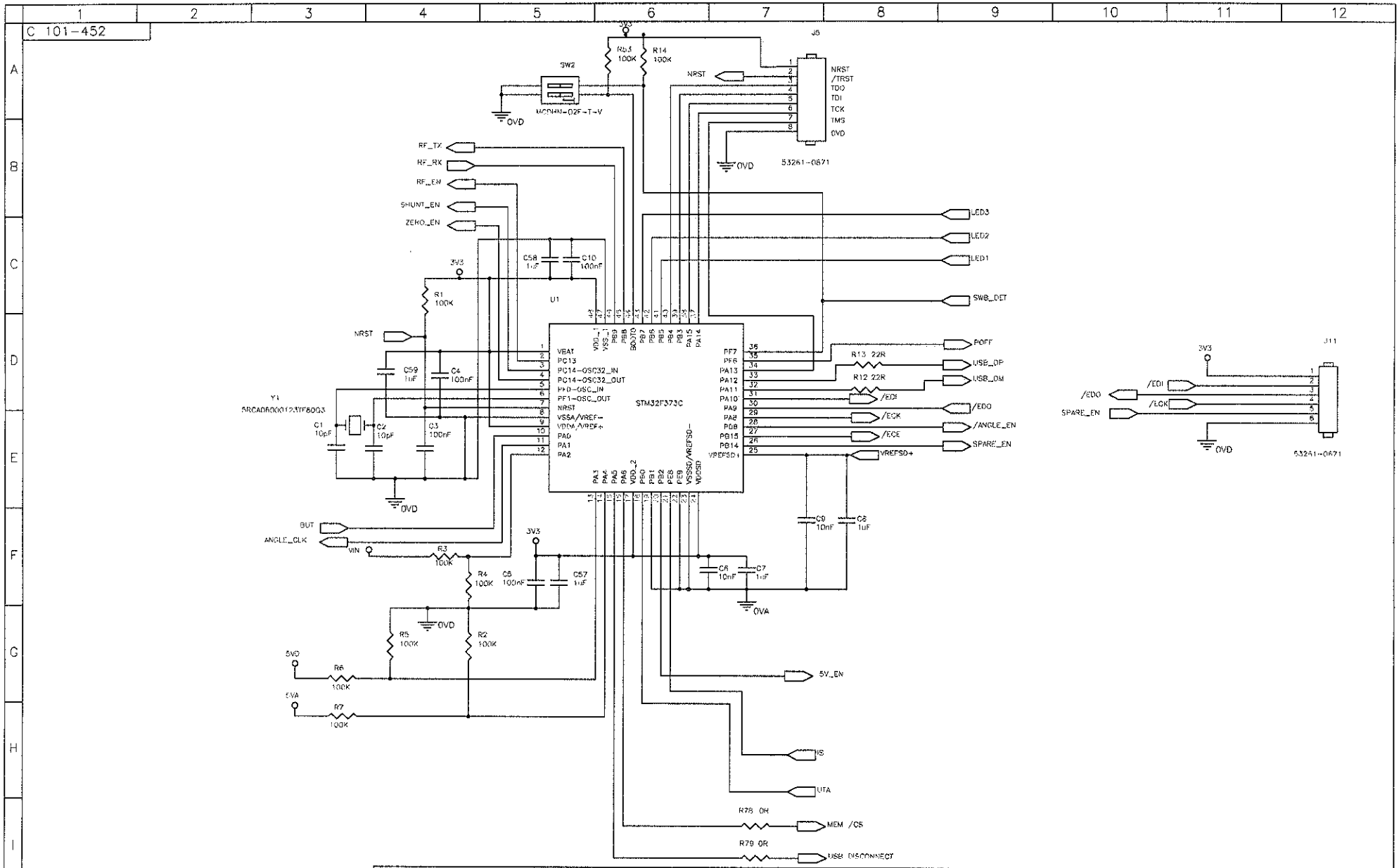
TITLE
DATA COLLECTOR TRANSDUCER MODULE

No
C 101-452

ISSUE E

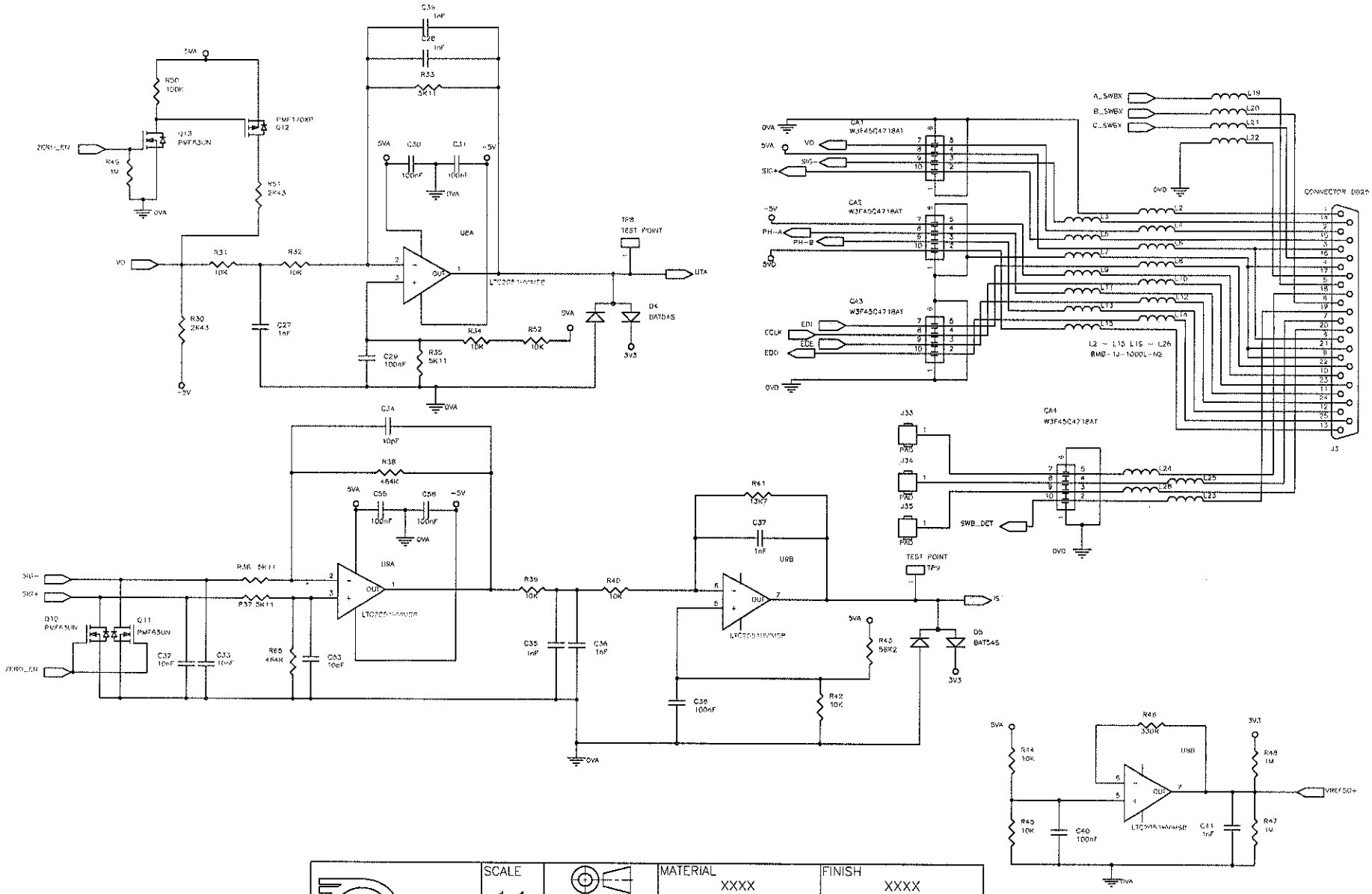
SHEET 1 OF 7

DO NOT SCALE



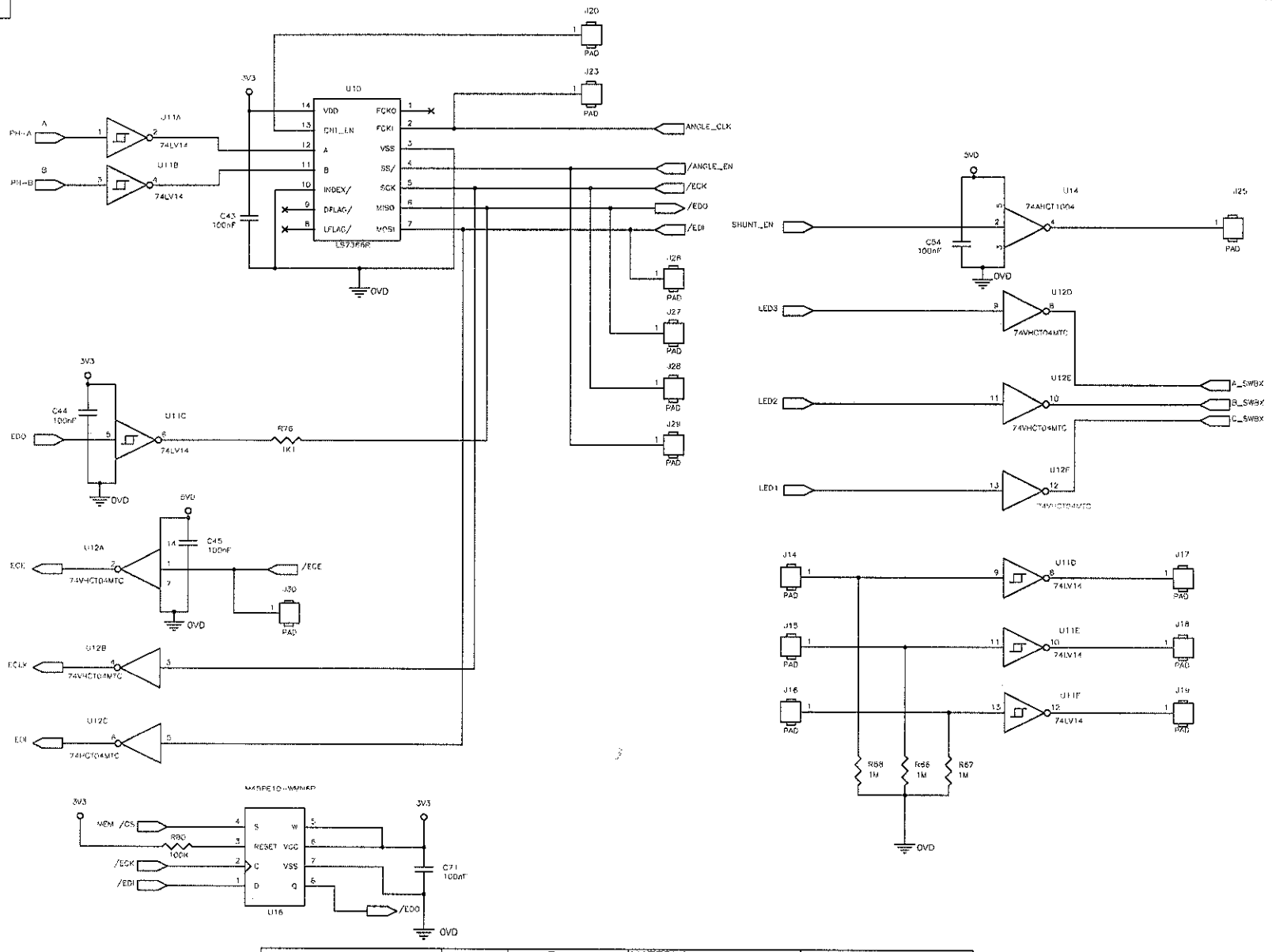
SCALE 1:1	THIRD ANGLE PROJECTION	MATERIAL XXXX	FINISH XXXX	
TOLERANCES UNLESS STATED X, ±0,5 ANGLES ±0,5° ,X ±0,2 ,XX ±0,1 THREADS TO BS3643 COARSE 6H/6g FIT DIMENSIONS IN MILLIMETRES UNLESS OTHERWISE STATED	TITLE DATA COLLECTOR TRANSDUCER MODULE	No C 101-452	ISSUE E	SHEET 2 OF 7
			DO NOT SCALE	

C 101-452



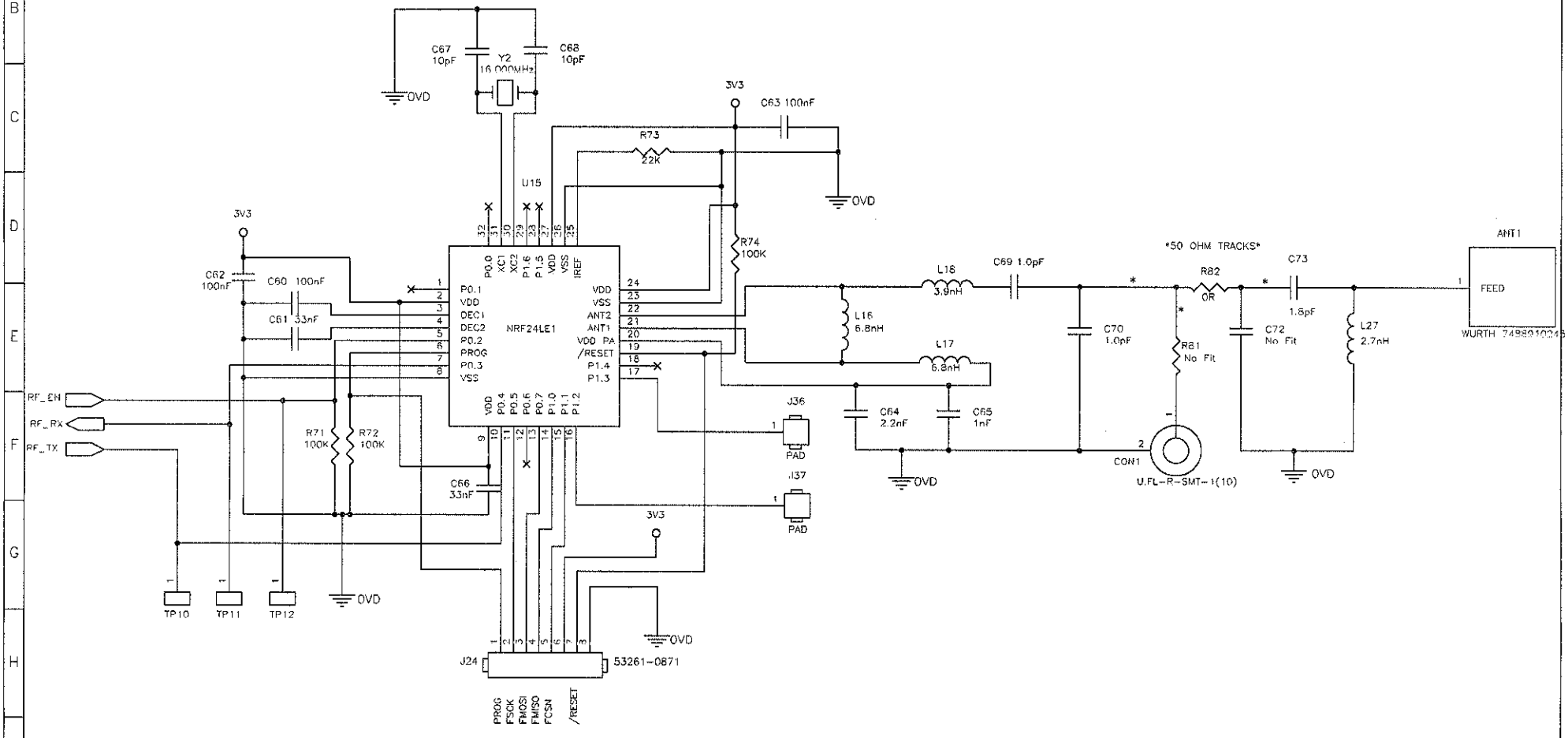
crane	SCALE 1:1	THIRD ANGLE PROJECTION	MATERIAL XXXX	FINISH XXXX
© COPYRIGHT 2014 ALL RIGHTS RESERVED	TOLERANCES UNLESS STATED X, ±0,5 ANGLES ±0,5° ,X ±0,2 ,XX ±0,1 THREADS TO BS3643 COARSE 6H/6g FIT DIMENSIONS IN MILLIMETRES UNLESS OTHERWISE STATED	TITLE DATA COLLECTOR TRANSDUCER MODULE	No C 101-452	ISSUE E / SHEET 3 OF 7 / DO NOT SCALE

C 101-452



SCALE 1:1	THIRD ANGLE PROJECTION	MATERIAL XXXX	FINISH XXXX	
TOLERANCES UNLESS STATED X, ±0,5 ANGLES ±0,5° .X ±0,2 .XX ±0,1 THREADS TO BS3643 COARSE 6H/6g FIT DIMENSIONS IN MILLIMETRES UNLESS OTHERWISE STATED		TITLE DATA COLLECTOR TRANSDUCER MODULE	No C 101-452	ISSUE E / SHEET 4 OF 7
				DO NOT SCALE

C 101-452



crane

SCALE 1:1	THIRD ANGLE PROJECTION	MATERIAL XXXX	FINISH XXXX		
TOLERANCES UNLESS STATED X, ±0.5 ANGLES ±0.5° .X ±0.2 .XX ±0.1 THREADS TO BS3643 COARSE 6H/6g FIT DIMENSIONS IN MILLIMETRES UNLESS OTHERWISE STATED	TITLE DATA COLLECTOR TRANSDUCER MODULE	No C 101-452	ISSUE E	SHEET 5 OF 7	DO NOT SCALE

C 101-452

ITEM	QTY	CIRCUIT REFERENCE	PART NUMBER	VALUE	TYPE	NO FIT ITEM
1	4	CA1,CA2,CA3,CA4	W3F45C4718AT	470pF	0612	
2	1	CON1	U.FL-R-SMT-1(10)			
3	6	C1,C2,C34,C53,C67,C68	MCCA000945	10pF	0603	
4	22	C3,C4,C5,C10,C13,C29,C30,C31,C38,C40,C43,C44,C45,C49,C51,C54,C55,C56,C60,C62,C63,C71	0603YC104JAT2A	100nF	0603	
5	4	C6,C9,C32,C33	0603YC103KAT2A	10nF	0603	
6	16	C7,C8,C11,C12,C14,C15,C16,C17,C18,C19,C20,C21,C22,C57,C58,C59	C1608X7R1C105K080AC	1uF X7R 16V	0603	
7	6	C23,C24,C25,C26,C48,C50	GRM188R60J106ME47D	10uF	0603	
8	9	C27,C28,C35,C36,C37,C39,C41,C64,C65	MCCA000957	1nF	0603	
9	1	C52	PHV-5R4V474-R	0.47F 5.4V		C52
10	2	C61,C66	GRM033R60J333KE01D	33nF	0603	
11	1	C69	MC000298	1.0pF	0603	
12	1	C70	06032U1R0BAT2A	1.0pF	0603	
13	1	C72	NOT FIT	NO FIT	SOT	C72
14	1	C73	MC000280	1.8pF	0402	
15	5	D1,D2,D3,D6,D7	LTST-C190EKT	LED	0603	
16	2	D4,D5	BAT54SW	BAT54SW	SOT323	
17	2	D8,D9	BAT54CW	BAT54CW	SOT323	
18	1	F1	MF-PSMF110X	1100mA RESETTABLE FUSE	0805	
19	1	J3	DSS-25-SD12(011)	DSS-25-SD12(011)		
20	2	J5,J24	53261-0871	MOLEX PICOBLADE 8		
21	1	J6	52271-0669	MOLEX FPC CONNECTOR		
22	24	J7,J8,J9,J14,J15,J16,J17,J18,J19,J20,J21,J22,J23,J25,J26,J27,J28,J29,J30,J33,J34,J35,J36,J37		PAD		
23	1	J11	53261-0671	MOLEX PICOBLADE 6		
24	1	L1	LQM2HPN1R5M	LQM2HPN1R5M	0806 2012	
25	22	L2,L3,L4,L5,L6,L7,L8,L9,L10,L11,L12,L13,L14,L15,L19,L20,L21,L22,L23,L24,L25,L26	MMZ1608Y102B	MMZ1608Y102B	0603	
26	2	L16,L17	L-14W6N8JV4E	6.8nH 0603	0603	
27	1	L18	0603CS-3N9XGLU	3.9nH 0603	0603	
28	1	L27	0402CS-2N7XGLU	2.7nH	0402	
29	9	Q1,Q5,Q6,Q7,Q8,Q9,Q10,Q11,Q13	PMF63UN	PMF63UN	SOT323	
30	4	Q2,Q3,Q12,Q14	PMF170XP	PMF170XP	SOT323	
31	25	R1,R2,R3,R4,R5,R6,R7,R14,R15,R17,R18,R19,R21,R22,R23,R50,R53,R56,R58,R59,R60,R71,R72,R74,R80	CPF0603F100KC1	100K	0603	
32	4	R61,R69,R78,R79	MC 0.063W 0603 0R	0R	0603	R61
33	4	R12,R13,R16,R70	MC 0.063W 0603 1% 22R	22R	0603	
34	11	R20,R31,R32,R34,R39,R40,R42,R44,R45,R52,R77	RN73C1J10KBTG	10K	0603	
35	9	R27,R28,R29,R47,R48,R49,R66,R67,R68,R83	MC 0.063W 0603 1% 1MR	1M	0603	
36	4	R24,R25,R26,R46	MC 0.063W 0603 1% 330R	330R	0603	
37	2	R30,R51	RN73C1J2K43BTG	2K43	0603	
38	4	R33,R35,R36,R37	RN73C1J5K11BTG	5K11	0603	
39	2	R38,R65	RP73PF2A464KBTDF	464K	0805	
40	1	R41	RN73C1J13K7BTG	13K7	0603	
41	1	R43	RN73C2A56K2BTDF	56K2	0603	
42	3	R54,R55,R76	MC 0.063W 0603 1% 1K1	1K1	0603	
43	1	R57	MC 0.063W 0603 1% 47K	47K	0603	
44	1	R62	NCP18XH103F03RB	THERM	0603	
45	4	R63,R64,R75	MC 0.063W 0603 1% 1K5	1K5	0603	
46	1	R73	MC 0.063W 0603 1% 22K	22K	0603	
47	1	R81,R82	CRCW0402000Z0ED	0R	0402	
48	1	ST1		STAR		
49	1	SW1	7914J-001-000	SW_PB_SPST		
50	1	SW2	MCDHN-02F-T-V	SW DIP-2/SM		
51	12	TP1,TP2,TP3,TP4,TP5,TP6,TP7,TP8,TP9,TP10,TP11,TP12	RCU-0C	TEST POINT	0603	
52	1	U1	STM32F373CCT6	STM32F373CCT6	48QFP	
53	1	U2	ADM660ARZ	ADM660	SO8	
54	1	U3	ADM8829ART	ADM8829	SOT-23(RT-6)	
55	2	U4,U5	LD2981ABM50	LD2981ABM	SOT-23-5L	
56	1	U6	ADP2503ACPZ-3.3-R7	ADP2503	LFCSP_WD	
57	1	U7	STM1061N30WX6	STM1061N30WX6	SOT-23	
58	2	U8,U9	LTC2051HV1MS8	LTC2051MS8	MSOP	
59	1	U10	LS7366R-TS	LS7366R-TS	TSSOP	
60	1	U11	SN74LV14APW	SN74LV14APW	TSSOP	
61	1	U12	74VHCT04MTC	74VHCT04MTC	TSSOP	
62	1	U13	BQ24032ARHLTG4	BQ24032ARHLTG4	QFN	
63	1	U14	74AHCT1G04	74AHCT1G04	SOT-353-1	
64	1	U15	NRF24LE1-F16Q32			
65	1	U16	M45PE10---VMN6	M45PE10-VMN6	SO8	
66	1	Y1	5RCA08000123TF80Q3	8MHz		
67	1	Y2	5RCA16000123TF50Q3	16MHz		
68	1	ANT1	7488910245	WURTH CHIP ANTENNA		

TOLERANCES UNLESS STATED
X, ±0,5 ANGLES ±0,5°
.X ±0,2
.XX ±0,1
THREADS TO BS3643 COARSE 6H/6g FIT
DIMENSIONS IN MILLIMETRES UNLESS OTHERWISE STATED

TITLE
DATA COLLECTOR
TRANSDUCER MODULE

No
C 101-452

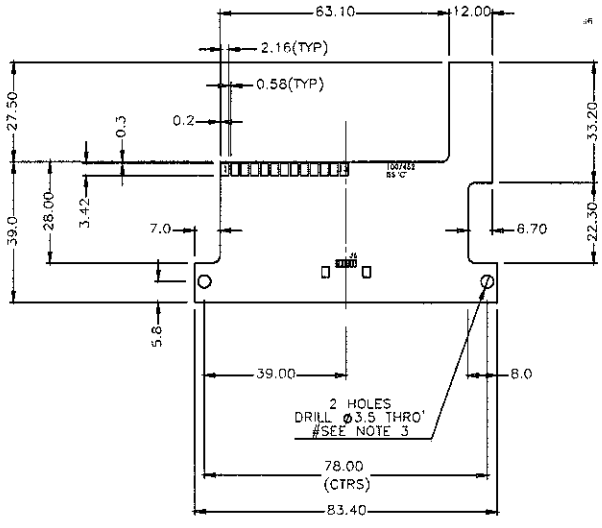
ISSUE
E

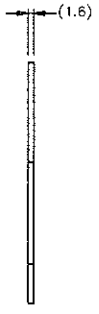
SHEET
7 OF 7

DO NOT SCALE

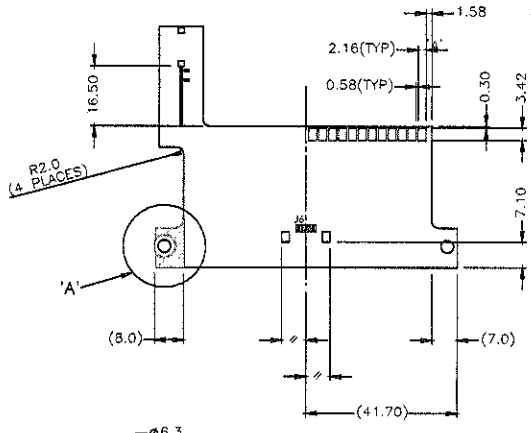
C 101-452

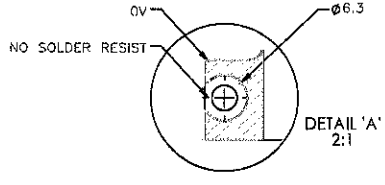
SIDE A



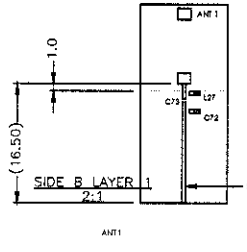


SIDE B

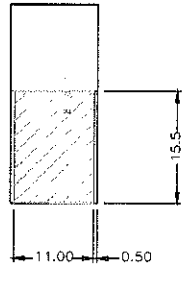




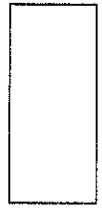
SIDE B LAYER 1
2:1



LAYER 2
2:1



LAYER 2
2:1



MATERIAL:
GLASS FIBRE LAMINATE 1.6mm ±10% THICK, DOUBLE SIDED COPPER CLAD
1oz/sq.ft COPPER BOARD TO BE RoHS COMPLIANT

FINISH:
SOLDER RESIST IN GREEN ON BOTH SIDES OF BOARD.
SILK SCREEN IN WHITE
P.C.B. ARTWORK No. 100/452 AND CURRENT ISSUE 'C' TO BE CLEARLY MARKED IN COPPER

NOTES:
1. ALL CONNECTORS AND TEST POINTS TO BE ON SIDE 'B'
2. 2. REMOVE ALL BURRS AND SHARP EDGES
3. 3. NO THROUGH PLATING FOR 2 Ø3.5 HOLES
4. 4. HATCHED AREA TO BE 0V
5. 5. GROUND LAYER MUST BE DIRECTLY UNDER SIDE B

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SCALE		MATERIAL	FINISH
1:1	THIRD ANGLE PROJECTION	XXXX	XXXX

TOLERANCES UNLESS STATED
X, ±0,5 ANGLES ±0,5°
,X ±0,2
,XX ±0,1
THREADS TO BS3643 COARSE 6H/6g FIT
DIMENSIONS IN MILLIMETRES UNLESS OTHERWISE STATED

TITLE: DATA COLLECTOR TRANSDUCER MODULE

No: C 101-452

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DO NOT SCALE