CDCE401 Evaluation Module Manual – High-Performance Analog/CDC

This manual explains how to use the CDCE401 evaluation module (EVM) and provides guidelines to build the customer's own systems. The manual includes schematics, layout, and bill of materials.

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1 Introduction

The CDCE401 is designed to achieve today's demanding challenges for crystal oscillator modules. The small form factor of the unpackaged die or the QFN package reduces the space consumption of the device to the technical minimum level of today's silicon technology.

The on-die trimming capacitance allows frequency trimming of the oscillator module after the manufacturing process. Therefore, by doing a post-manufacturing programming, crystal manufacturing tolerances can be trimmed out.

During power up or with each enabling, the CDCE401 oscillator start-up circuit switches off all oscillator capacitors (CXI, CXO, and CBASE) to maximize negative impedance during start-up. After a certain time (1/XTAL-frequency × 217 ~ 1.311 ms–6.554 ms), the capacitances are connected to tune to the trimmed frequency range.

An on-die EEPROM enables nonvolatile storage of the frequency setting. For the transfer of the programming into the EEPROM, the CDCE401 takes advantage of the SDATA input. In-circuit programming of the device is possible.

Unlike other EEPROM-based devices, it is not necessary to apply a high supply voltage to the device in order to program it.

The CDCE401 accepts crystals from 20 MHz up to 100 MHz. For lower frequencies, the CDCE401 provides a programmable post divider.

The CDCE401 features a wide supply-voltage range. This makes the device ideal to use at today's most commonly used supply voltage of 2.5 V, and operation at supply voltages of 2.8 V, 2.85 V, and 3 V for cellular applications can be addressed with a single device. Therefore, use of the device in multiple different application spaces is possible, reducing inventory costs.

The CDCE401 is characterized to work in the industrial temperature range from –40°C to 85°C.

Optional: QFN Package Terminal Assignment
For evaluation purposes, the CDCE401 is available in a QFN package together with the EVM described in this document.

If you need assistance, send an E-mail to clocks_apps@list.ti.com.

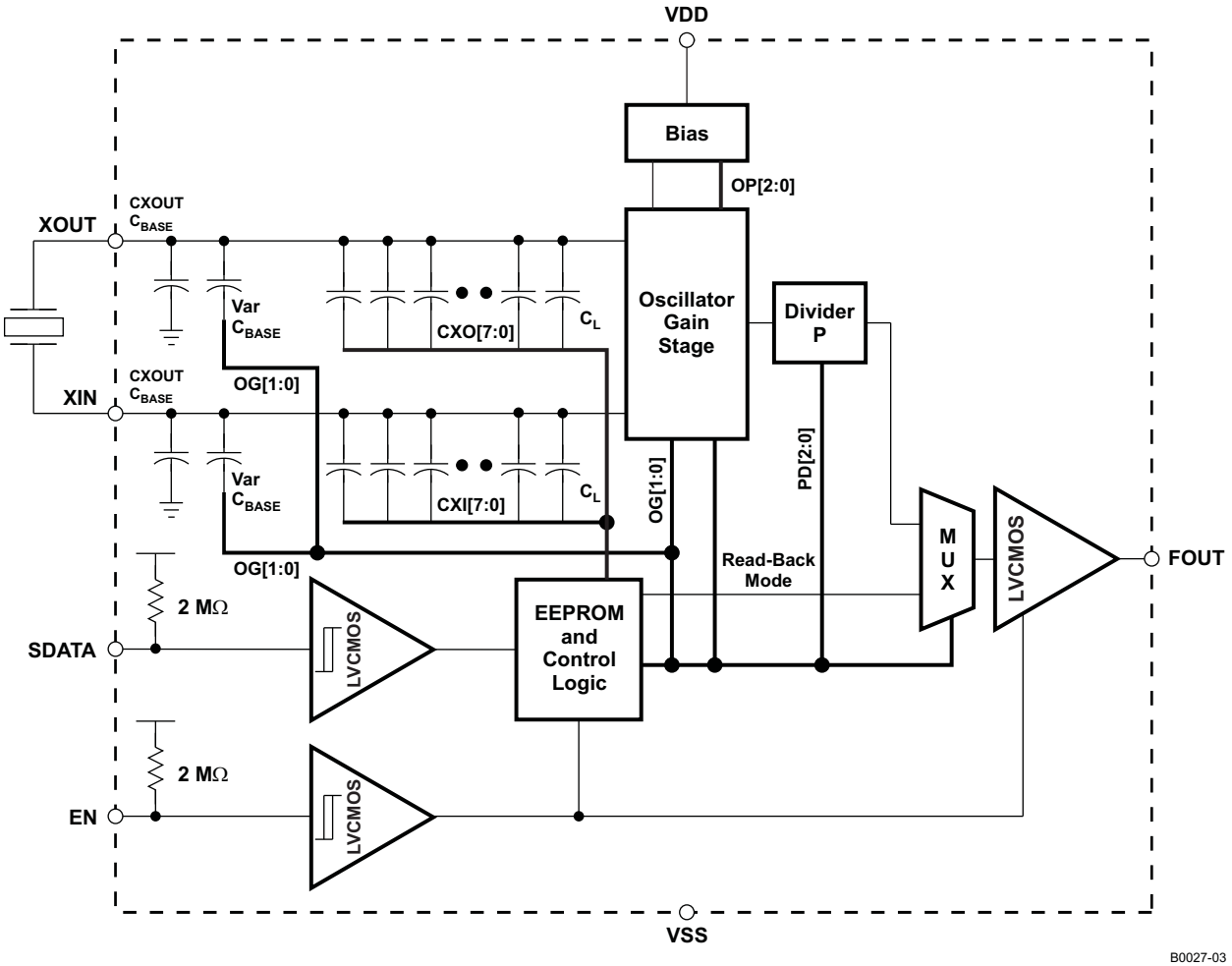


Figure 1. Block Diagram of CDCE401

2 Quick Start

In order to set up the EVM quickly and to take some measurements using the default settings, the following actions are required:

1. Supply 3.3 V to J1 (VCC), and 0 V to J2 (GND).
2. Initialize the MSP430 by pressing pushbutton switch SW3, *MSP RESET.*
3. Observe that after power up, LEDs D3 and D2 indicate the presence of a supply voltage. If the MSP430 is already running correctly, then the LED on the serial data stream, D1, also lights.
4. Connect FOUT to an oscilloscope or to a frequency counter. Use an active probe or high-impedance probe with C_{load} < 1 pF. Loading the output with a 50-Ω termination causes the output swing to reduce (but it will work).
5. To see the *serial programming data*, connect a high-impedance oscilloscope probe to J4 (SDATA) or TP1.
6. Ensure that all switches are set correctly:
   - Switch ON: SW5 (SLEEP_ENB)
   - Switch ON: SW1/1 (SDATA can be monitored by this)
   - Switch ON: SW1/2 (MSP430 SDATA)
   - Switch OFF: SW2/1 (EN and SDATA are connected together)
   - Switch OFF: SW2/2 (EN to GND is disabled)
7. To initialize the serial programming stream, set DIP switch SW4 to the desired programming sequence and press pushbutton switch SW6, *PROGRAM INIT*. A list of all programmed modes is given in Table 5.

Now the CDCE401 EVM is ready to perform all desired measurements.

3 EVM Hardware

This section describes the CDCE401 EVM hardware.

3.1 Board View

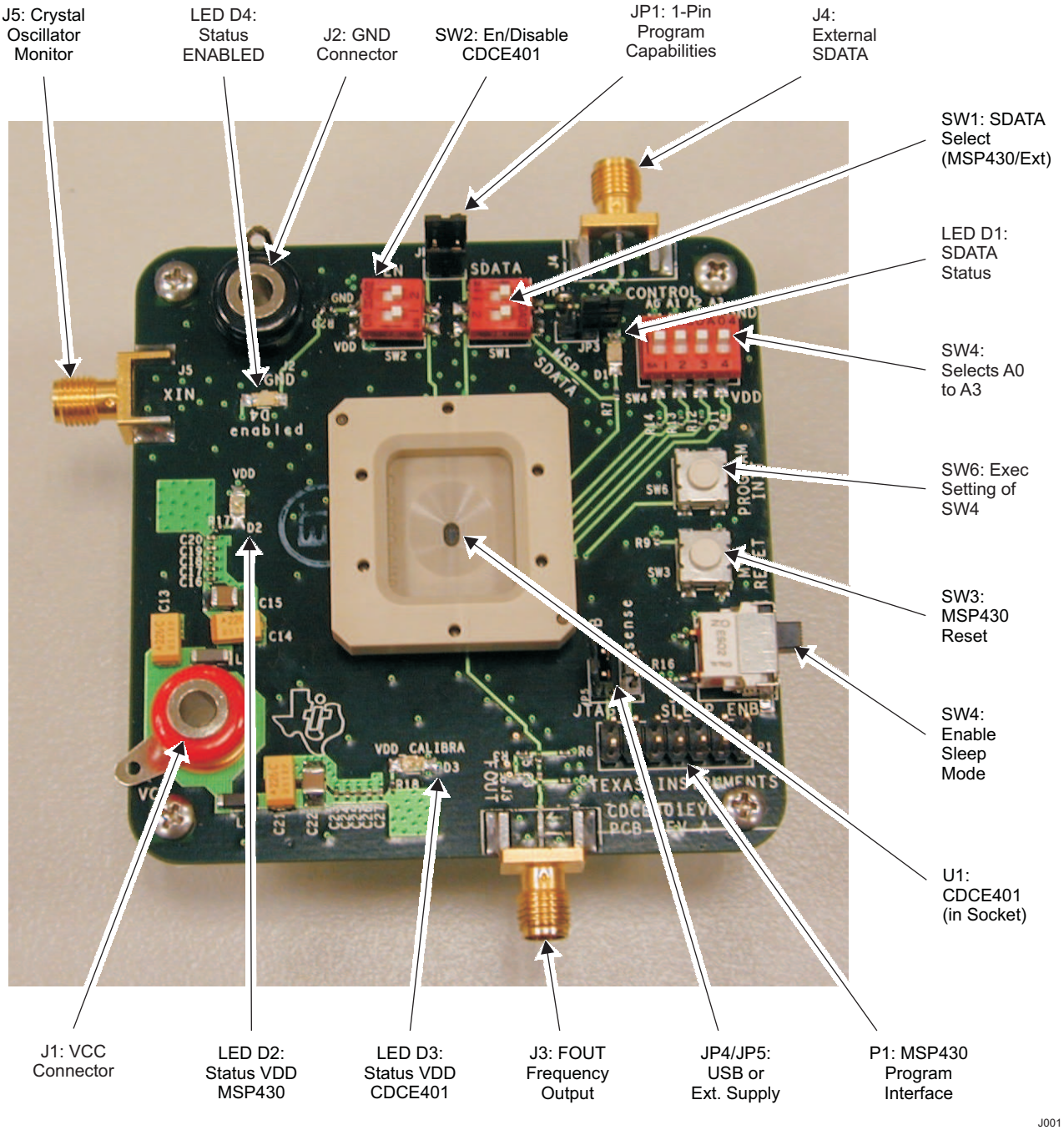


Figure 2. CDCE401 EVM Board Top View

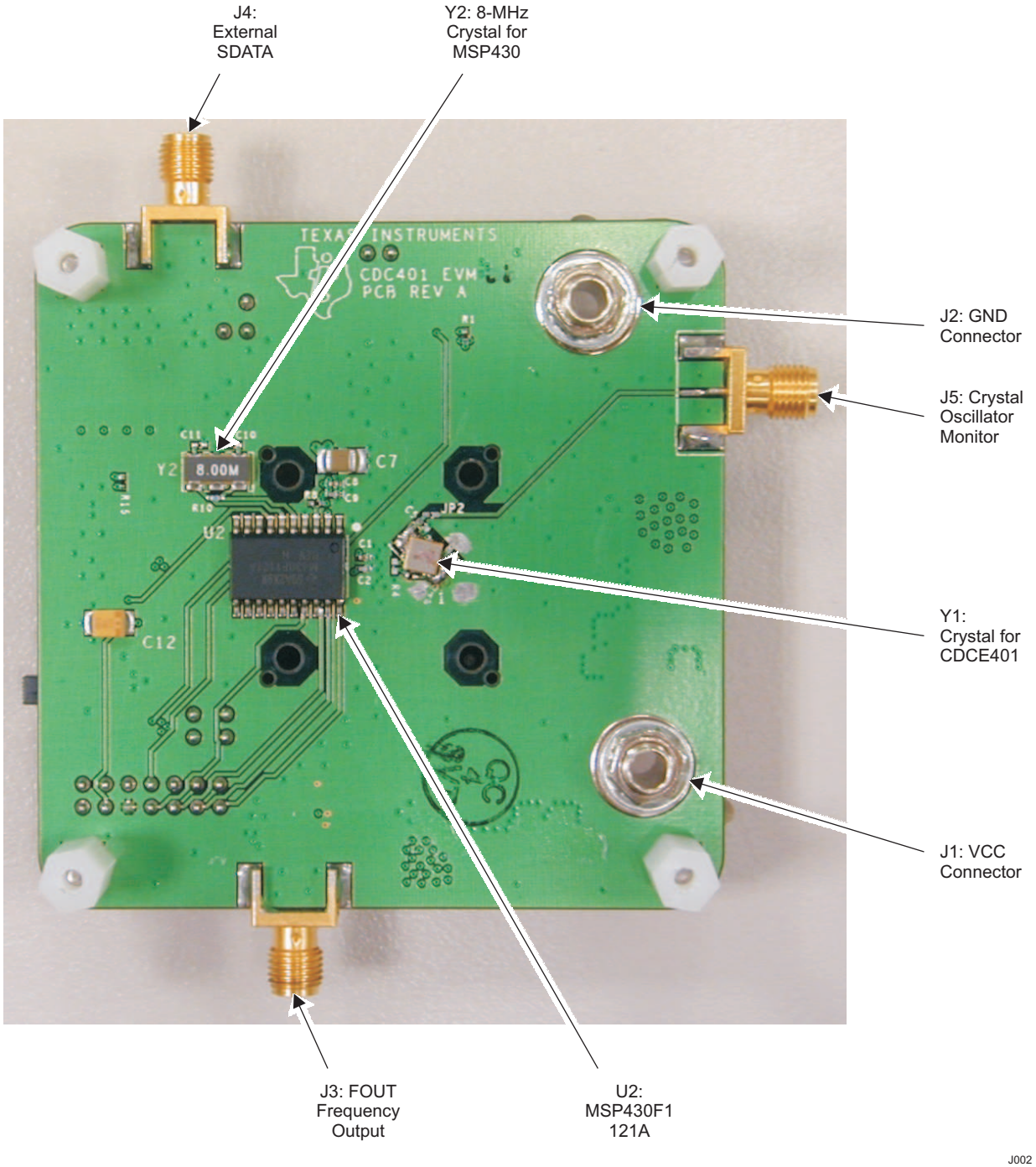


Figure 3. CDCE401 EVM Bottom View

The CDCE401 is either soldered or pressed on the EVM by a press-socket to the area shown in Figure 4.

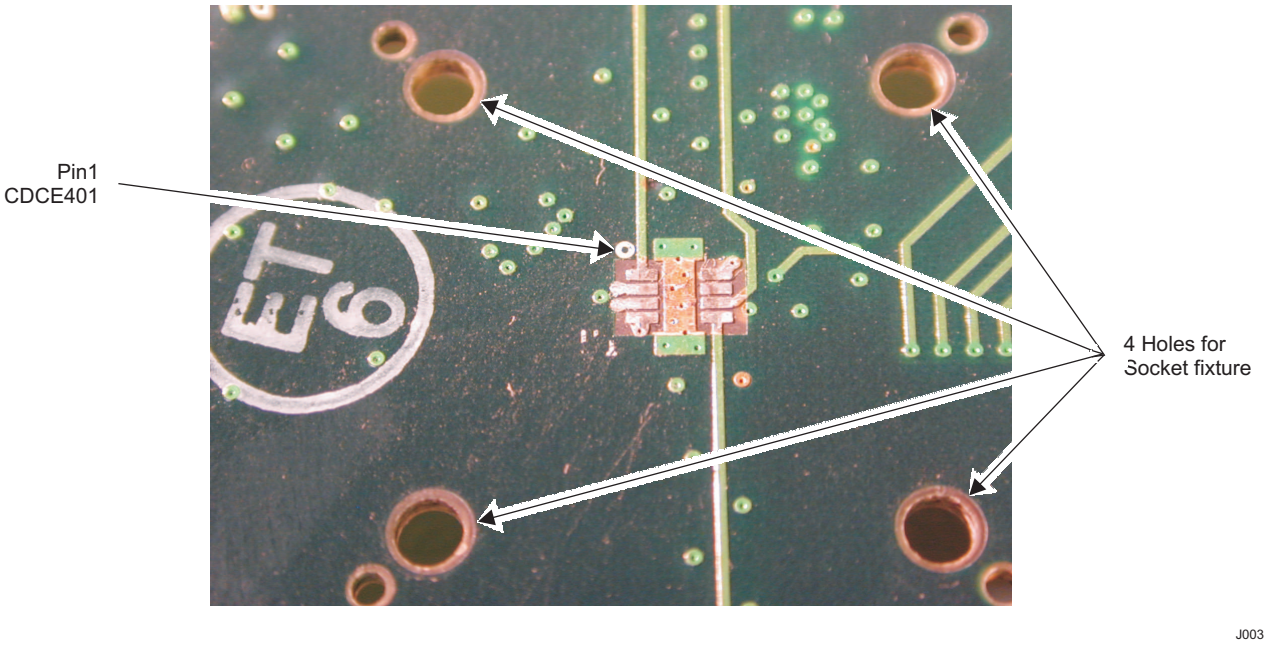


Figure 4. CDCE401 Socket Detailed

The solder pads support a great variety of different crystal sizes in SMD from 2520 (shown in Figure 5), 3225 to 5032.

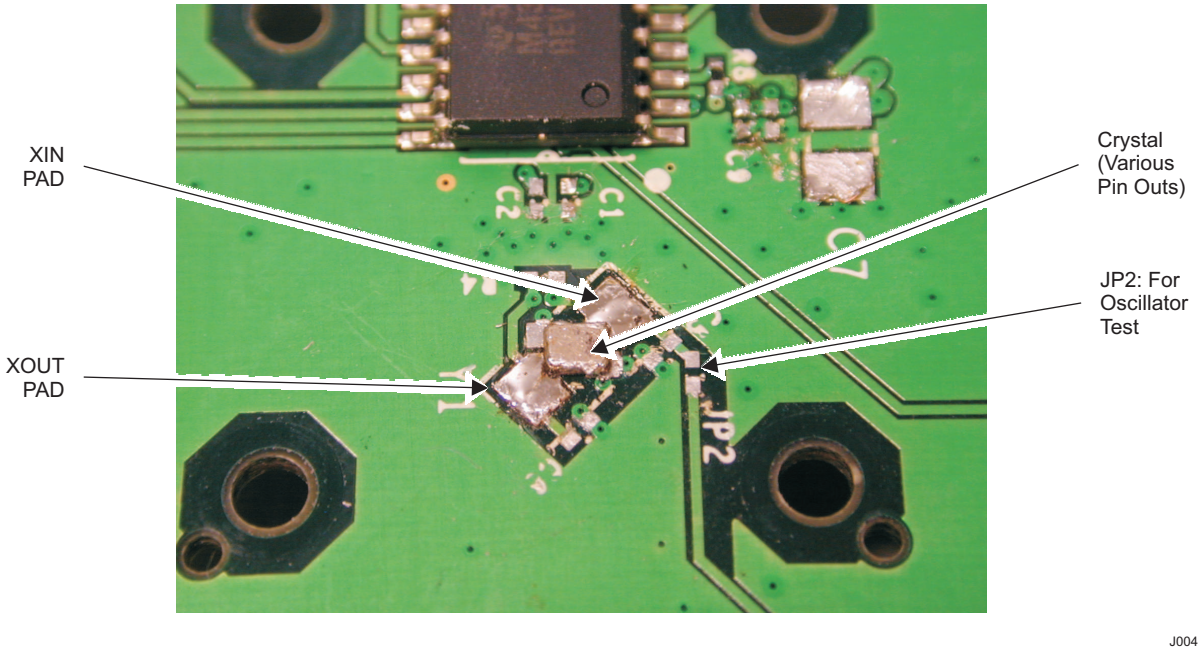


Figure 5. CDCE401 Crystal Socket Detail

3.2 Connector, Switch, and Indicator Descriptions

Table 1. Connectors, Switches and Indicators

Reference	Description
J1	Power supply, 3.3-V nominal (2.25 V–3.6 V tolerant)
J2	GND
J3	FOUT LVCMOS frequency output. Optimized for the attachment of oscilloscope or frequency counter with high-impedance input. See Figure 6.
J4	SDATA input for external programming of the EVM [e.g., using automated test equipment (ATE)]
J5	Crystal oscillator test output (JP2 must be shorted for the monitoring of XIN.)
P1	JTAG programming interface for the MSP430
JP1	Jumper to short EN input and SDATA input. Close this jumper to test the one-pin programming feature.
JP2	Solder jumper to connect XIN to crystal oscillator test output J5.
JP3	Jumper to terminate SDATA input with a 50-Ω resistor. Use this jumper if the external automated test equipment (ATE) requires a 50-Ω terminated line.
JP4	Jumper for sensing the external supply voltage with USB-FET-programmer.
JP5	Jumper to select that board is powered by the USB connector. Important: do not select JP4 and JP5 at the same time, only one or the other.
SW1	SDATA select switch. See Table 3.
SW2	Enable/disable switch for CDCE401. See Table 2.
SW3	Button for MSP430 hardware reset. See Table 4.
SW4	Four DIP switches to select one out of 16 preprogrammed SDATA/EN programming sequences from the MSP430 into the CDCE401 (See Table 5 for more details.)
SW5	Enable/disable of MSP430 (low-power mode 4 = all parts including MSP430 oscillator switch off. The output of the MSP430 remains in the last state). This can be used to measure current consumption of the CDCE401.
SW6	Button to initialize the programming sequence from the MSP430 into the CDCE401 via SDATA signal
D1	LED to display status of the SDATA signal
D2	LED to display status of VDD for the MSP430
D3	LED to display status of VDD for the CDCE401
D4	LED to display status of the ENABLE signal

3.3 Hardware Configuration

3.3.1 Power Supply (J1, J2, D2, D3)

Supply 3 V ±10% (or 2.5 V ±10%) to **J1** and **J2** using a stabilized external power supply. A battery is acceptable for this purpose. If the MSP430 development tool (USB-version) is used, ensure, that JP5 is bridged and JP4 is left open.

CAUTION

Do not supply more than 3.6 V on J1. For EEPROM programming, use a supply voltage of 3 V ±100 mV.

LED **D2** indicates that VDD for the MSP430 is present and LED **D3** indicates that VDD for the CDCE401 is present.

3.3.2 Frequency Output FOUT (J3)

On SMA connector **J3** (FOUT), the user can measure the output frequency of the oscillator. The output is loaded with the standard measurement load for the CDCE401 (see Figure 6). Ensure that the oscilloscope or frequency counter has a high-impedance input; otherwise, the output amplitude decreases.

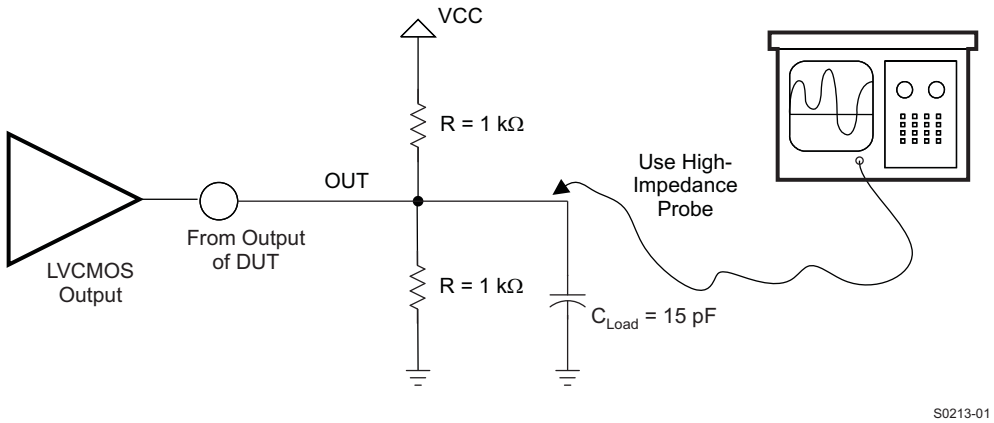


Figure 6. FOUT Load and Measurement Topology

3.3.3 Oscillator Test In/Out (J5, JP2)

Bridging connection **JP2** with solder connects the CDCE401 crystal input, XIN, to SMA connector **J5** for monitoring purposes. It is also possible to use **J2** as the input to feed in an ac signal (but XTAL should be removed in this case). It is possible to monitor the input-to-output performance of the CDCE401 in buffer mode.

3.3.4 Enable/Disable CDCE401 (SW2)

Table 2. SW2 Functional Table (EN)

SW2/2	SW2/1	EN to CDCE401
OFF	OFF	High impedance, use if JP1 is used (SDATA and EN are connected together).
OFF	ON	Enable CDCE401 by pullup to VDD (JP1 must be disconnected for this.)
ON	OFF	Disable CDCE401 by pullup to VDD (JP1 must be disconnected for this.)
ON	ON	Not recommended (high current consumption)

3.3.5 Control of SDATA (J4, JP1, JP3, SW1, D1, TP1)

The SDATA input of the CDCE401 can be controlled by the MSP430 or by an external programming utility. The source controlling the CDCE401 is selected by the settings of switch **SW1,** listed in Table 3.

Table 3. SW1 Functional Table (SDATA)

SW1/2	SW1/1	SDATA to CDCE401
OFF	OFF	High impedance, not recommended (SDATA is pulled high through internal pull-up resistor)
OFF	ON	SDATA coming from external source
ON	OFF	SDATA coming from MSP430
ON	ON	SDATA coming from MSP430 and can be monitored at SMA connector J4

LED **D1** lights if a high level is present on the SDATA pin or if a programming sequence is sent to the CDCE401.

If the programming is done using an external programming utility, the CDCE401 EVM provides an SMA connector, **J4**, for easy hookup. Alternatively, **TP1** can be used to hook up the data stream to the EVM board. Jumper **JP3** allows termination of the SDATA input with a 50-Ω termination resistor. This might be useful for automated test equipment which requires a 50-Ω line termination.

Jumper JP1 allows the shorting of SDATA to the EN pin, reducing the number of logic pins from two down to one pin only. The input pin performs double duty, and a virtual *one-pin programming interface* can be achieved.

3.3.6 MSP430 Programming Interface (P1, SW3, SW4, SW5, SW6, D1)

The MSP430 provides for onboard programming of the CDCE401. To achieve this, all the elements necessary are already built into the EVM board. The MSP430 has a flash memory where the necessary EVM program is stored. Usually, EVMs have the program preinstalled, so no download of the program into the MSP430 is necessary. The user can determine if the CDCE401 program is running by checking whether LED **D1** is switched on.

The MSP430 is programmed via the JTAG interface **P1**. To develop and modify the program, MSP430 Development Tool IAR Version 3.0 was used. For further information on how to program the MSP430, see the relevant resources available from TI, which are listed in Section 5.1.

The MSP430 can be reset by pressing pushbutton switch **SW3**. Switch **SW5** is used to bring the MSP430 into *low-power mode*. In this mode, the MSP430 disables all circuits internally, including the oscillator of the MSP430. The outputs remain in the state which they had before. This mode is useful to remove all potential disturbances coming from the MSP430 so that the CDCE401 can be measured without any external distortions.

Table 4. SW2 Functional Table (SLEEP_ENABLE)

SW5	SDATA to CDCE401
OFF	MSP430 is in sleep mode = LPM
ON	MSP430 is enabled

Using switch **SW4**, it is possible to execute up to 16 preprogrammed SDATA programming sequences. They are binary-coded as SW4/1 = A0; SW4/2 = A1; SW4/3 = A2 and SW4/4 = A3. If one of the switches is switched ON, a 0 is coded; if the switch is OFF a 1 is coded by the MSP430. See Table 5 for further details. The transfer of the data stream from the MSP430 to the CDCE401 on the SDATA line is initialized by pressing pushbutton switch SW6 (PROGRAM INIT).

Table 5. SW4 Functional Table (Address Selection A0:A3)

	SW4/4	SW4/3	SW4/2	SW4/1	Function						
Mode	A3	A2	A1	A0	Word 0 CXI[7:0]	Word 1 CXO[7:0]	Word 2 OP[2:0]	OG[1:0]	PD[2:0]	RAM/ EEPROM	Comments
0	0	0	0	0	0000 0000	0000 0000	000	11	000	EEPROM	OG = 11, Ct off, div = 1
1	0	0	0	1	1111 1111	1111 1111	000	11	000	EEPROM	OG = 11, Ct on, div = 1
2	0	0	1	0	0110 0000	0110 0000	000	11	000	EEPROM	OG = 11, Ct default, div = 1
3	0	0	1	1	0000 0000	0000 0000	000	01	000	EEPROM	OG = 01, Ct off, div = 1
4	0	1	0	0	1111 1111	1111 1111	000	01	000	EEPROM	OG = 01, Ct on, div = 1
5	0	1	0	1	0110 0000	0110 0000	000	01	000	EEPROM	OG = 01, Ct default, div = 1
6	0	1	1	0	0000 0000	0000 0000	000	10	000	EEPROM	OG = 10, Ct off, div = 1
7	0	1	1	1	1111 1111	1111 1111	000	10	000	EEPROM	OG = 10, Ct on, div = 1
8	1	0	0	0	0110 0000	0110 0000	000	10	000	EEPROM	OG = 10, Ct default, div = 1
9	1	0	0	1	0000 0000	0000 0000	000	00	000	EEPROM	OG = 00, Ct off, div = 1
10	1	0	1	0	1111 1111	1111 1111	000	00	000	EEPROM	OG = 00, Ct on, div = 1
11	1	0	1	1	0110 0000	0110 0000	000	00	000	EEPROM	OG = 00, Ct default, div = 1
12	1	1	0	0	0110 0000	0110 0000	000	00	001	EEPROM	OG = 00, Ct default, div = 2
13	1	1	0	1	1111 1111	1111 1111	000	11	000	RAM	Test mode, Ct off, CBASE off
14	1	1	1	0	0110 0000	0110 0000	000	11	111	RAM	OG = 11, Ct default, div off (to measure core ICC)
15	1	1	1	1	Readback mode						

4 Schematic, Board Layout, Part List

This section contains the CDCE401 EVM schematic, the board layouts and the parts list.

4.1 Schematic

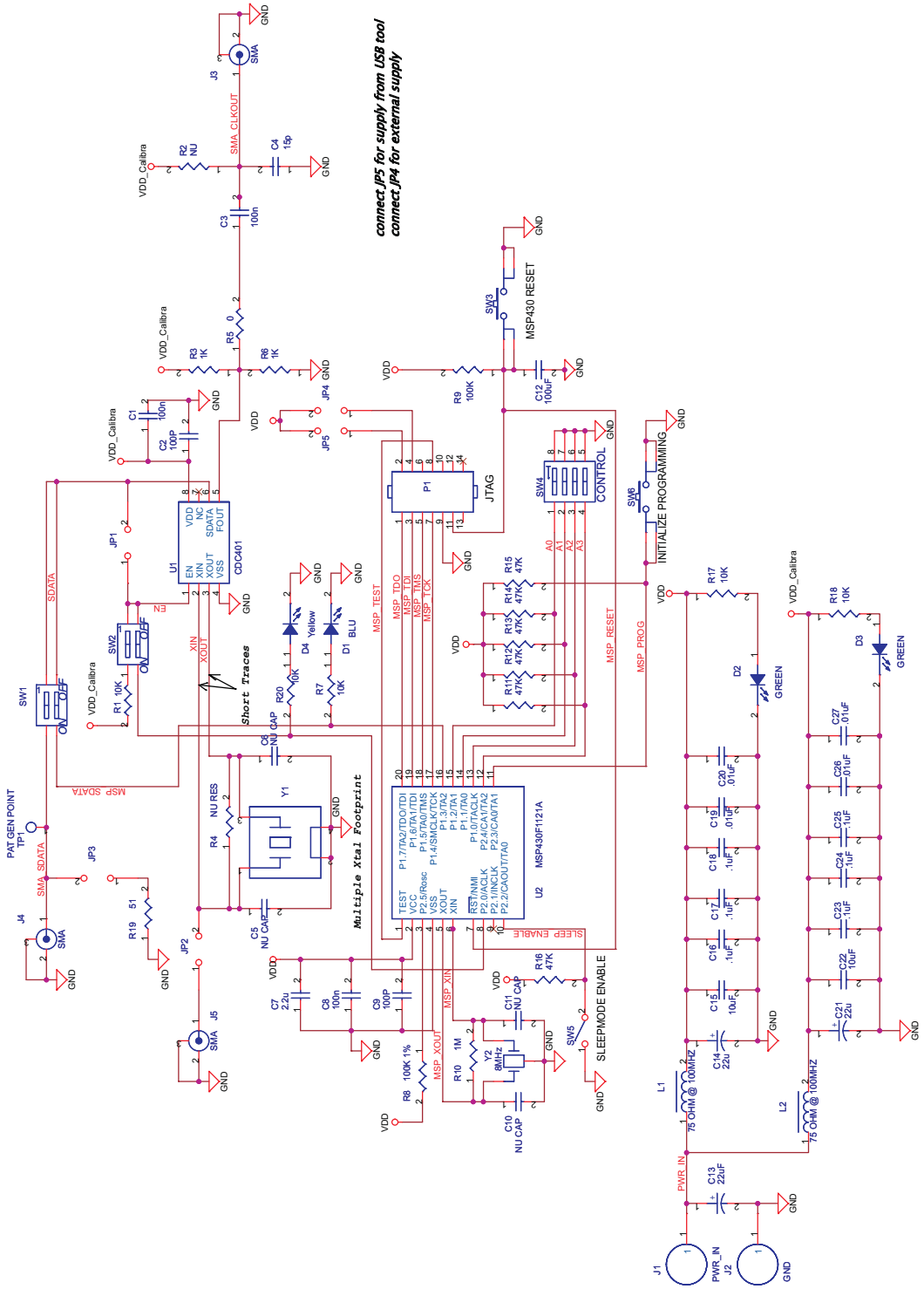


Figure 7. Schematic CDCE401 EVM

4.2 EVM Board Layout

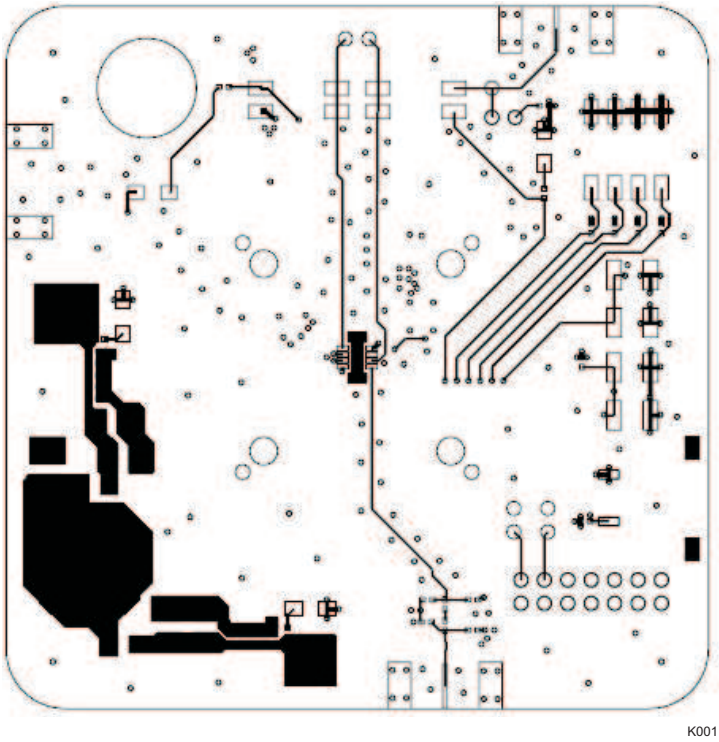


Figure 8. Top Layer EVM

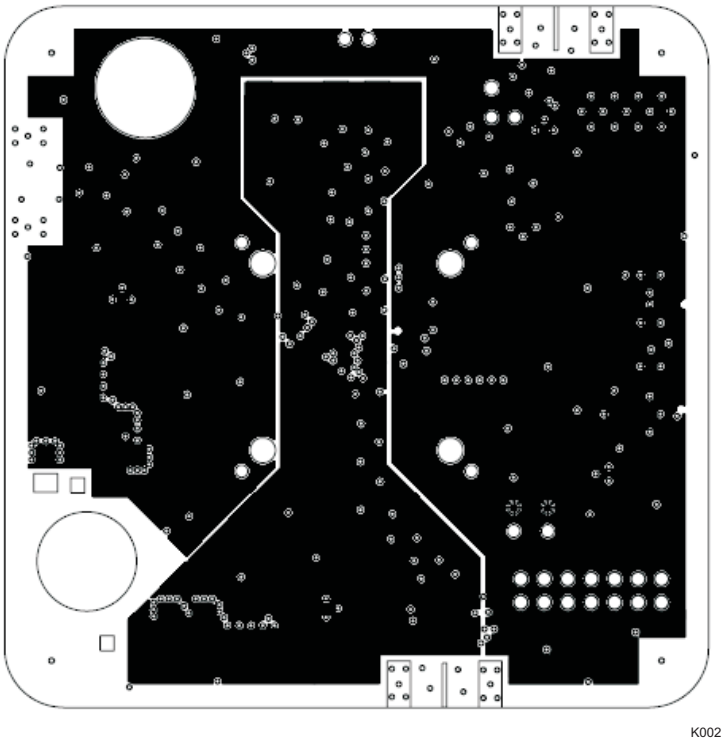
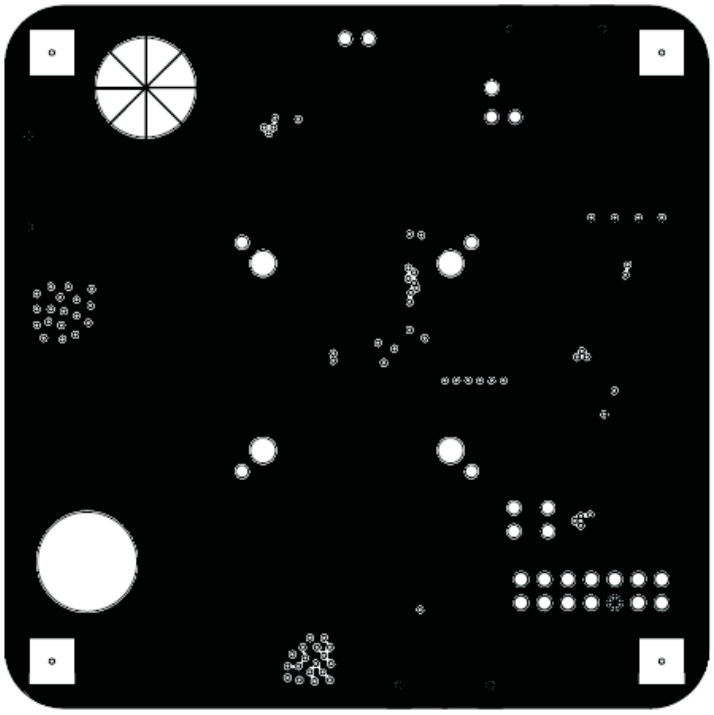


Figure 9. PWR Layer EVM



K003

Figure 10. GND Layer EVM

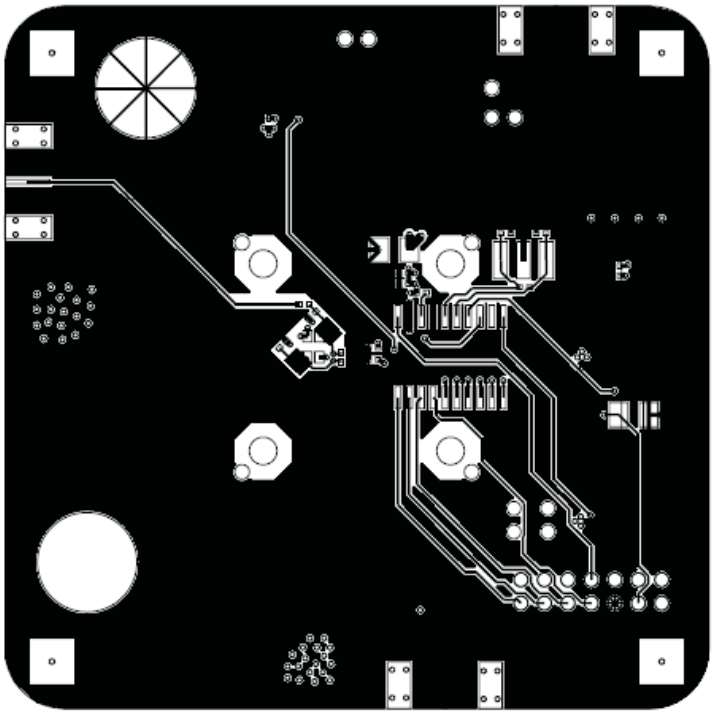


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Figure 11. Bottom Layer EVM

4.3 Parts List

Table 6. Bill of Material CDCE401 EVM

Item	Quantity	Reference	Value	Part Number
1	1	C1,C8	100 nF	Panasonic ECJ-0EB1E104K
2	2	C2,C9	100 pF	Panasonic ECJ-0EB1E101K
3	1	C3	10 nF	Panasonic ECJ-0EB1E103K
4	1	C4	15 pF	Panasonic ECJ-0EC1H100D
5	4	C5, C6, C10, C11	NU CAP	NU
6	1	C7	2.2 µF	Murata RM32MR71C225KC01L
8	1	C12	100 µF	Kemet T494B107M006AS
9	1	C13	22 µF	Panasonic ECS-T1CC226R
10	2	C21, C14	22 µF	Panasonic ECS-T1CC226R
11	2	C22, C15	10 µF	Panasonic ECJ-4YB1C106K
12	6	C16–C18, C23–C25	0.1 µF	Panasonic ECJ-0EB1A104K
13	4	C19, C20, C26, C27	0.01 µF	Panasonic ECJ-0EB1E103K
14	1	D1	Blue	Panasonic LNJ911W8BRA
15	2	D3, D2	Green	Fairchild Semi QTLP651C-IG
16	1	D4	Yellow	
17	5	JP1–JP5	Jumper	Header 2pos, 0.100 ctr
18	1	J1	PWR_IN banana jack	SPC Technologies 845R
19	1	J2	GND banana jack	SPC Technologies 845B
20	3	J3–5	SMA	Johnson Comp 142-0701-851
21	2	L1, L2	75 Ω at 100 MHz	Murata BLM41P750SPT
22	1	P1	Header 7x2/SM	Header 7X2, 0.100 ctr
23	5	R1, R7, R17, R18, R20	10 kΩ	Panasonic ERJ-2RKF1002X
24	1	R2	NU	NU
25	2	R3, R6	1 kΩ	Panasonic ERJ-2RKF1001X
26	1	R4	NU RES	Panasonic ERJ-2RKF1004X
27	1	R5	0	Panasonic ERJ-2GEJ000X
29	1	R8	100 kΩ, 1%	Panasonic ERJ-2RKF1003X
30	1	R9	100 kΩ	Panasonic ERJ-2RKF1003X
31	1	R10	1 MΩ	Panasonic ERJ-2RKF1004X
32	6	R11–R16	47 kΩ	Panasonic ERJ-2GEJ473X
33	1	R19	51 Ω	Panasonic ERJ-2GEJ510X
34	2	SW1, SW2	SW DIP-2/SM	C&K SDA05H1SKD
35	2	SW3, SW6	SW, pushbutton	KT11P3JM
36	1	SW4	Control	C&K SDA04H1SKD
37	1	SW5	Sleep mode/enable	C&K ES02MSAKE
38	1	TP1	PAT GEN POINT	Keystone Elec 5012
39	1	U1	CDCE401	CDCE401
40	1	U2	MSP430F1121A	TI MSP430F1121AIDW
41	1	Y1	NU	VARIABLE
42	1	Y2	8 MHz	ECS-SR1-8.00-B
43	4	MP3	Standoff	
44	4	MP2	Screw	

5 Document Information

5.1 Related Documentation from Texas Instruments

- *CDCE401 Oscillator IC With Electronic Calibration* data sheet (SCAS820)
- *MSP430C11x1, MSP430F11x1A Mixed Signal Microntroller* data sheet (SLAS241)

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