SRI LANKA INSTITUTE OF INFORMATION TECHNOLOGY

EC2132 – Microcomputers

Driving MAX7221 LED seven-segment display using PIC16F877A

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1. Abstract

The aim of this assignment is to display the EN number on a seven segment display. For this task the PIC16F877A microcontroller and drive/control LED Seven Segment Display MAX7221 was used. Assembler was used as the programming language. The circuit was constructed using Proteus simulation software.

2. Introduction

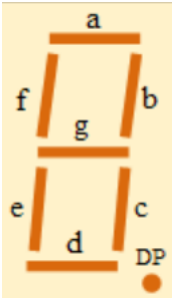
MAX7221 is a compact, serial input/output common-cathode display driver that interfaces microcontrollers to 7-segment numeric LED displays of up to 8 digits. This chip is compatible with SPI and many serial communication protocols. This chip needs only 3 control lines from your microcontroller to drive the display. Seven segment displays are used for devices such as bar graph displays, industrial controllers, panel meters and LED matrix displays. The seven segments are assigned letters from A to G. There is an optional decimal point that can be used to display non integer numbers.

3. Objectives

- Identify the features and functions of the Max 7221 display driver
- Become proficient in programming microcontrollers using assembly
- Learn the principles of circuit design
- Understand the applications of seven segment displays

4. Background reading

4.1 Seven segment displays



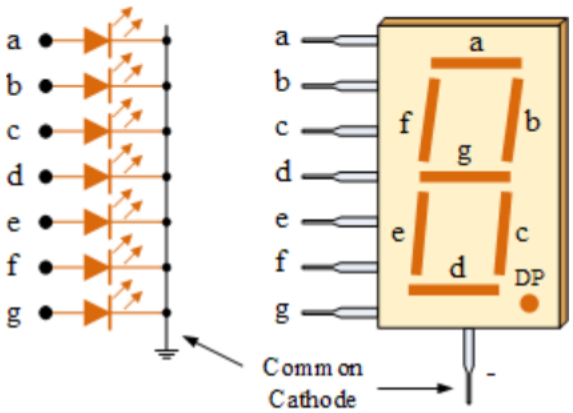
A seven-segment display contains seven LEDs arranged in a rectangular manner as shown above. There is an additional 8th LED is used to indicate a decimal point.

Each of these seven LEDs is known as a segment. Multiple segments can be connected together to display numbers greater than 10.

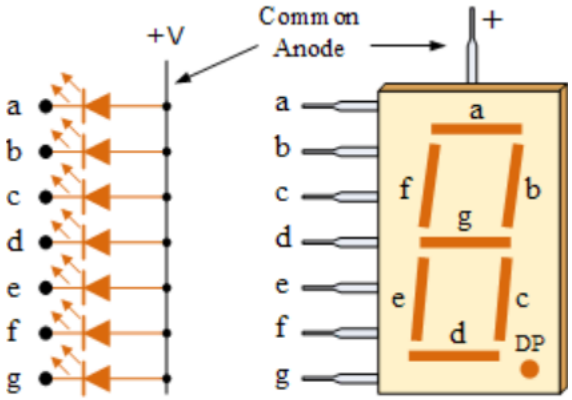
4.1.1 Types of seven segment displays

There are two types of seven segment displays. Each LED has 2 connecting pins. The common pin is used to identify the type of display. These 2 types are;

- Common cathode display
- Common anode display

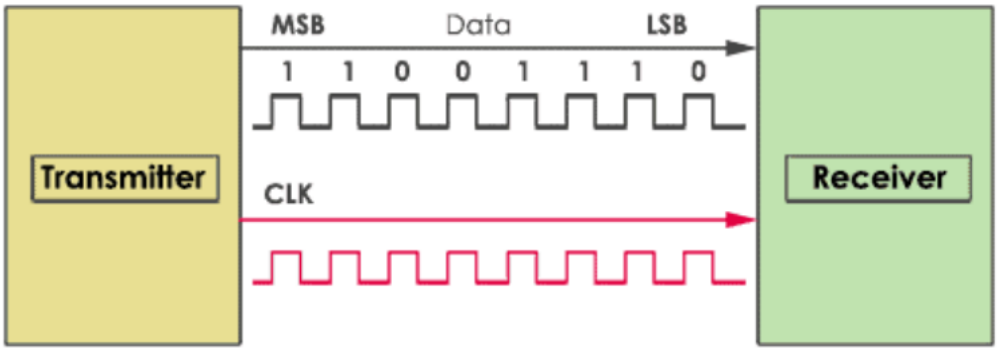


In the common cathode display all the cathode terminals of the LEDs are connected to the ground. A logic high should be provided to light up the LEDs.



In the common anode display all the cathode terminals of the LEDs are connected to the Vcc. A logic low should be provided to light up the LEDs.

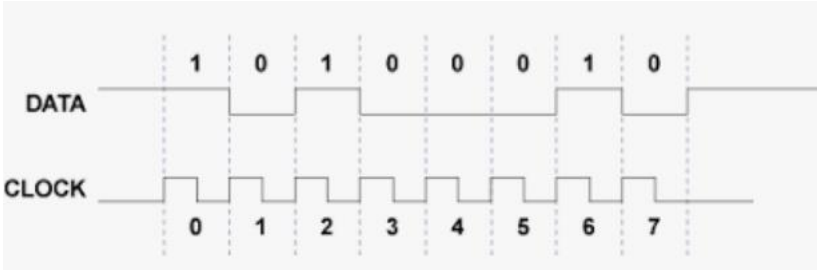
4.2 Serial communication



Serial communication is method where data is fed one bit at a time in sequential manner between two devices. This is used to transfer data between data processing equipment and peripherals. There are two types of serial communication:

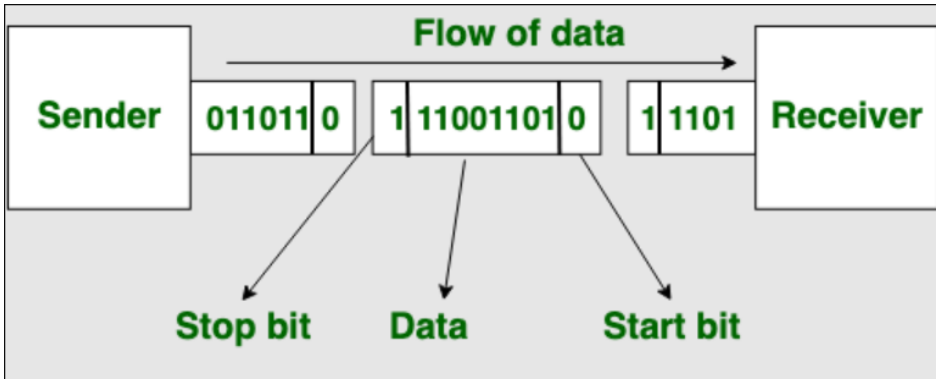
- Synchronous
- Asynchronous

4.2.1 Synchronous serial communication



A clock is used to synchronize the data transmission between the two devices. This does not require start or stop bits. Therefore this is faster than asynchronous serial communication.

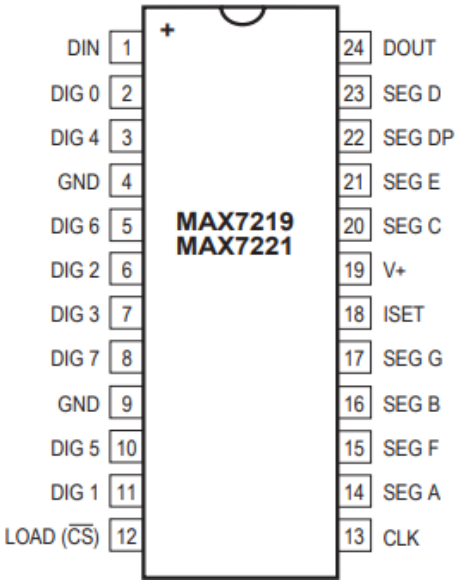
4.2.2 Asynchronous serial communication



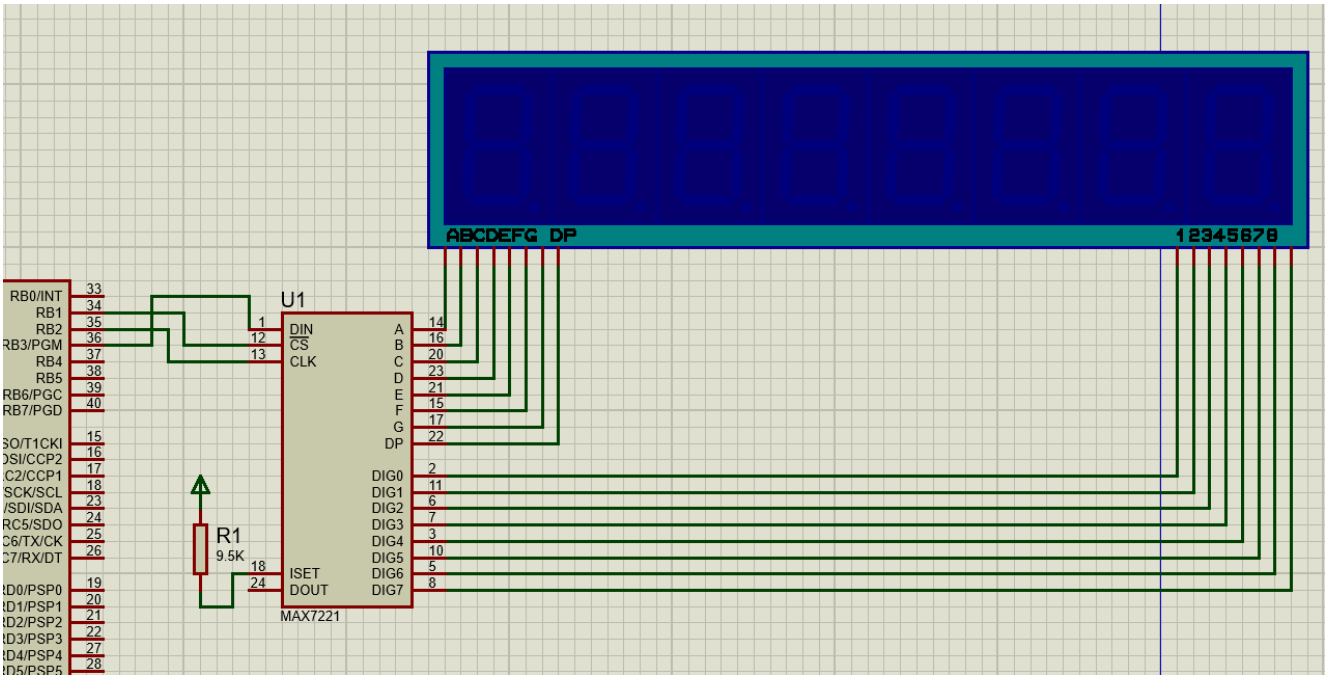
This method does not have a clock signal. A start bit and a stop bit is used to validate the data between the transmitter and the receiver. The time interval of data transmission is random.

5. Methodology

5.1 Pin configuration and selection



PIN	NAME	FUNCTION
1	DIN	Serial-Data Input. Data is loaded into the internal 16-bit shift register on CLK's rising edge.
2, 3, 5–8, 10, 11	DIG 0–DIG 7	Eight-digit drive lines that sink current from the display common cathode. The MAX7219 pulls the digit outputs to V+ when turned off. The MAX7221's digit drivers are high-impedance when turned off.
4, 9	GND	Ground. Both GND pins must be connected.
12	LOAD (MAX7219)	Load-Data Input. The last 16 bits of serial data are latched on LOAD's rising edge.
	$\overline{CS}$ (MAX7221)	Chip-Select Input. Serial data is loaded into the shift register while $\overline{CS}$ is low. The last 16 bits of serial data are latched on $\overline{CS}$'s rising edge.
13	CLK	Serial-Clock Input. 10MHz maximum rate. On CLK's rising edge, data is shifted into the internal shift register. On CLK's falling edge, data is clocked out of DOUT. On the MAX7221, the CLK input is active only while $\overline{CS}$ is low.
14–17, 20–23	SEG A–SEG G, DP	Seven Segment Drives and Decimal Point Drive that source current to the display. On the MAX7219, when a segment driver is turned off it is pulled to GND. The MAX7221 segment drivers are high-impedance when turned off.
18	ISET	Connect to V_{DD} through a resistor (R_{SET}) to set the peak segment current (Refer to *Selecting R_{SET} Resistor and Using External Drivers* section).
19	V+	Positive Supply Voltage. Connect to +5V.
24	DOUT	Serial-Data Output. The data into DIN is valid at DOUT 16.5 clock cycles later. This pin is used to daisy-chain several MAX7219/MAX7221's and is never high-impedance.



- Pins 1, 12 and 13 were used to feed data into the MAX7221 display.
  The ports of the pic16F877A were selected as follows:
    - Port B, pin 1 – CLK
    - Port B, pin 2 – CS
    - Port B, pin 3 – DIN

- The seven segments A to G and the decimal point were connected to the display
- The DIG 0 -DIG 7 pins were also connected to the display as shown above.
- The ISET pin was connected to the V_{DD} through resistor

5.2 Data format

D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
X	X	X	X	ADDRESS				MSB	DATA						LSB

The MAX7221 display has a 16 bit serial data format. The bits from 11 to 8 specify the address of the data. The next 8 bits contain the data.

5.3 Initialization of registers

The MAX7221 has 5 registers that should be initialized before data can be fed.

- Shutdown register
- Decode mode register
- Intensity register
- Scan limit register
- Display test register

REGISTER	ADDRESS					HEX CODE
	D15–D12	D11	D10	D9	D8	
No-Op	X	0	0	0	0	0xX0
Digit 0	X	0	0	0	1	0xX1
Digit 1	X	0	0	1	0	0xX2
Digit 2	X	0	0	1	1	0xX3
Digit 3	X	0	1	0	0	0xX4
Digit 4	X	0	1	0	1	0xX5
Digit 5	X	0	1	1	0	0xX6
Digit 6	X	0	1	1	1	0xX7
Digit 7	X	1	0	0	0	0xX8
Decode Mode	X	1	0	0	1	0xX9
Intensity	X	1	0	1	0	0xXA
Scan Limit	X	1	0	1	1	0xXB
Shutdown	X	1	1	0	0	0xXC
Display Test	X	1	1	1	1	0xXF

5.3.1 Shutdown register

MODE	ADDRESS CODE (HEX)	REGISTER DATA							
		D7	D6	D5	D4	D3	D2	D1	D0
Shutdown Mode	0xXC	X	X	X	X	X	X	X	X
Normal Operation	0xXC	X	X	X	X	X	X	X	1

- The address of this register is (0xXC)
- The normal operation mode was selected (0x01)

5.3.2 Decode mode register

DECODE MODE	REGISTER DATA								HEX CODE
	D7	D6	D5	D4	D3	D2	D1	D0	
No decode for digits 7–0	0	0	0	0	0	0	0	0	0x00
Code B decode for digit 0 No decode for digits 7–1	0	0	0	0	0	0	0	1	0x01
Code B decode for digits 3–0 No decode for digits 7–4	0	0	0	0	1	1	1	1	0x0F
Code B decode for digits 7–0	1	1	1	1	1	1	1	1	0xFF

- The address of this register is (0xX9)
- Code B decode for digits 7-0 was selected (0x01)

5.3.3 Display test register

MODE	REGISTER DATA							
	D7	D6	D5	D4	D3	D2	D1	D0
Normal Operation	X	X	X	X	X	X	X	0
Display Test Mode	X	X	X	X	X	X	X	1

- The address of this register is (0xXF)
- The normal operation mode was selected (0x0))

5.3.4 Intensity register

DUTY CYCLE		D7	D6	D5	D4	D3	D2	D1	D0	HEX CODE
MAX7219	MAX7221									
1/32 (min on)	1/16 (min on)	X	X	X	X	0	0	0	0	0xX0
3/32	2/16	X	X	X	X	0	0	0	1	0xX1
5/32	3/16	X	X	X	X	0	0	1	0	0xX2
7/32	4/16	X	X	X	X	0	0	1	1	0xX3
9/32	5/16	X	X	X	X	0	1	0	0	0xX4
11/32	6/16	X	X	X	X	0	1	0	1	0xX5
13/32	7/16	X	X	X	X	0	1	1	0	0xX6
15/32	8/16	X	X	X	X	0	1	1	1	0xX7
17/32	9/16	X	X	X	X	1	0	0	0	0xX8
19/32	10/16	X	X	X	X	1	0	0	1	0xX9
21/32	11/16	X	X	X	X	1	0	1	0	0xXA
23/32	12/16	X	X	X	X	1	0	1	1	0xXB
25/32	13/16	X	X	X	X	1	1	0	0	0xXC
27/32	14/16	X	X	X	X	1	1	0	1	0xXD
29/32	15/16	X	X	X	X	1	1	1	0	0xXE
31/32	15/16 (max on)	X	X	X	X	1	1	1	1	0xXF

- The address of this register is (0xXA)
- The maximum brightness was selected (0xXF)

5.3.5 Scan limit register

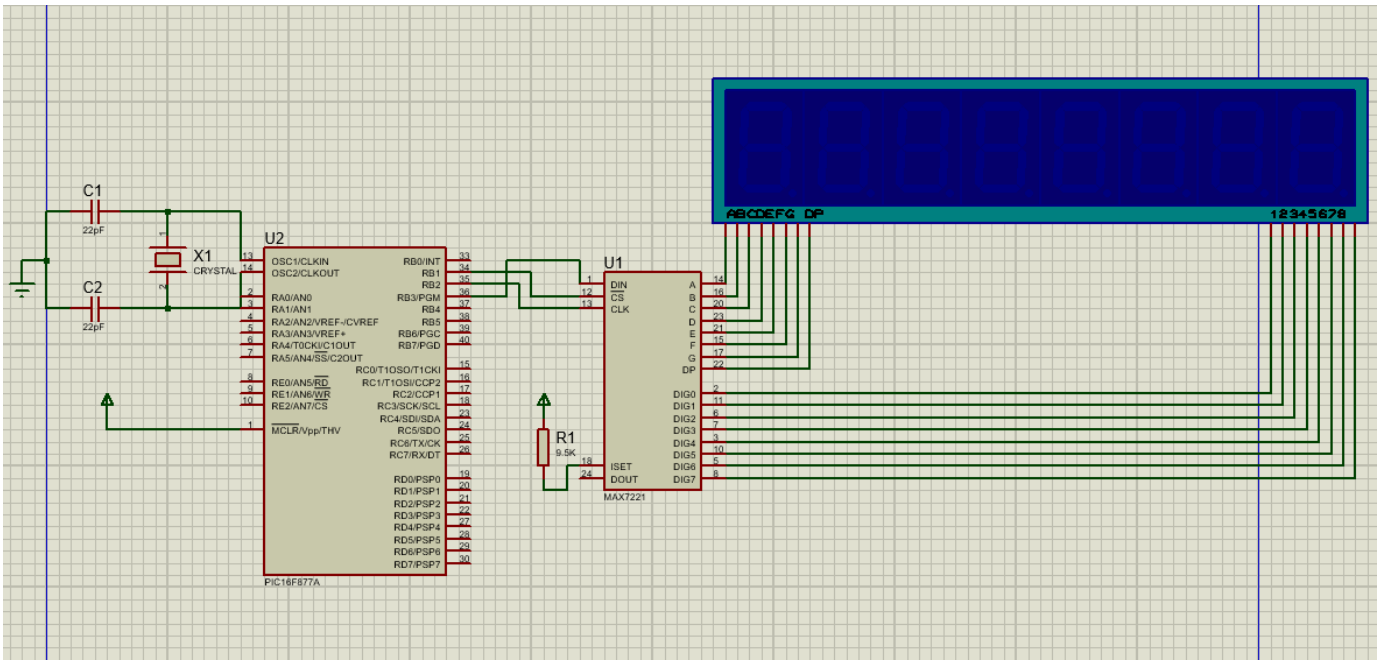
SCAN LIMIT	REGISTER DATA								HEX CODE
	D7	D6	D5	D4	D3	D2	D1	D0	
Display digit 0 only*	X	X	X	X	X	0	0	0	0xX0
Display digits 0 & 1*	X	X	X	X	X	0	0	1	0xX1
Display digits 0 1 2*	X	X	X	X	X	0	1	0	0xX2
Display digits 0 1 2 3	X	X	X	X	X	0	1	1	0xX3
Display digits 0 1 2 3 4	X	X	X	X	X	1	0	0	0xX4
Display digits 0 1 2 3 4 5	X	X	X	X	X	1	0	1	0xX5
Display digits 0 1 2 3 4 5 6	X	X	X	X	X	1	1	0	0xX6
Display digits 0 1 2 3 4 5 6 7	X	X	X	X	X	1	1	1	0xX7

- The address of this register is (0xXB)
- The option to display digits 0-7 was selected (0xX7)

5.4 Circuit set up

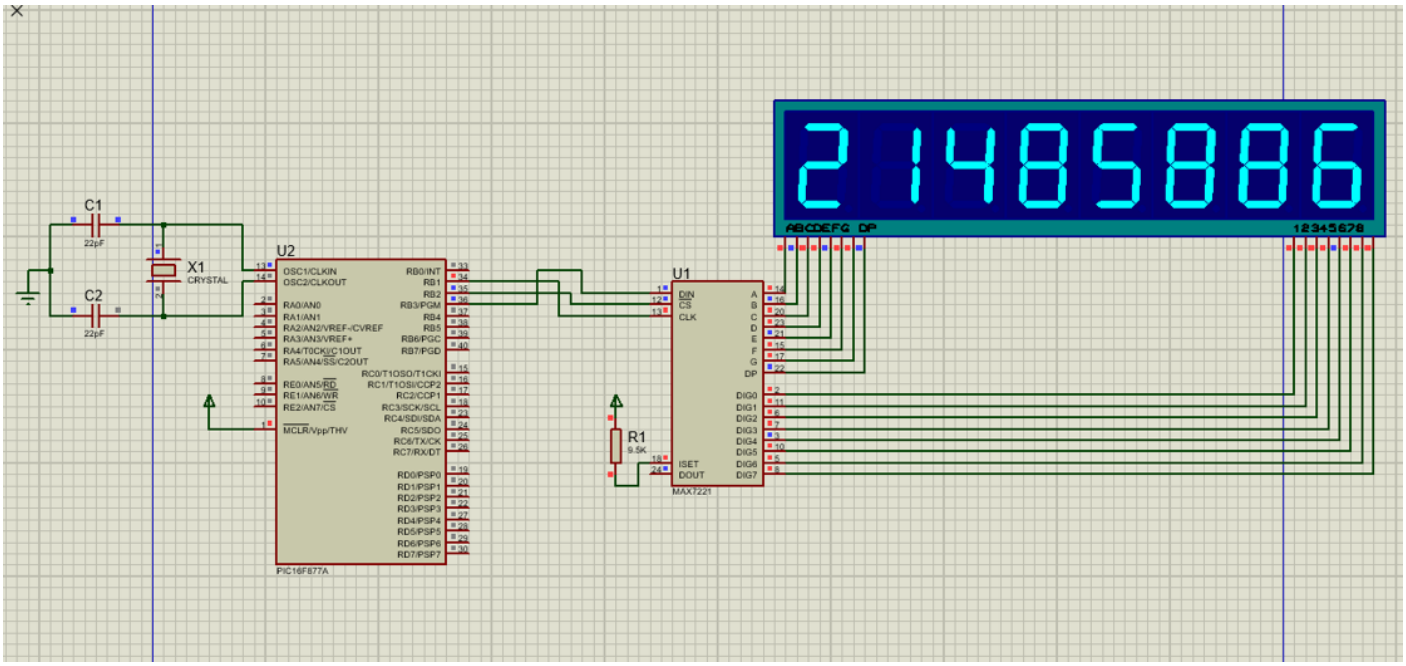
Components used:

- MAX7221 display driver
- PIC16F877A microcontroller
- 7 segment, 8 digit cathode display
- Crystal oscillator



6. Results

The required output was obtained from the Proteus simulation as shown below:



7. Conclusion

The task of this assignment was to display the EN number on a seven segment display. This was achieved by programming the PIC16F877A microcontroller using the mplab software. The Proteus simulation software was used to construct the circuit and ensure that the required output is obtained. The MAX7221 display driver was used to interface the microcontroller to the display.

8. References

- Codrey electronics, 2018, What is serial communication and how it works. Available at: https://www.codrey.com/embedded-systems/serial-communication-basics/ (Accessed 24th July 2022)

- Electronics Tutorials, 2022, 7 segment display. Available at: https://www.electronics-tutorials.ws/blog/7-segment-display-tutorial.html (Accessed 24th July 2022)

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