High-Accuracy, Ultra-Low Power, 16Bit Relative Humidity and Temperature Sensor

1 Features

- Relative humidity accuracy: ±2.5%RH
- Temperature accuracy: ±0.2 °C
- Supply voltage: 1.6 V to 5.5 V
- Average current: 0.4 μA (at meas. rate 1 Hz)
- Idle current: 0.1uA
- Resolution: 0.01%RH, 0.01℃
- Operating range: 0-100%RH, -40~125°C
- Communication Interface: I2C, up to 1MHz
- Variable power heater
- NIST traceability
- JEDEC JESD47 qualification

2 Applications

- Smart home
- Air quality/dehumidifier
- Washer & dryer
- Consumer electronics
- Cold chain transportation
- Wireless sensor

3 Description

GD30TSHTV4 is a new-generation single-chip integrated temperature and humidity sensor of GD, which can offer configurable I²C addresses, 0x44(default). The built-in heater can be activated in anti-dew occasions, and the heater power is configurable.

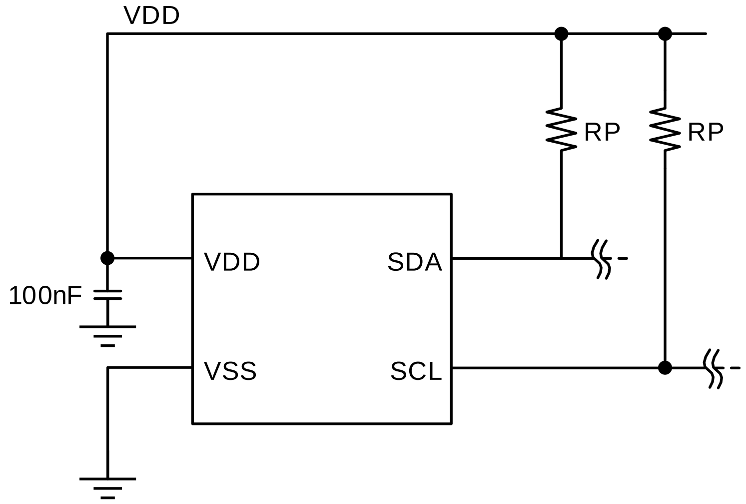
The four-pin dual-flat-no-leads package is suitable for surface mount technology (SMT) processing.

Device Information[1]

PART NUMBER	PACKAGE	BODY SIZE (NOM)
GD30TSHTV4	DFN-4	1.50mm x 1.50mm

1. For packaging details, see *Package Information* section.

Simplified Application Schematic



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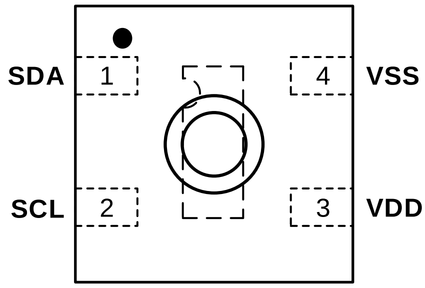
4 Device Overview

4.1 Pin Assignment

DFN Package
4-Pin Top View



4.2 Pin Description

PINS		PIN TYPE[1]	FUNCTION
NAME	NUM		
SDA	1	IO	Data pin; input/output.
SCL	2	IO	Serial clock; input/output
VDD	3	P	Supply voltage; input
VSS	4	G	Ground.

1. P = power, G = Ground, IO=input and output.

5 Parameter Information

5.1 Absolute Minimum and Maximum Ratings

Exceeding the operating temperature range (unless otherwise noted)[1]

SYMBOL	PARAMETER	MIN	MAX	UNIT
V_{DD}	Power supply	−0.3	6	V
T_A	Operating temperature range	−40	125	°C
T_J	Junction temperature range		150	°C
T_{stg}	Storage temperature	−40	150	°C

1. The maximum ratings are the limits to which the device can be subjected without permanently damaging the device. Note that the device is not guaranteed to operate properly at the maximum ratings. Exposure to the absolute maximum rating conditions for extended periods may affect device reliability.

5.2 Recommended Operation Conditions

SYMBOL[1]	PARAMETER	MIN	TYP	MAX	UNIT
V_{DD}	Supply voltage	1.6	3.3	5.5	V
T_A	Operating Temperature range	−40		125	°C

5.3 Electrical Sensitivity

SYMBOL[1]	CONDITIONS	VALUE	UNIT
$V_{ESD(HBM)}$	Human-body model (HBM), ANSI/ESDA/JEDEC JS-001-2017[1]	±7000	V
LU	Latch-Up, per JESD 78, Class IA	±200	mA

1. JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.

5.4 Electrical Characteristics

The following data are the characteristics of the chip in the temperature ranges from −40°C to +125°C and the power supply voltage ranges from 1.6V to 5.5V (Typical operating conditions are +25°C and 3.3V), unless otherwise specified.

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNIT
Power supply						
V_{DD}	Power Supply Voltage		1.6	3.3	5.5	V
V_{POR}	Power-up/down level		0.8		1.0	V
$V_{DD,slew}$	Slew rate change of the supply voltage				20	V/ms
I_{DD}	Supply current	Idle state	0.08	0.1	0.15	μA
		Measuring		300	500	
		High repeatability		2		
		Med repeatability		1.2		
		Low repeatability		0.4		
V_{IL}	Low level input voltage		0		$0.3xV_{DD}$	V
V_{IH}	Low level input voltage		$0.7xV_{DD}$		V_{DD}	V
R_P	Pull up resistors		390			Ω
C_B	Cap bus load				400	pF
Timing Specification for the Sensor System[1]						
t_{PU}	Power-up time	After hard reset, $V_{DD} \geq V_{POR}$		0.3	1	ms
t_{SR}	Soft reset time	After soft reset			1	ms
$t_{MEAS,l}$	Measurement duration	Low repeatability		1.3	1.6	ms
$t_{MEAS,m}$		Medium repeatability		3.7	4.5	ms
$t_{MEAS,h}$		High repeatability		6.9	8.3	ms
t_{Heater}	Heater-on duration	Long pulse	0.9	1	1.1	s
		Short pulse	0.9	1	1.1	s

1. Max. values are measured at 1.6 V supply voltage.

5.5 Humidity Sensor Characteristics

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNIT
Accuracy			±2.5	See Figure 1	%RH
Repeatability Error		0.25	0.15	0.08	%RH
Resolution			0.01		%RH
Hysteresis	at 25°C		±0.8		%RH
Specified Range	Measurement Range	0		100	%RH
Response Time	τ63%		4		Second
Long Term Drift			<0.3		%RH /year

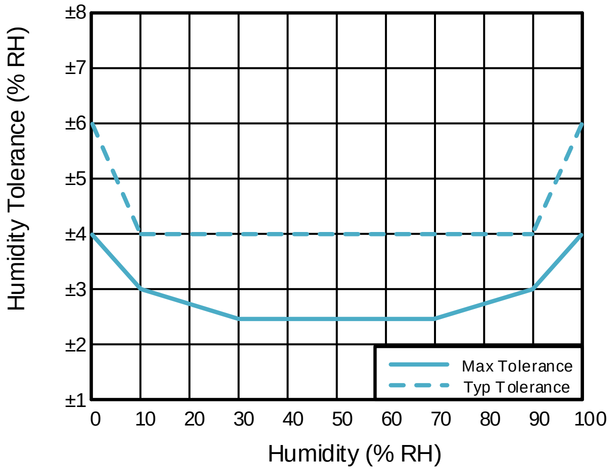


Figure 1. Tolerance of RH @25°C for GD30TSHTV4

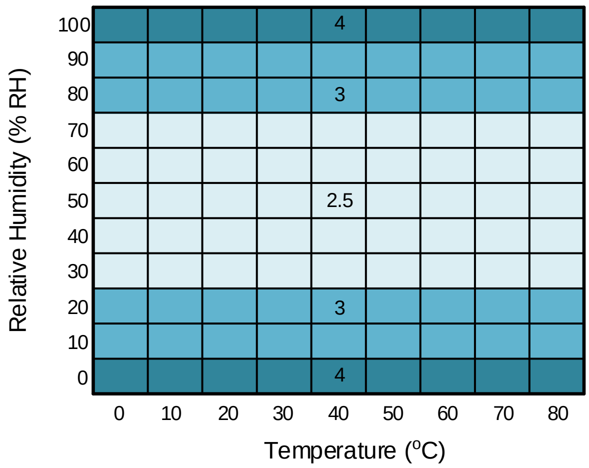


Figure 2. Typical RH Accuracy Tolerance Over Humidity and Temperature for GD30TSHTV4

5.6 Temperature Sensor Characteristics

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNIT
Accuracy			±0.2	See Figure 3	°C
Repeatability Error		0.1	0.07	0.04	°C
Resolution			0.01		°C
Specified Range	Measurement Range	−45		125	°C
Response Time	τ63%		2		second
Long Term Drift	Max			<0.03	°C/year

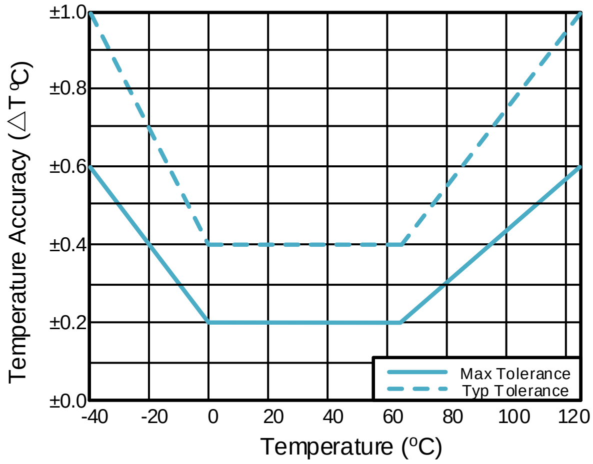


Figure 3. Temperature accuracy of GD30TSHTV4

6 Functional Description

6.1 Block Diagram

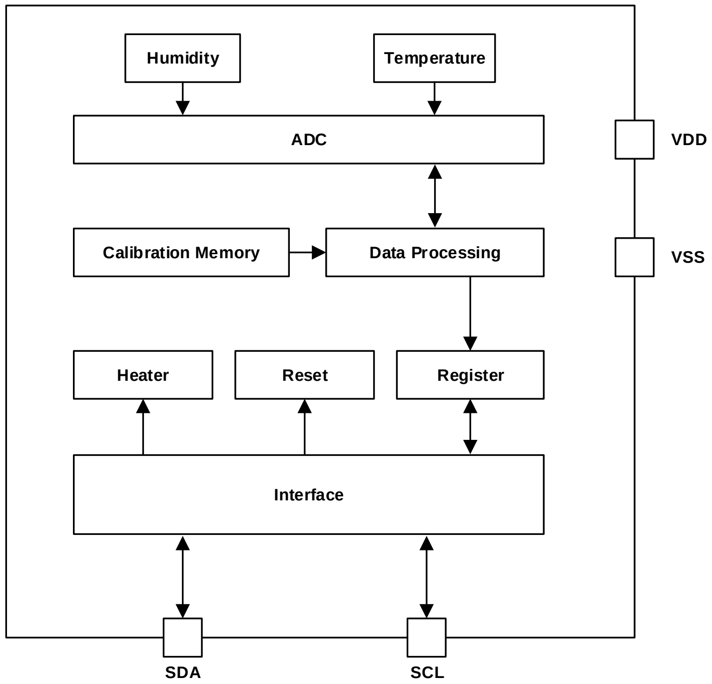


Figure 4. GD30TSHTV4 Block Diagram

6.2 Operation

6.2.1 I²C Communication

I²C communication is based on NXP's I²C-bus specification. Supported I²C modes are standard, fast mode, and fast mode plus. Data is transferred in multiples of 16-bit words. In order to increase reliability of data transfer, I²C glitch protection is offered in form of 8-bit checksum (cyclic redundancy check = CRC). All transfers must begin with a start condition (S) and terminate with a stop condition (P). To finish a read transfer, send not acknowledge (NACK) and stop condition (P). Addressing a specific slave device is done by sending its 7-bit I²C address followed by an eighth bit, denoting the communication direction: "zero" indicates transmission to the slave, i.e. "write", a "one" indicates a "read" request. The sensor does not support clock-stretching. In case the sensor receives a read header and if the conversion remains unfinished, it will return a NACK. Measurement data can only be received once and will be deleted from the sensor's register after the first acknowledged I²C read header.

Figure 5. Typical I2C Communication Timing of GD30TSHTV4

As shown in Figure 5, this is the typical I²C communication timing for the GD30TSHTV4 series. First a write header is sent to the I²C slave, followed by a command, for example "measure RH&T with highest precision". After the measurement is finished, the read request directed to this I²C slave will be acknowledged and transmission of data will be started by the slave.

All details on the timing are following the interface specification of NXP's user manual UM10204 Rev.6,4 April 2014. Please follow mandatory capacitor and resistor requirements given in 5.4.

6.2.2 Data Type and Length

I²C bus operates with 8-bit data packages. Information from the sensor to the master has a checksum after every second 8-bit data package. Humidity and temperature data will always be transmitted in the following way: The first value is the temperature signal (2x8-bit data + 8-bit CRC), the second is the humidity signal (2x8-bit data + 8-bit CRC).

6.2.3 Checksum Calculation

For read transfers each 16-bit data is followed by a checksum with the following properties.

PROPERTY	VALUE
Name	CRC-8
Message Length	16 bit
Polynomial	0x31($X^8+X^5+X^4+1$)
Initialization	0xFF
Reflect Input/Output false/false	false / false
Final XOR	0x00
Examples	CRC(0xBEEF) = 0x92

6.2.4 Command Description

COMMAND (HEX)	RETURNED BYTES	DESCRIPTION [return values]
0xFD	6	Measure T & RH with high repeatability [2 byte T-data + 1 byte CRC + 2 byte RH-data + 1 byte CRC]
0xF6	6	Measure T & RH with medium repeatability [2 byte T-data + 1 byte CRC + 2 byte RH-data + 1 byte CRC]
0xE0	6	Measure T & RH with lowest repeatability [2 byte T-data + 1 byte CRC + 2 byte RH-data + 1 byte CRC]
0x89	6	Read serial number [2 byte data + 1 byte CRC + 2 byte data + 1 byte CRC]
0x94		soft reset [ACK]
0x39	6	Activate heater with 200mW for 1s, including a high precision measurement just before deactivation
0x32	6	Activate heater with 200mW for 0.1s, including a high precision measurement just before deactivation
0x2F	6	Activate heater with 110mW for 1s, including a high precision measurement just before deactivation
0x24	6	Activate heater with 110mW for 0.1s including a high precision measurement just before deactivation
0x1E	6	Activate heater with 20mW for 1s including a high precision

COMMAND (HEX)	RETURNED BYTES	DESCRIPTION [return values]
		measurement just before deactivation
0x15	6	Activate heater with 20mW for 0.1s including a high precision measurement just before deactivation

1. If the sensor is not ready to process a command e.g. because it is still measuring, it will response with NACK to the I²C read header. Given heater power values are typical and valid for VDD=3.3 V.

6.2.5 Conversion of Signal Output

The digital sensor signals correspond to following humidity and temperature values:
Relative humidity conversion formula (result in %RH):

$$RH = (-6 + 125 \times \frac{S_{RH}}{2^{16} - 1})$$

Temperature conversion formula (result in °C & °F):

$$T\left[{}^{\circ}C\right] = -45 + 175 \times \frac{S_T}{2^{16} - 1}$$

$$T\left[{}^{\circ}C\right] = -49 + 315 \times \frac{S_T}{2^{16} - 1}$$

The RH conversion formula allows values to be reported which are outside of the range of 0%RH to 100%RH. Relative humidity values which are smaller than 0 %RH and larger than 100 %RH are non-physical, however, these “uncropped” values might be found beneficial in some cases (e.g. when the distribution of the sensors at the measurement boundaries are of interest). For all users who do not want to engage in evaluation of these non-physical values, cropping of the RH signal to the range of 0 %RH to 100 %RH is advised.

6.2.6 Serial Number

Each sensor has a unique serial number, that is assigned with specific rules during production. It is stored in the OTP (one-time-programmable) memory and cannot be manipulated after production. The serial number is accessible via I²C command 0x89 and is transmitted as two 16-bit words, each followed by an 8-bit CRC.

6.2.7 Reset and Abort

A reset of the sensor can be achieved in three ways:

1. Soft reset: send the reset command described in 6.2.7.
2. I²C general call reset: all devices on I²C bus are reset by sending the command 0x06 to the I²C address 0x00.
3. Power down (incl. pulling SCL and SDA low).

Any command that triggers an action at the sensor can be aborted via I²C general call reset or soft reset.

6.2.8 Heater Operation

The sensor incorporates an integrated on-chip heater which can be switched on by the set of different commands. Three heating powers and two heating durations are selectable. After reception of a heater-on command, the sensor executes the following procedure:

1. The heater is enabled and the timer starts its count-down;

2. On timer expiration a temperature and humidity measurement with the highest repeatability is started, the heater remains enabled;

3. After the measurement is finished the heater is turned off;

4. Temperature and humidity values are now available for readout.

The maximum on-time of the heater commands is one second in order to prevent overheating of the sensor by unintended usage of the heater. In cases where periodic heating is required, it is necessary to ensure that the duty cycle of the heater's on and off times is less than 10%.

Possible Heater Use Cases:

1. Removal of condensed / spray water on the sensor surface. Although condensed water is not a reliability / quality problem to the sensor, it will however make the sensor non-responsive to RH changes in the air as long as there is liquid water on the surface.

2. Creep-free operation in high humid environments. Periodic heating pulses allow for creep-free high-humidity measurements for extended times.

Important notes for operating the heater:

1. The heater is designed for a maximum duty cycle of 10%, meaning the total heater-on-time should not be longer than 10% of the sensor's lifetime.

2. During operation of the heater, sensor specifications are not valid.

3. The temperature sensor can additionally be affected by the thermally induced mechanical stress, offsetting the temperature reading from the actual temperature.

4. The sensor's temperature (base temperature + temperature increase from heater) must not exceed Tmax = 125 °C in order to have proper electrical functionality of the chip.

5. The heater draws a large amount of current once enabled (up to 70 mA in the highest power setting). Although a dedicated circuitry draws this current smoothly, the power supply must be strong enough to avoid large voltage drops that could provoke a sensor reset.

6. If higher heating temperatures are desired, consecutive heating commands must be sent to the sensor. The heater shall only be operated in ambient temperatures below 65 °C or else it could drive the sensor outside of its maximal operating temperature (125°C).

7 Application Information

The GD30TSHTV4 is a single-chip integrated temperature and humidity sensor with a wide supply voltage range, supporting I²C communication. The typical application circuit is as follows.

7.1 Typical Application Circuit

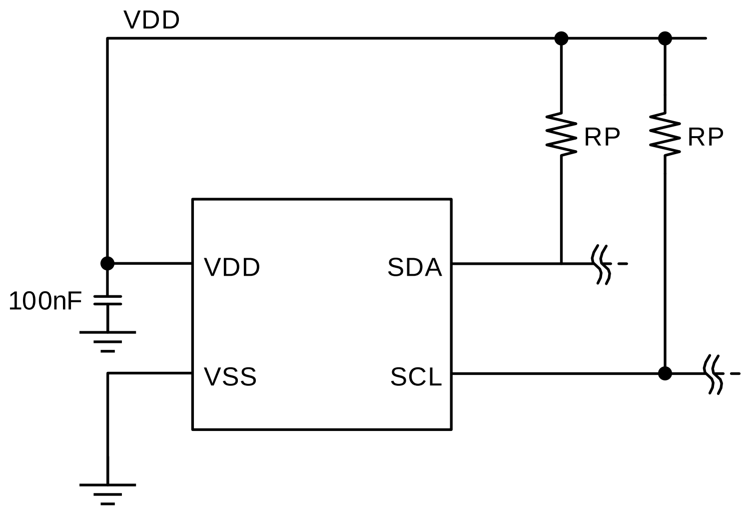
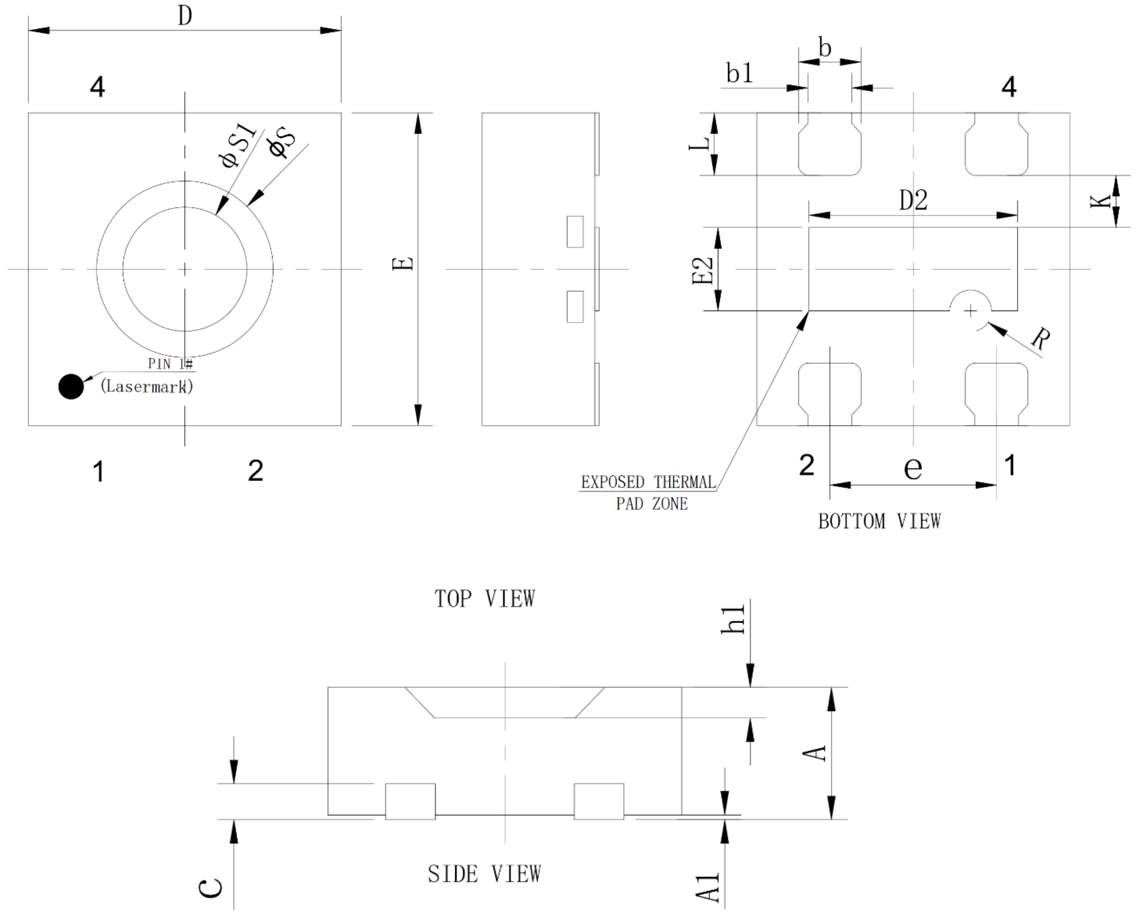


Figure 6. GD30TSHTV4 Reference Circuit

8 Package Information

8.1 Outline Dimension

DFN-4 Package Outline



NOTES:

1. All dimensions are in millimeters.
2. Package dimensions does not include mold flash, protrusions, or gate burrs.
3. Refer to the *Table 1. DFN-4 dimensions(mm)*.

Table 1. DFN-4 dimensions(mm)

SYMBOL	MIN	NOM	MAX
A	0.49	0.54	0.59
A1	0	0.02	0.05
b	0.25	0.30	0.35
b1		0.21REF	
c		0.152REF	
D	1.45	1.50	1.55
D2	0.90	1.00	1.10
E	1.45	1.50	1.55
E2	0.30	0.40	0.50
e		0.80BSC	
K		0.25REF	
L	0.25	0.30	0.35
R		0.10REF	
Φ S		0.60BSC	
Φ S1		0.50BSC	
h1		0.13	

9 Ordering Information

Ordering Code	Package Type	ECO Plan	Packing Type	MOQ	OP Temp(°C)
GD30TSHTV4JETR-I	DFN-4	Green	Tape & Reel	2000	−40°C to +125°C

10 Revision History

REVISION NUMBER	DESCRIPTION	DATE
1.0	Initial release and device details	2024
1.1	Version upgrade	2025

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