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Technical Documentation

MCS-EB1

Colour Sensor Evaluation Board

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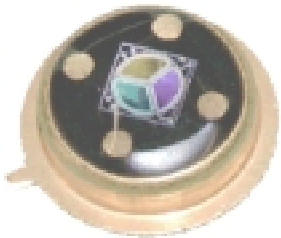
1. INTRODUCTION

Industrial colour sensing and monitoring is becoming easier. Where colours need to be identified or comparative colour measurement is performed with little effort and in a highly dynamic environment, MAZeT's colour sensor designs are just the right tool. Like the human eye, sensors of this type use the three-range method for colour detection.



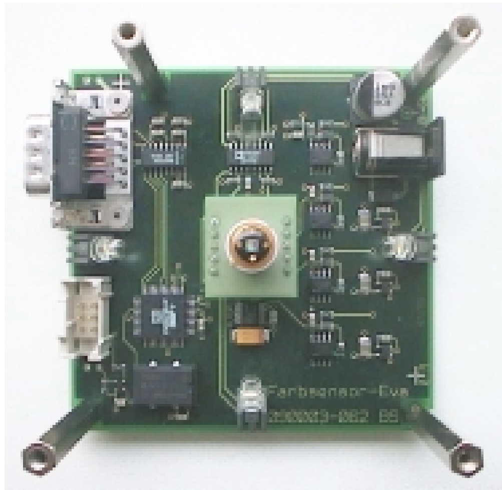


Figure 1: MCS3AT colour sensor with MCS-EB1 evaluation board

The MCS-EB1 provides an 8052-based µC-platform. It is used to demonstrate the principle of colour detection with the help of the newly designed JENCOLOUR colour sensors.

Four white light LED's illuminate a test surface under an incident angle of 45° (approx.). At a distance of 20 mm along the surface orthogonal, diffusely reflected light is detected and digitised by the JENCOULOR colour sensor.

For communication between the PC and the MCS-EB1, an RS232 interface is available. It reads the sensor data and sets the required parameters.

Comfortable PC software allows manual gain selection for the current-voltage converter. In addition to the 10-bit ADC output values obtained for the various RGB photocurrents, the normalised colour portions and mixed colours are represented in an intuitive manner.

The MCS-EB1 platform may also serve as an exemplary circuit application for composing other simple colour detection systems with JENCOLOUR colour sensors.

2. STARTUP

2.1 Included in delivery

Standard MCS-EB1s delivery includes the following components:

- One MCS-EB1
- One MCS base adapter board
- One MCS3xx three-element colour sensor
- One plug-in 7.5 V power pack
- One RS232 cable
- Two diskettes with installation software
- One documentation set

2.2 System requirements

To perform sensor start-up, the following system requirements are necessary:

- 150 MHz or higher Pentium PC
- Eight MB RAM
- Five MB free memory space on hard-disk
- One free serial interface
- One 3.5“ floppy disk drive
- Windows9x or Windows/NT 4.0

2.3 Connection of components

The sensor components must be connected as shown in this general system chart.

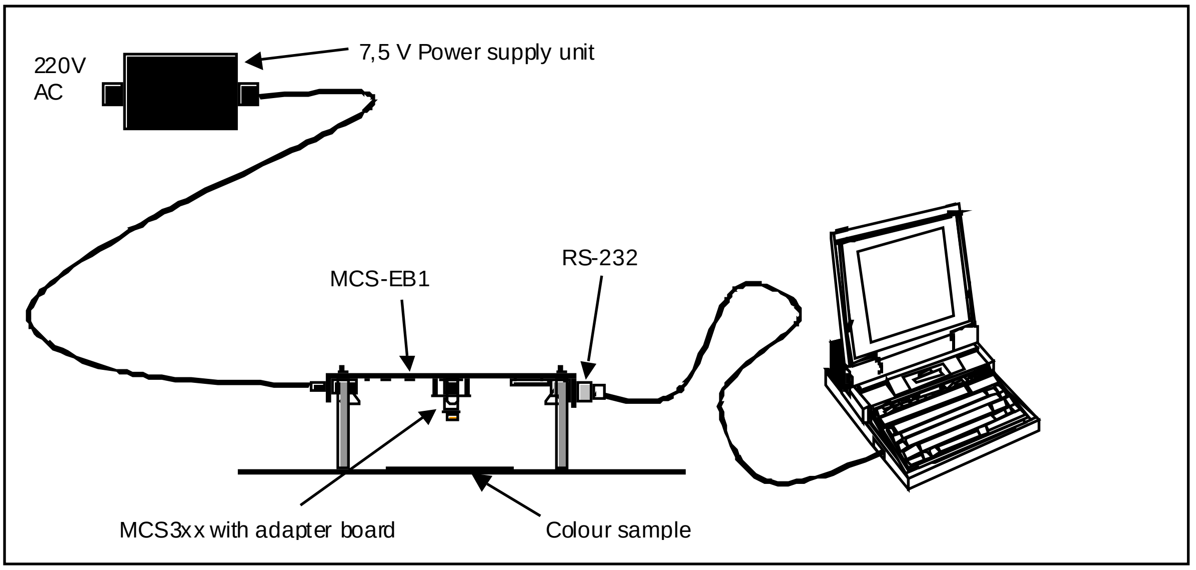


Figure 2: Connection of Eva-Board components

2.4 Software installation

To install the PC software, insert diskette 1 in a disk drive of your PC. Start the "setup.exe" program and follow the installation instructions.

The set-up program will install the required program files on your PC. The configuration path contains the colour channel assignment for the currently mounted colour sensor. It must be transferred to the same path, which also keeps the program files. The corresponding file is then loaded at the moment of program starting, which represents a necessary precondition for system initialisation and a faultless program start (see also 5.3 Selection of sensor type).

3. HARDWARE

3.1 Colour sensor

JENCOLOUR MCS3xx colour sensors consist of 3 Si-PI N photodiodes integrated on chip. They are designed as segments of a circle, which measures 2.0 mm in diameter. Si-PIN photodiodes have been selected for operation with signal frequencies up to one MHz.
Dielectric colour filters are integrated to sensitise each of the three photodiodes for a particular colour range, preferentially the basic colours of red, green and blue. In standard version, each sensor is delivered in a TO5 package with transparent casting compound or protective glass or in a SOP8 package with clear plastic cover. Other packaging types can be customised on special request.

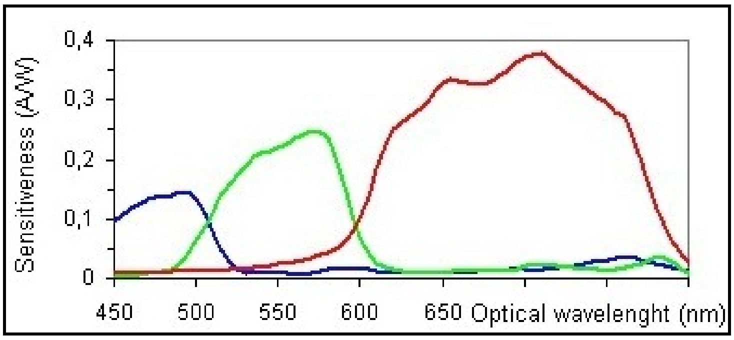


Figure 3: Typical spectral sensitivity graph of three-element colour

For MCS3 sensors, dielectric colour filters are used. These are directly located on the photodiodes. The sensor thus forms a compact optical set-up. Since these filters reflect light in the blocked colour ranges, they are much more resistant to aging than colour filters, which are based on the absorption principle. Besides this, dielectric filters warrant high temperature stability and resistance to environmental influences. This makes them perfectly suited to perform stabile in applications with hard ambient conditions.

Because of their multi-layer stack set-up, filters of this kind can be employed to handle different functions. For special applications (for example, restriction to a small colour range), the spectral filter characteristics can be matched to customer request specifications.

In terms of contact points, each sensor provides an anode for the corresponding colour range and one common cathode. As with conventional photodiodes, the photocurrent can be recorded and reprocessed with the help of simple amplifier circuitry.

3.2 Evaluation board

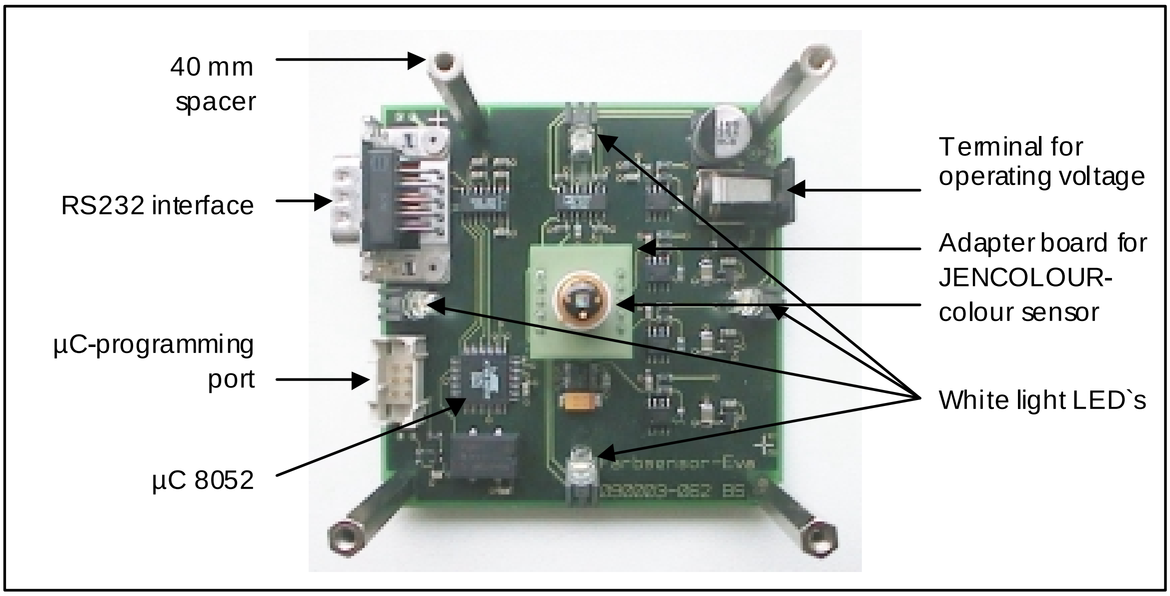


Figure 4: Colour sensor evaluation board MCS-EB1

Figure 5 represents a principal working diagram of the colour sensor evaluation board.

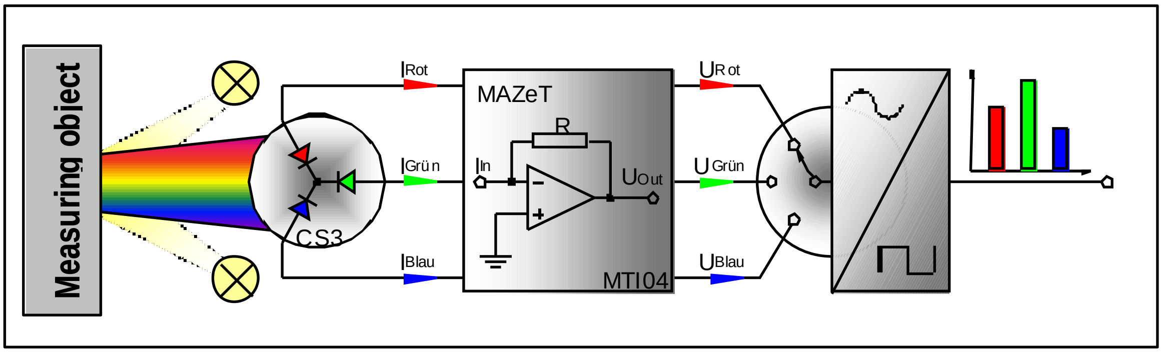


Figure 5: Functioning of the MCS-EB1

Four white light LED's under an angle of 45° illuminate the sample under test. The JENCOLOUR colour sensor detects the reflected light in the three colour ranges of red, green and blue. This occurs in a plane, which is perpendicular to the sample surface. Due to the selected design arrangement of 45° for illumination and 90° for actual measurement, it is also possible to measure more strongly reflecting surfaces. Various adapter board modifications are available for matching to the requested packaging version.

A four-channel transimpedance converter (MTI04) transforms the incoming photocurrents into equivalent voltages. Through selection of a suitable gain factor the range of output voltages can be matched to the photocurrent to be measured. Finally, the voltage signals are digitised in an AD converter.

A µ-controller handles all access operations to the various board components and maintains communication with a PC. As part of these processes, AD values can be transferred, required gain factors be set and illumination LED's be turned on and off.

4. µC SOFTWARE

The purpose of the µC software is to allow access to the board components: illuminator, gain factor and AD converter. In addition, it provides PC communication via an RS232 port. For PC communication, the evaluation board works in slave mode. This means that a requested action will only be executed if a corresponding command was transferred via the serial port.

The tables below show the various command codes with corresponding transfer data:

Command	Data sent forward	Data sent back	Meaning
F	---	1.10	Reads version number
B	x (8-bitvalue)	---	Sets µC-port2
C	---	high-Channel1, low-Channel1, high-Channel2, low-Channel2, high-Channel3, low-Channel3, high-Channel4, low-Channel4	Reads ADC values

Table 1: Command codes

Transfer commands of type "F“, "B“ and "C“ must be terminated by a CR („/r“). They are transferred as a string. Data transfers are organised in byte blocks.
(Version number = 4 bytes, setting µC port = 1 byte, ADC values = 8 bytes)

The code for µC port setting is as follows:

Bit	7	6	5	4	3	2	1	0
Comment.	LED	---	---	---	---	---	SW2	SW1

Table 2: Bit assignments of µC-port2

Illumination	LED / Bit 7
Off	0
On	1

Table 3: Illuminator LEDs

Current range	SW1 / Bit 1	SW2 / Bit 2
Up to 100 µA	0	0
Up to 5 µA	1	0
Up to 500 nA	1	1

Table 4: MIT gain factors (current ranges)

5. PC SOFTWARE

Once all components are connected as shown on Figure 2: Connection of Eva-Board components, and the PC software is installed, software start-up procedures may begin for the board.
The graphical user screen has been developed under LabWindows/CVI to allow easy access to the evaluation board with intuitive representation of the measured values.The graphical user screen has been developed under LabWindows/CVI to allow easy access to the evaluation board with intuitive representation of the measured values.

5.1 Starting the software

To start the PC software, select "evaboard.exe". It will query the desired language.

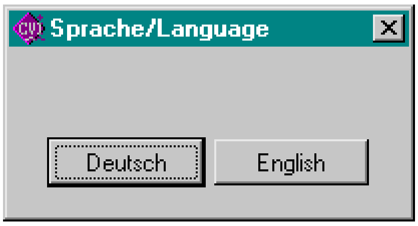


Figure 6: Selection of language

5.2 Selection of serial interface

After language selection, the graphical user screen opens and the software queries which RS232 interface is to be used for PC communication with the MCS-EB1 evaluation board.

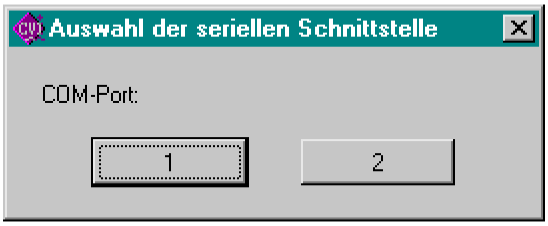


Figure 7 Selection of serial interface

On each program start, RS232 interface communication is automatically set as follows:

Baud	9600
Data bits	8
Parity	None
Stop bit	1
Protocol	None

Table 5 RS232-Interface configuration

In the event of a faulty connection (which will be detected by initial testing), the program is aborted. Make sure that the correct COM port is selected and able to communicate with the evaluation board.

5.3 Selection of sensor type

Once interface communication is successfully established, a configuration file can be loaded. A special window will open for this purpose.

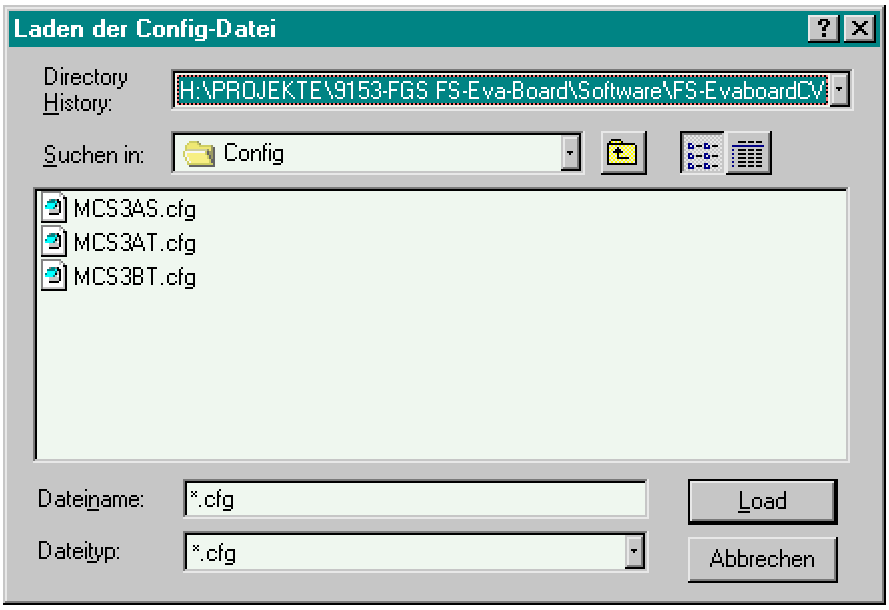


Figure 8 Window for configuration file loading

A configuration file contains the terminal assignments for a mounted sensor and the contact vias through a selected adapter base. Depending on the selected sensor type, one of the three following files needs to be loaded:

Type	Description	File
MCS3AT	TOP5 base with transparent globe top	mcs3at.cfg
MCS3BT	TO5 base with top and glass window (IR filter)	mcs3bt.cfg
MCS3AS	SOP8 packaging	mcs3as.cfg

Table 6 cfg - file

Warning!

Loading the wrong file may result in a mis-allocation of the colour channels for signal acquisition. Terminate the program in any such case. Then restart the program and load the file that corresponds to the selected sensor.

The system is now ready to perform black/white balancing.

You are advised to read the following chapters carefully before you proceed to data acquisition.

5.4 Graphical user screen

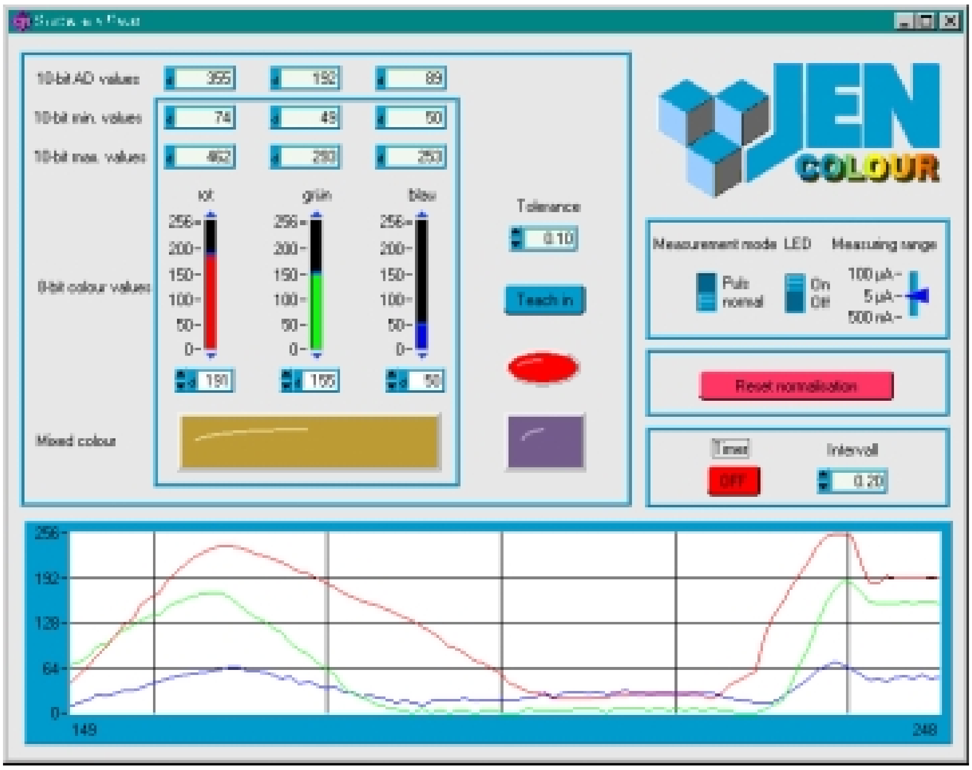


Figure 9 MSC-EB1 user screen

5.4.1 Measured value representation

Measured values are displayed in four categories.

"10 bit AD values" indicates the sensor signal level (amplified photocurrent converted into voltage). Conversion into the corresponding photocurrents is not described in this document.

"10 bit min. values" shows a black "Offset" value and "10 bit max. values" a white "Saturation" value for the respective colour. Both are used as inputs for normalisation to "8 bit colour values" and subsequent "Mixed colour" representation. The "8 bit colour values" are also recorded in the graphical chart at the screen bottom.

5.4.2 Board set-ups

Measured values can be recorded in continuous or in pulse mode. Mode selection is via a “Measurement mode" binary switch. The advantage of pulse mode operation is a relatively small sensitivity to slowly changing ambient light conditions.

The "LED" switch allows the white light LED illuminators to be turned on and off in continuous measurement mode.

A "Measuring range" ring slide is provided to select a gain factor for current-to-voltage conversion. The selected factor will set photocurrent measurement to ranges of 0 – 100 µA, 0 – 5 µA or 0 – 500 nA.

The gain setting should always be selected such that the ADC can not reach its limitation when a surface with strongly diffuse reflection (e.g. sheet of white paper) is illuminated. For working with LED illumination, the 0 – 5 µA photo current measuring range is recommended.

On actuation of the command button "Reset normalisation", "10 bit max. values" will be reset. Following any such reset, black and white level balancing must be carried out again in order to guarantee a faultless colour signal normalisation. Balancing is carried out in the same manner for pulse mode and continuous mode.

Cyclic recording and display of measured values can be triggered or halted by clicking the "Timer" button. The "Interval" numerical field is provided for selecting a suitable repeat rate between 0.1 and 5 seconds.

5.4.3 Starting a measurement

Use the "LED" switch for turning the LED's on. Then press the "Timer" button to trigger data acquisition in which digitised sensor values are continuously read .

5.4.4 Black/white balancing

Black/white balancing is performed each time when measurement is triggered with a new configuration.

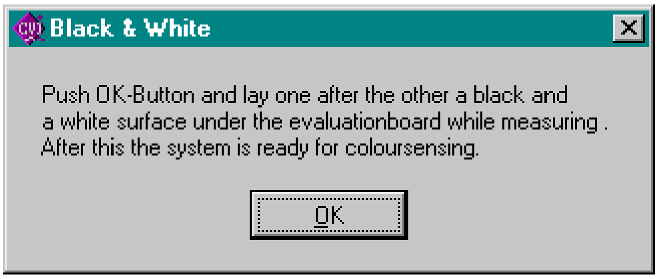


Figure 10: Black/white balancing

Place a black sample (minimal reflection) and a white sample (maximal reflection) in working position below the sensor to determine the offset and the saturation levels for all 3 colour ranges. These are displayed in fields "10 bit min. values" ("10-Bit Min-Werte") and "10 bit max. values" ("10-Bit Max-Werte") and updated if necessary while measurement lasts.

The resulting work range can be further optimised through variation of the measuring range. In any case, working selections should be such that a data overflow is prevented.

5.4.5 Colour sensing

On successful completion of a black/white balancing cycle, a randomly selected colour sample may be placed in working position. Each colour, broken down into its RGB portions (with progression bar), is displayed in a concurrently changing graphic and a mixed colour generation field.

Composition of the various RGB portions into a mixed colour may produce mismatches with the actual sample colour. These differences may be corrected with the help of special mathematical algorithms, which consider the spectral distribution of the illumination source and the spectral sensitivity of the sensor as well as other aspects. In the given sensor application version, no such signal processing function has been included on purpose.

5.4.6 Teaching a colour

Another function has been integrated into the sensor software to allow the teaching and recognition of a colour. On pushing the "Teach in" button, the recorded RGB values of a sample surface colour will be saved and the trained mixed colour be represented in the bottom area. A "Tolerance" field is available to define a desired interval for recognition of any of the three colours (e.g. 0.10 = > interval limits are ±10% around the trained RGB values).
The elliptical field below turns green (remains red otherwise) if a colour is displayed (recognised) within the trained RGB interval limits.

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