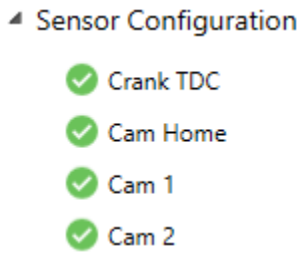
Spitronics - ECU - Crank and Cam Angle Sensors - Guide



1. Overview

These inputs are required by the ECU to determine exact crank and cam angles so that spark and injection timing can be calculated. For wasted spark and split-sequential injection, only a crank sensor is required, as long as it has a TDC mark or is used with a distributor.

Each product has:
• Crank (TDC) sensor input
• Cam (Home) sensor input

Additional Cam Inputs

Mercury3 also has two additional cam inputs:
• Cam1
• Cam2

These are used for cam loop control functionality *(not yet developed)*.

👉 Even if the hardware does not have physical Cam1 and Cam2 sensors, these settings are still used in software to configure cam control parameters
👉 For more on cam control, see the Cam Control document

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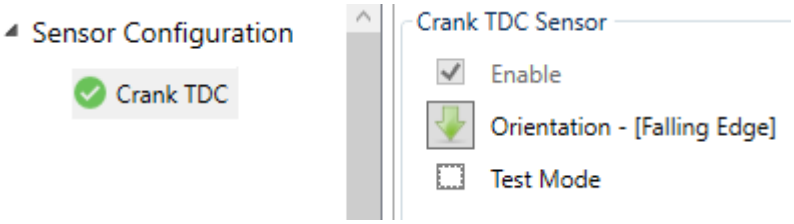
2. Crank Signal (TDC)

The crank angle sensor is used by the ECU to determine crank position as the engine rotates.



Sensor Location

• Crankshaft
• Flywheel
• Distributor
• Encoder (CAS)

Signal Behaviour

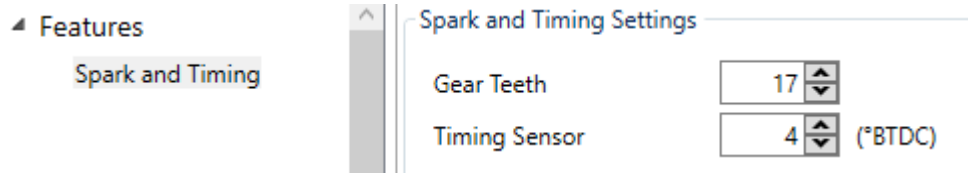
• Generates pulses per revolution
• A reference event (missing tooth or pattern deviation) indicates crank angle position

Examples

• 36-1 trigger → missing tooth reference
• 12-tooth wheel → evenly spaced pulses with no reference → requires home pulse or distributor
• Distributor → multiple pulses over two revolutions → may have TDC or home component → rotor distributes spark so TDC is not critical → rotor phasing is critical

👉 If mounted on cam:
• 24 teeth = represents 2 crank revolutions
• Often referred to as 24+TDC, but is actually 12+TDC or Home

Crank Sensor Timing



Crank sensor timing or alignment is done by two settings:
• Gear Teeth → coarse adjustment
• Timing Sensor °BTDC → fine adjustment

👉 These settings behave differently for different crank sensor signal setups. Refer to each setup in the Crank Sensor Types manuals

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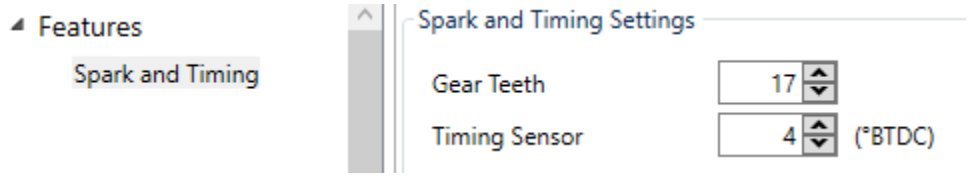
3. Cam Signal (Home)

Home indicates a deviation that differentiates between two engine revolutions.



👉 This allows the ECU to determine:
• Engine stroke (compression vs exhaust)
• Full 720° cycle position

👉 Home signal enables full sequential operation
👉 Sometimes it is used as a TDC component when the crank sensor has even patterns

Sensor Location

The cam sensor is always mounted on the camshaft. It can be one of the following:
• Standalone sensor
• Integrated in distributor
• Encoder (CAS)

Signal Behaviour

• Generates pulses per camshaft revolution (720°)
• A reference event (variable pattern per revolution) indicates engine stroke position

Examples

• 3 even pulses trigger → one pulse on one revolution and two pulses on the other revolution
• 4 uneven pulses trigger → one pulse may be longer, indicating one of the two revolutions

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4. TDC vs Home Pulse (Important)

TDC

TDC refers to a deviation in the crank pulse train that allows the ECU to identify a reference position.

👉 This reference point:
• Does NOT have to be exactly at TDC
• Must be defined correctly in the software

From this reference, the ECU calculates full 360° crank position.

What the ECU Uses This For

• Coil start charge timing
• Coil firing timing
• Injector start timing

👉 Injector stop timing is time-based for repeatability

👉 Coil charge start timing may vary slightly with RPM changes

Home

Home refers to a deviation in the cam pulse train that allows the ECU to identify stroke position.

👉 This reference point:
• Can be any pattern as long as it differs between two revolutions
• Must be defined correctly in the firmware to identify stroke

From this reference, the ECU calculates full 720° crank position.

What the ECU Uses This For

- Stroke identification
- Full sequential features
- TDC reference

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5. Software Setup – Full Sequential

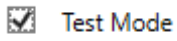
To enable full sequential functionality, the cam home pulse must be set up correctly.

First, set up the engine for wasted spark and split or full sequential injection using the crank sensor only, if possible. The engine can also be tuned in this state.

👉 This makes it easier to determine the correct home position using the injection method

👉 If the sensor pattern requires a home pulse, this may not be possible. In most cases, firmware will already be written for the application

Test Mode



- Test mode disables fuel injection during setup
- Used to determine correct home position
- Error codes are displayed in the status bar

👉 Always disable test mode after setup

Cam Home Tooth Setup

Although crank trigger patterns are mostly standard (e.g. 60-2, 36-1), cam signals are not standardised.

- Cam sensors may be magnetic, but most are Hall sensors
- Cam patterns are often irregular or inconsistent
- Tooth count and position may vary between revolutions

👉 Hall sensors are preferred because they allow clearer signal definition and flexible tooth shapes

Cam signals characteristics differ in two main ways:
- Number of pulses per revolution
- Position of pulses relative to crank signal

Most engines use position variation rather than pulse count variation.

👉 Spitronics firmware is designed primarily for position-based differentiation

👉 Engine-specific firmware may be created for other configurations

Test Mode Procedure

1. Enable Crank Test Mode
2. Crank the engine repeatedly
3. Observe error codes

👉 Stroke identification works by comparing crank patterns between two revolutions

• If patterns are identical → error
• If patterns differ → no error

Finding the Synchronising Tooth

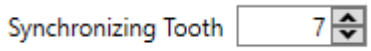
1. Start with tooth = 1
2. Crank engine → error should appear
3. Increase tooth value step-by-step
4. Clear errors (press C) after each change
5. Identify range where error disappears

Example
• Error stops at tooth 4
• Error returns at tooth 12

👉 Valid range = 4 to 11

Calculation:
(4 + 11) ÷ 2 = 7

👉 Set Synchronising Tooth = 7



Practical Notes

• Avoid long cranking periods → starter may overheat
• Allow cooling time between attempts
• Save the map between tests

👉 If a startup map already exists, this step may not be required

Stroke Identification Methods

The ECU must identify the correct engine stroke (compression vs exhaust) to enable full sequential operation.

Two methods are available:

1. Full Sequential Spark Method (Primary Method)

This method uses ignition behaviour to confirm correct stroke alignment.

Procedure

1. Start engine in **wasted spark mode**
2. Ensure coils are wired as **COP (one coil per driver)**
3. Set correct:
   • Gear Teeth
   • Timing Sensor

👉 Timing light and ECU timing must match

4. Save settings and switch engine OFF
5. Select **Full Sequential COP mode**
6. Restart engine

Result

• Engine starts → correct stroke
• Engine does not start → incorrect stroke

Correction

Adjust Gear Teeth by one full revolution:

Example (60-2 trigger):
• Add 60 teeth → move timing one revolution forward
• Subtract 60 teeth → move timing one revolution backward

Example:
• Original = 18 → New = 78
• Original = 74 → New = 14

👉 This aligns the ECU with the compression stroke and TDC position

2. Injection Synchronisation Method (Alternative / Fine Tuning)

This method uses AFR response to determine correct stroke and optimise injection timing.

Basic Strategy

For full sequential injection:
• Add an offset of approximately half a revolution

Example (60-2 gear):
• 60 teeth = 360°
• 30 teeth = 180°

👉 Start injection at ~30 teeth before TDC

Example Adjustment

If the intake valve closes slightly after TDC:
• Use a value such as 28 teeth
👉 28 teeth × 6° = 168° BTDC

Procedure

1. Warm engine to operating temperature

2. Set engine to idle
3. Adjust **Injection Sync Tooth** gradually

Observation Method
• Injection on open valve → leaner AFR
• Injection on closed valve → richer AFR

Adjustment
1. Increase tooth value until AFR becomes leaner
2. Decrease value until AFR becomes richer again

👉 This indicates the transition from open valve to closed valve region

Result
• Correct compression stroke identified
• Optimal injection timing established

Injection Timing Strategy

Injection timing should be referenced to intake valve position.

Recommended Approach
• Start injection just after intake valve closes
• Fuel atomises on the hot valve
• Provides stable and repeatable AFR

High Load / High RPM
• Injection duration increases
• Injection may extend into next intake cycle

👉 This is acceptable and forms part of the same effective injection event

⚠ Avoid starting injection too early before valve closure
This may result in inconsistent fuel delivery between cycles

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6. Important

⚠ Wasted spark systems may display double timing on timing light