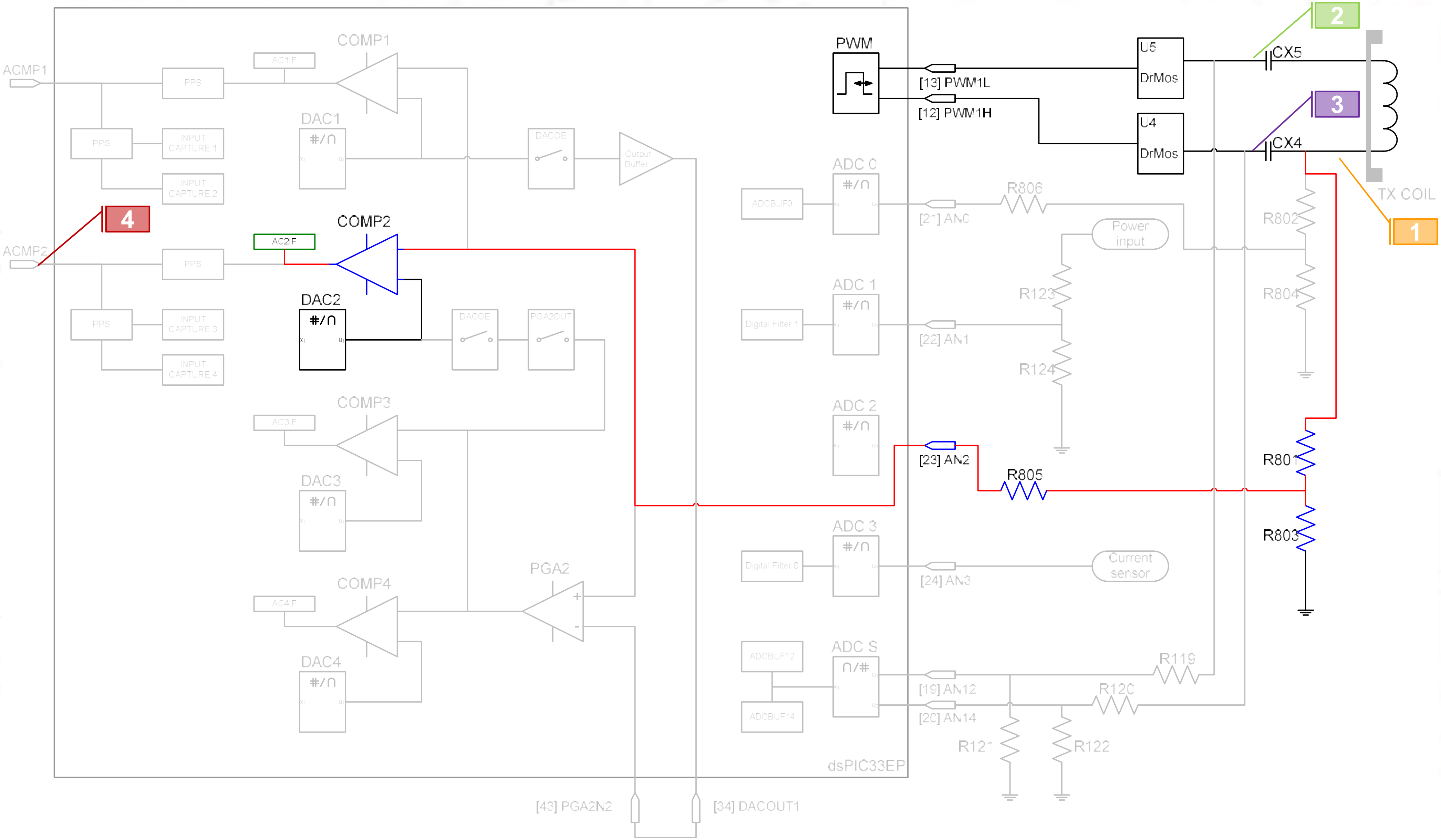
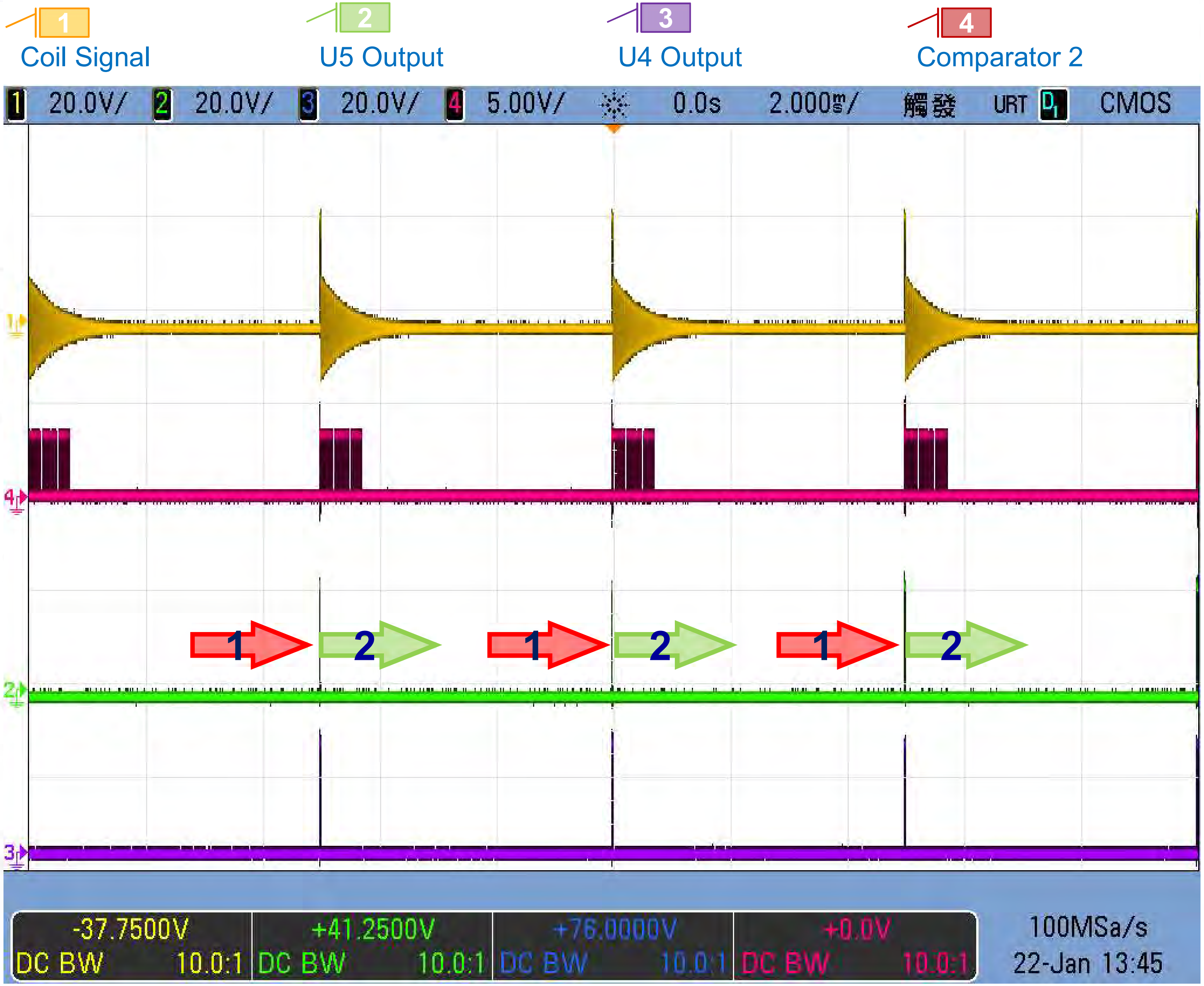
Z04. Configuration for FOD



Z05. TX Cyclically Detects Metalic Foreign Objects Before RX is Connected to Power Supply



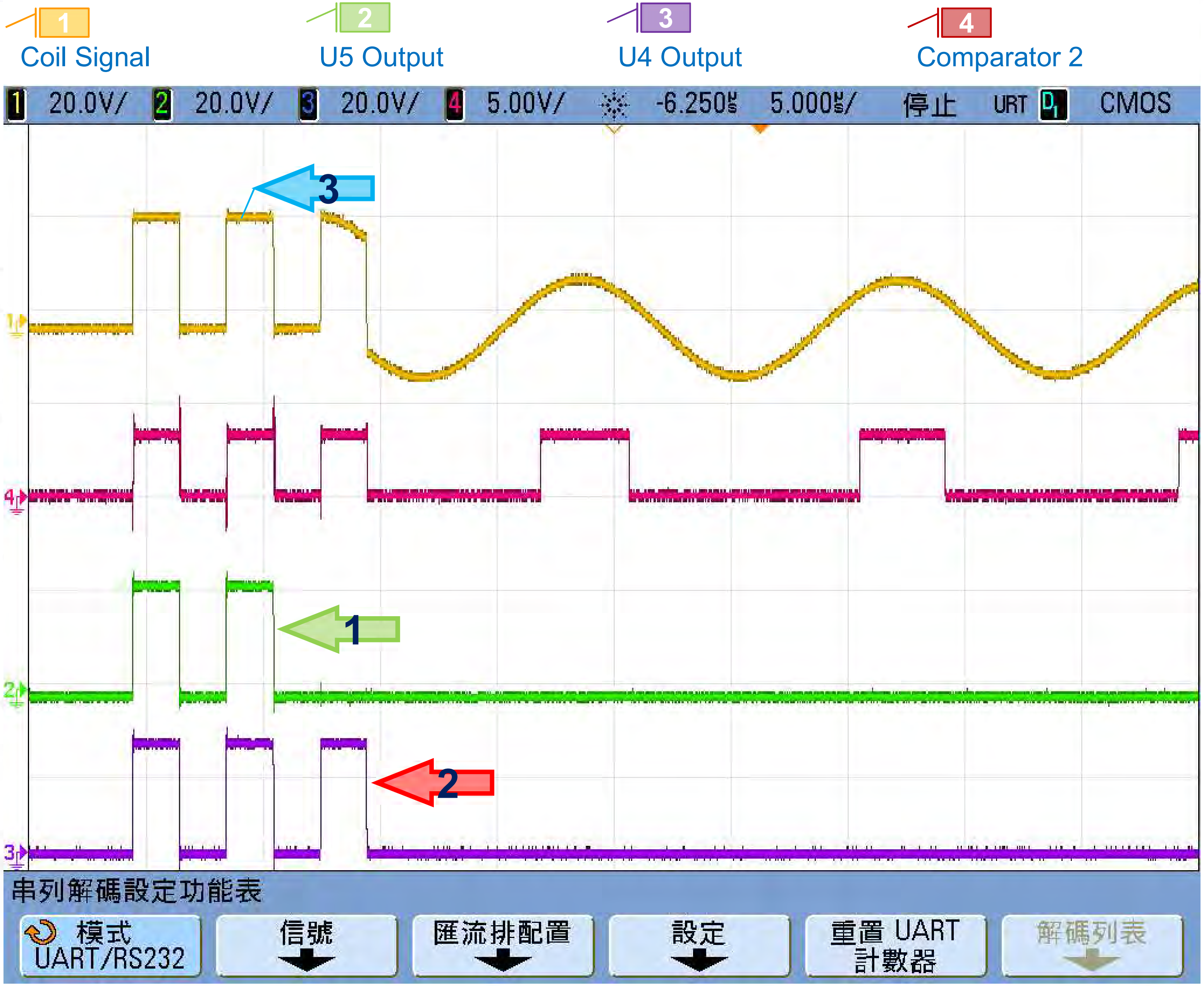
Detection Phases:
[1]Short-term driving
[2]Measuring procedure

After [1] controls the original PWM end output-driven switch element through the program to generate voltage change and resonance completion. Then enter the program [2]

In Phase [2], decetor will periodically observe whether the comparator has a trigger state to measure the attenuation rate of the resonant signal.

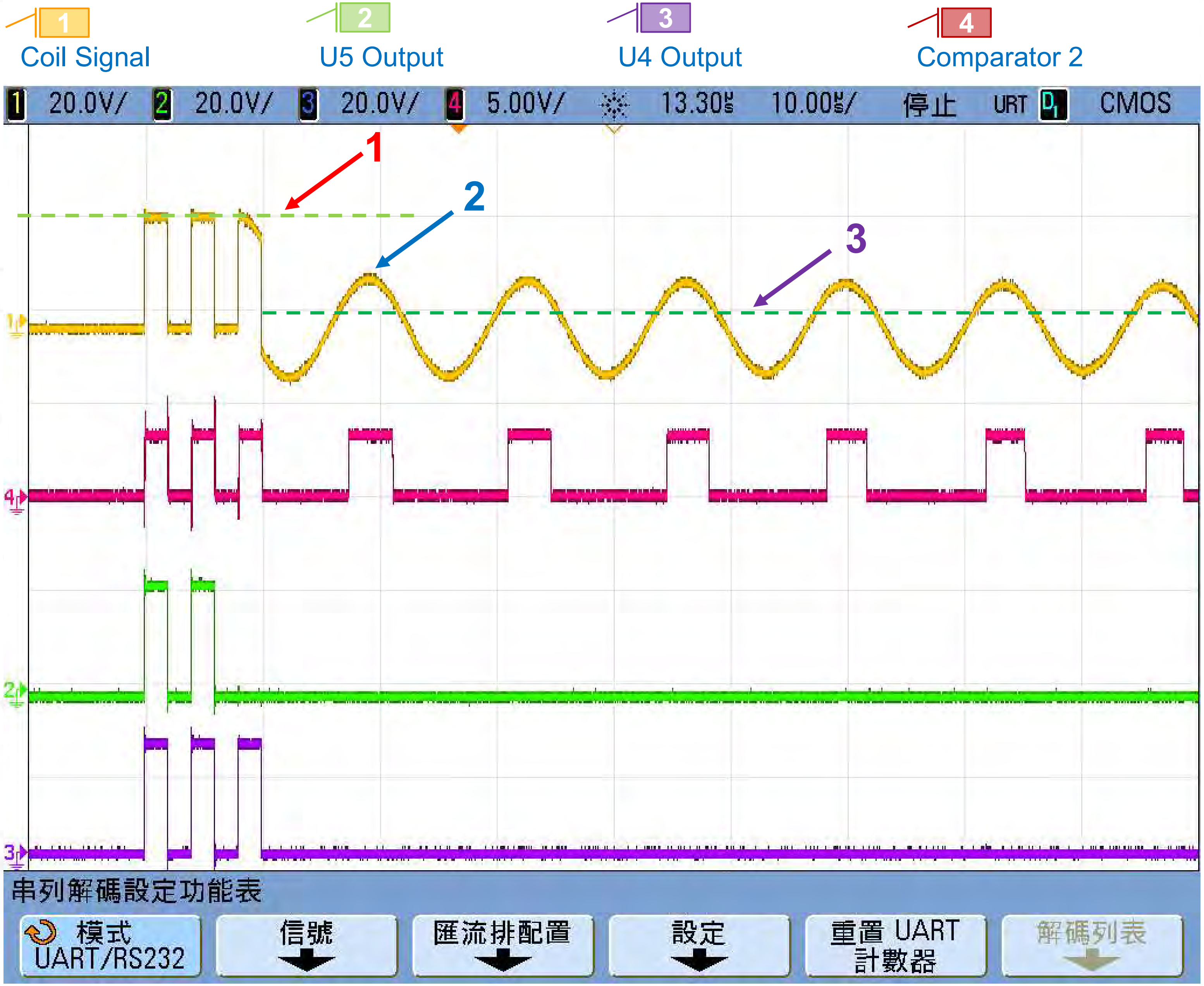
This detection procedure has a very low power consumption due to the very short time to drive the switching components.

Z06. Measurement of Driving Voltage



U4&U5 are both in full-bridge driving structure
When the voltages at both ends are the same, the coil will not be driven. Therefore, when the high potential and the low potential are simultaneously cut, the coil does not resonate but the voltage on the coil changes with the output voltage of the driver.
In Phase [1], switch potentials simultaneously for U4&U5. The coil voltage changes accordingly.In Phase [2], the low potential of the output of U5 is remained. After the output of U4 is switched once, drive the coil. The coil begins to resonate.The driving of U4 will consume some power, but because of the short-time driving, the power consumption is very small.Start the ADC conversion measurement to measure the voltage value at Phase [3]. This voltage value is used to set the subsequent measurement voltage.

Z07. Set the DAC2 Voltage to Discriminate

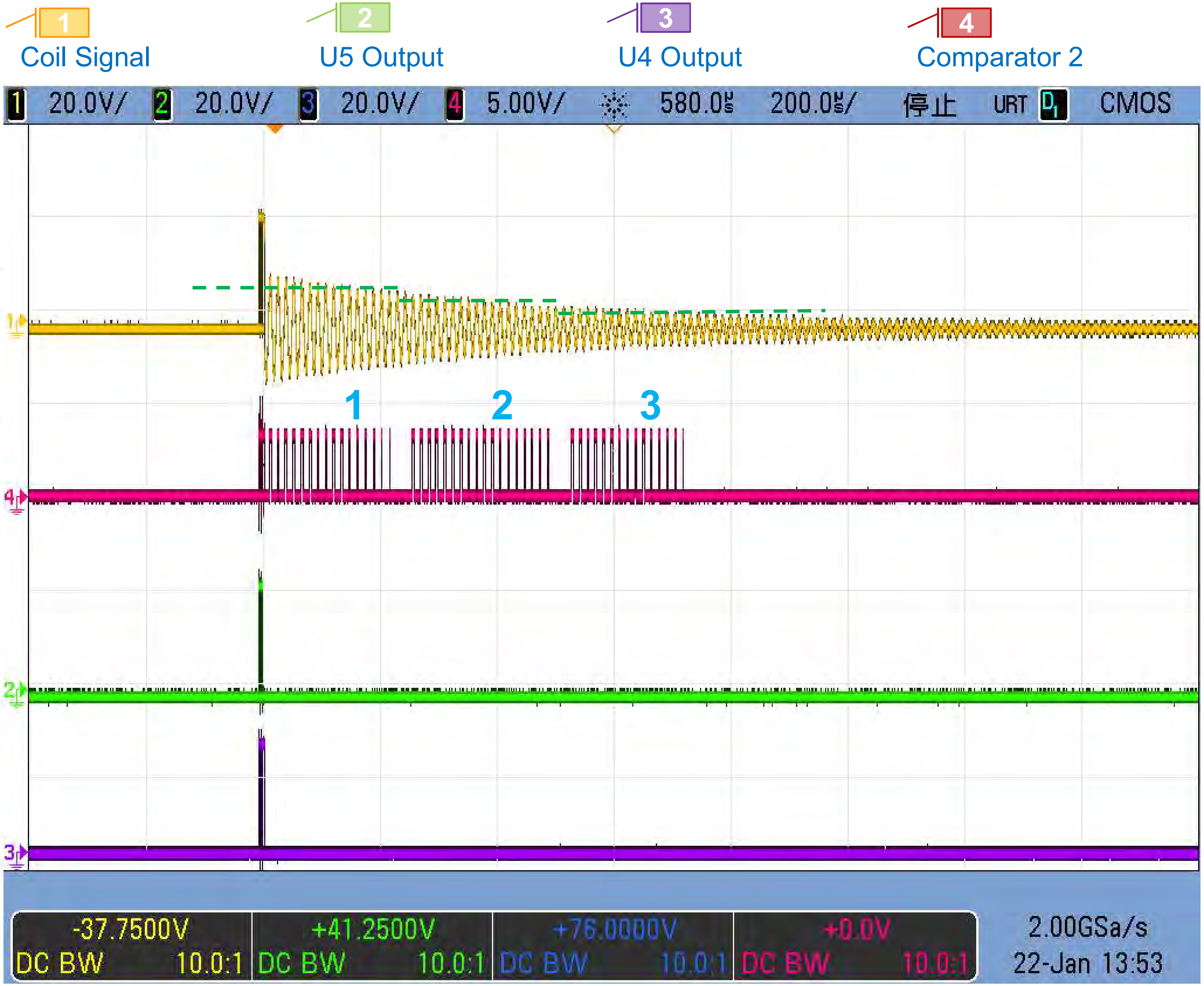


[1]Drive the voltage
[2]The first peak after resonance
[3] Set DAC2 discrimination voltage

Firstly measure the [1]`s drive voltage and then calculate the [3]`s level voltage at a fixed ratio.
This approach ensures a stable resonant attenuation time at different drive voltages.
Eliminate the misjudgment caused by the change in the length of the attenuation time after the change of the driving voltage
The height of the first peak after resonance is at almost 1⁄2 of the driving voltage.

Therefore, set the first [3] discrimination voltage to 1⁄4 of the drive voltage to ensure that the comparator output can be triggered.

Z08. After a Short-term Drive, the Coil Signal Begins to Resonate

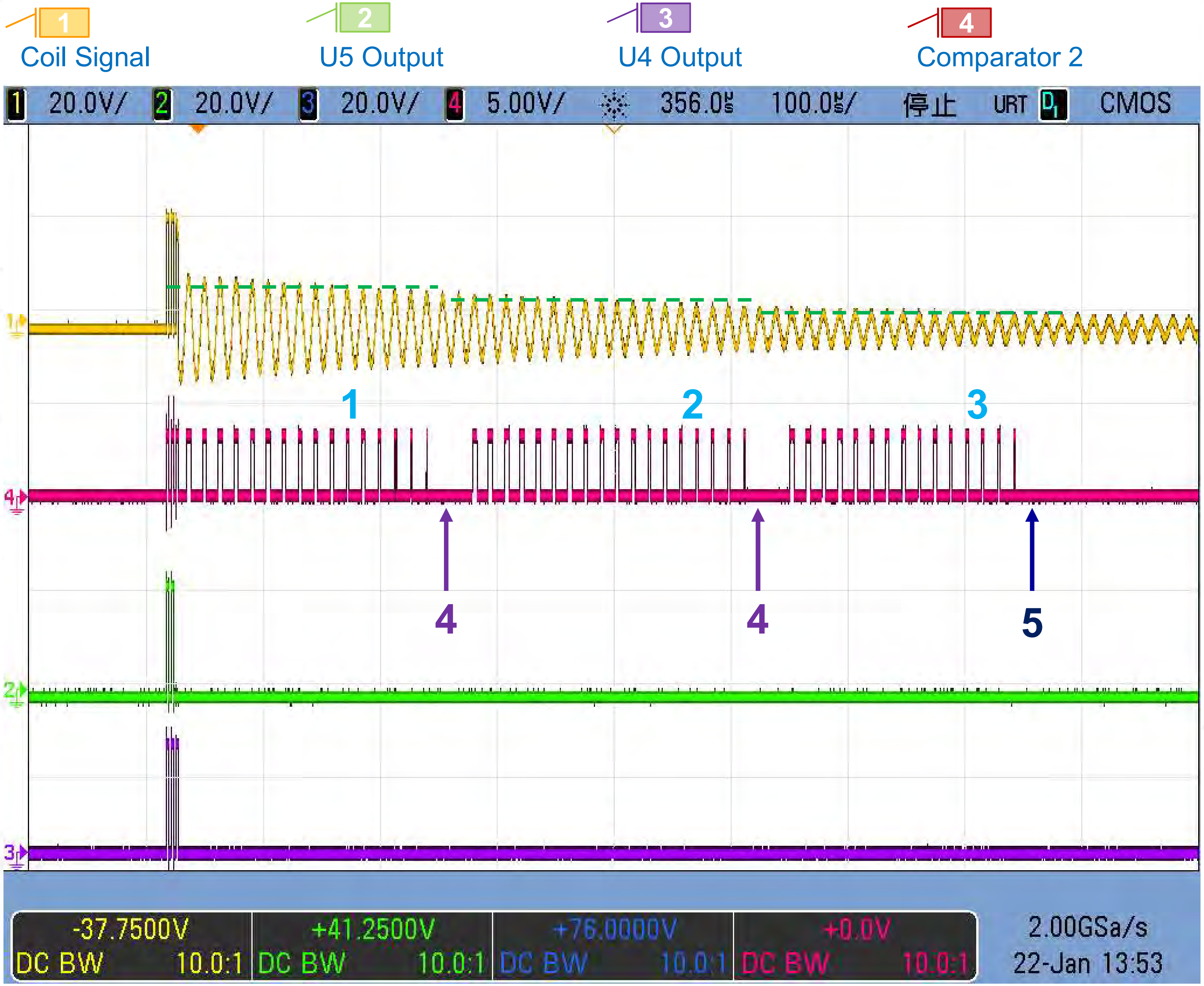


After driving, the coil resonance begins to attenuate naturally.
The attenuation rate is related to the match of coil and capacitor. The coil and capacitor of the same specification will have the similar attenuation speed
Therefore, the average value of each new coil and circuit of the design needs to be found in the trial stage as the basis for discrimination.

[1] set to 1/4 trigger
[2] set to 1/8 trigger
[3] set to 1/16 trigger

At the[1], set the voltage to 1/4 drive voltage. The voltage is reduced to [2], 1/8 drive voltage when the trigger does not occur during the check time. If there is no trigger, the voltage shold be reduced to [3], 1/16 drive voltage

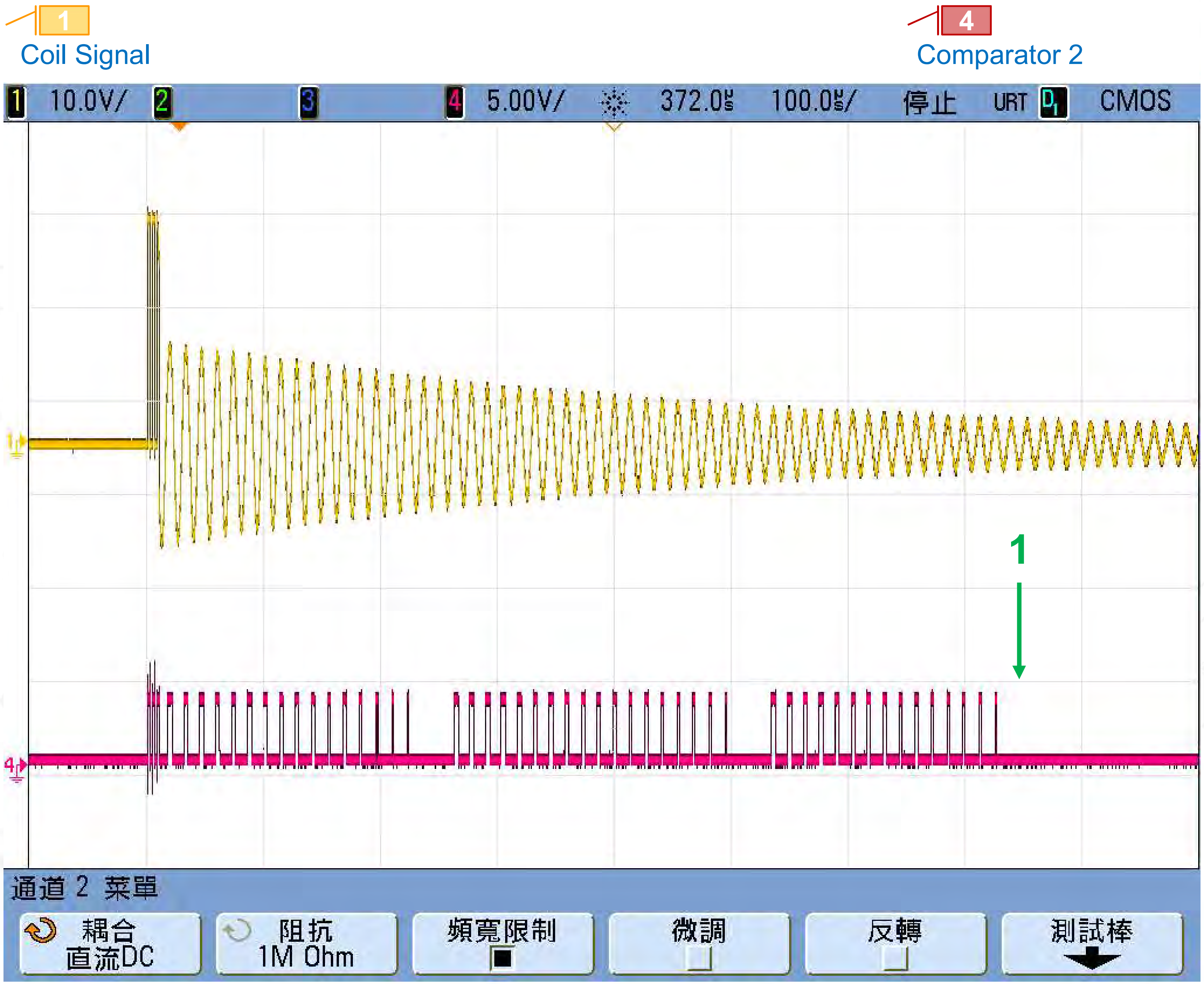
Z09. Use the Comparator Output to Judge the Amplitude of the Resonant Signal



At normal attenuation speed [1] [2] [3] The time of the three segments will be close. The purpose of this design is to avoid moise misjudgment.
If the difference between the triggering times of the three segments is too large, it can be excluded as noise.

The action set in DAC2 is to reduce the voltage of DAC2 when the triggering [4] does not occur within the check time. When there is no trigger after 1/16 of the third segment [5], the length of the ending time of the resonance attenuation is measured for this time.

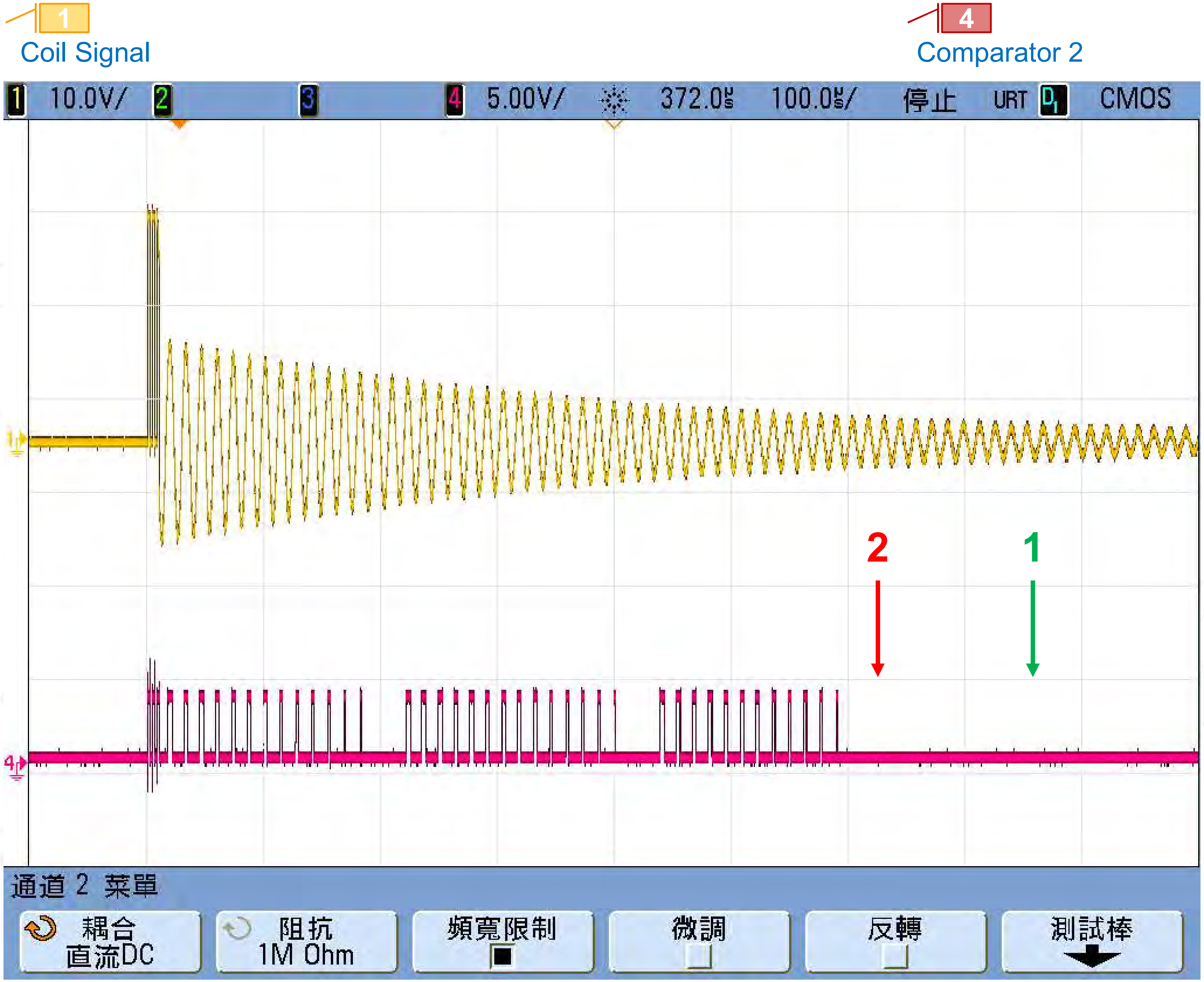
Z10. Use the Length of Trigger Time to Judge Whether There is a Metalic Foreign Object



[1] represents the end of the resonant signal attenuation time of this coil without any metalic foreign object

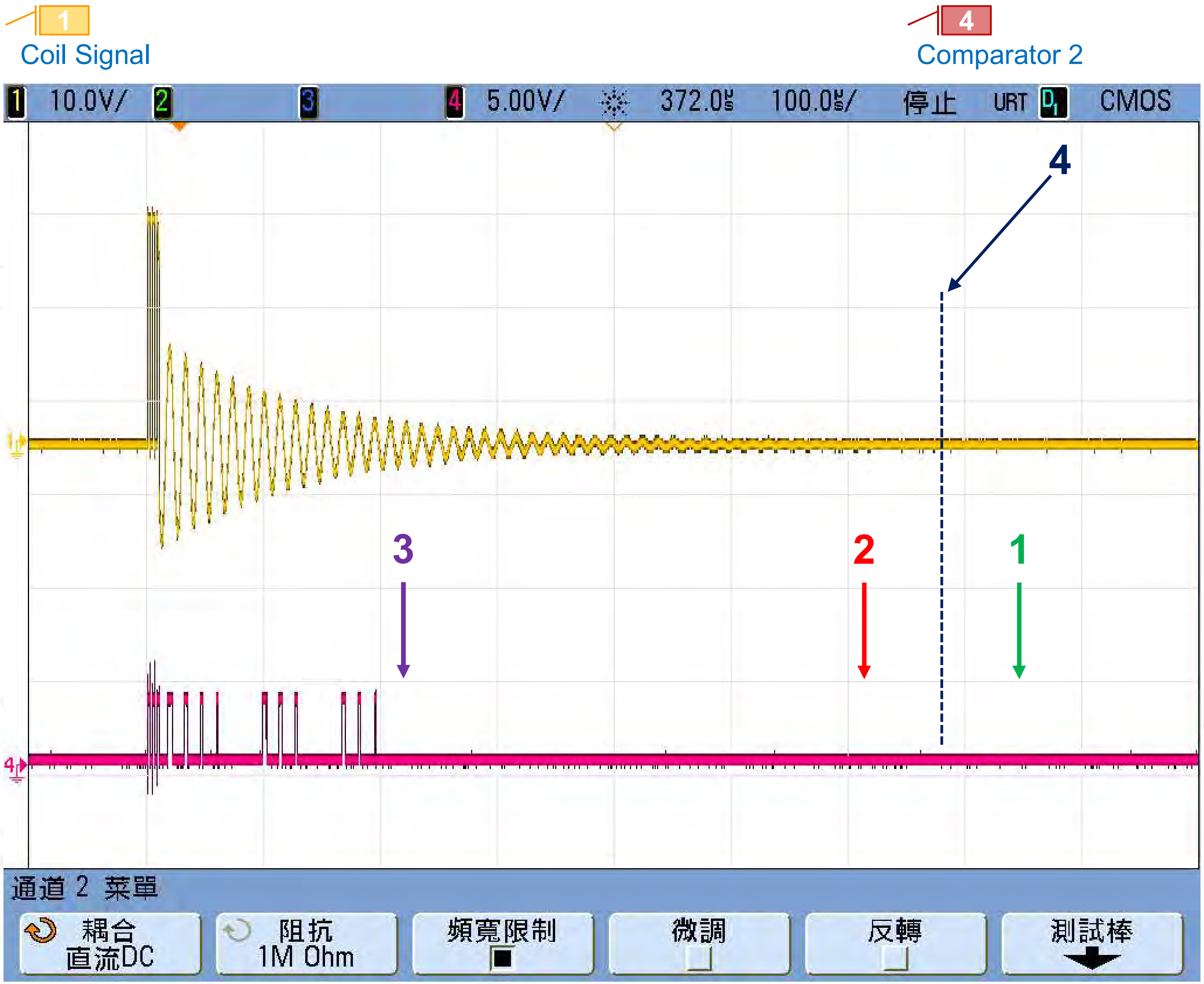
It can be seen that after a short-term drive, the coil will oscillate for a long time without external resistance.

Z11. Trigger Time Become Shorter with Metalic Foreign Objects



As long as there is a metalic object on the coil, the attenuation of resonance will be accelerated. The end time will reach the position of [2]. This measurement technique is very sensitive. The basis of the judgement is that the electromagnetic power resistance on the coil will absorb the power of the object, which will make the attenuation faster. Therefore, objects that are harmful to wireless charging can be identified.

Z12. Signals for Large Metalic Foreign Objects

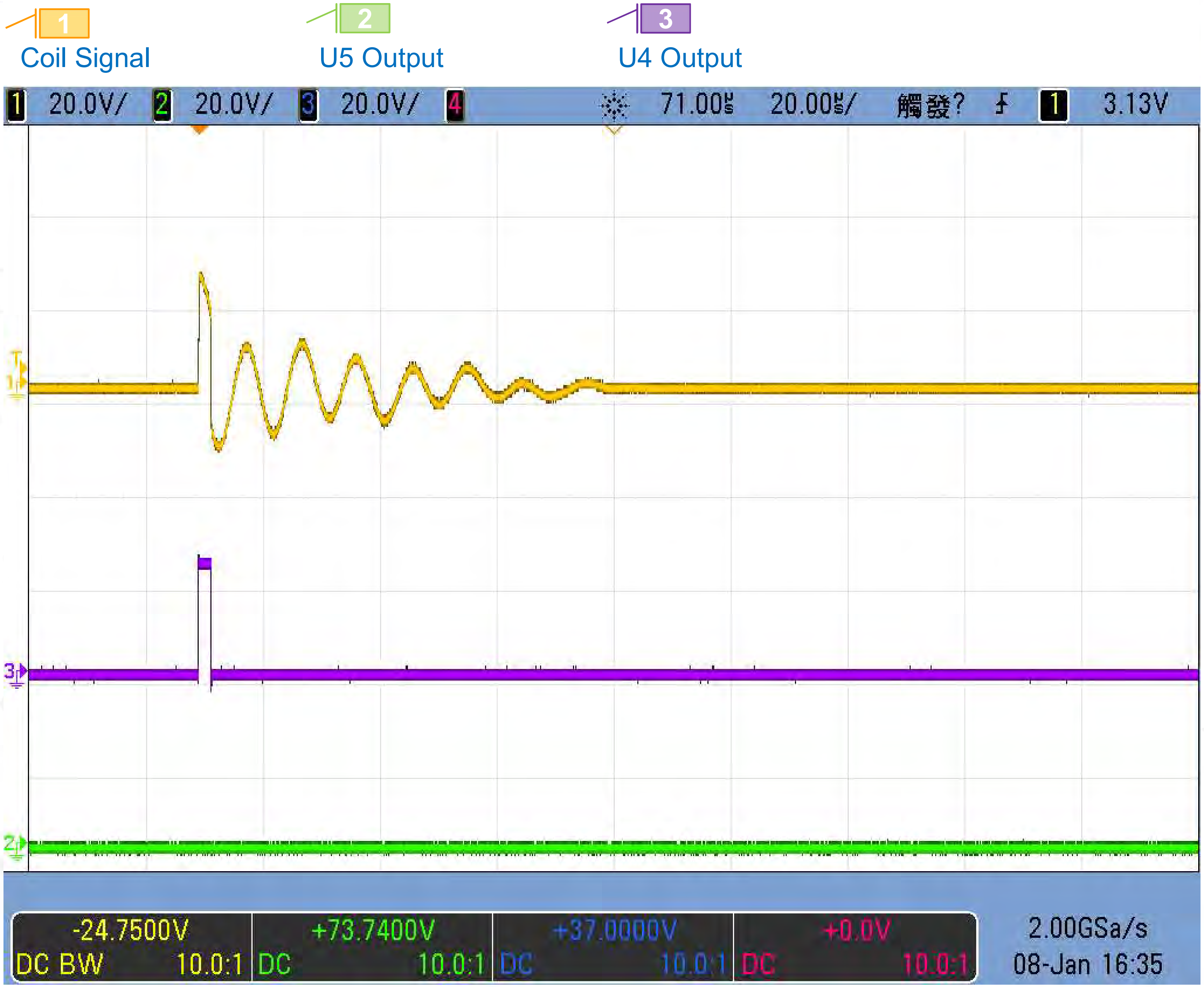


When there is a large metalic object, it will absorb power greatly, so that the attenuation is very fast. At the ending point, the signal will run to the position of [3].

The judgement signal must firstly know the [1] distribution position of the coil factory value and then set [4] as the critical line in the soft body. As long as the measurement result is shorter than [4], it can be judged as having metal.

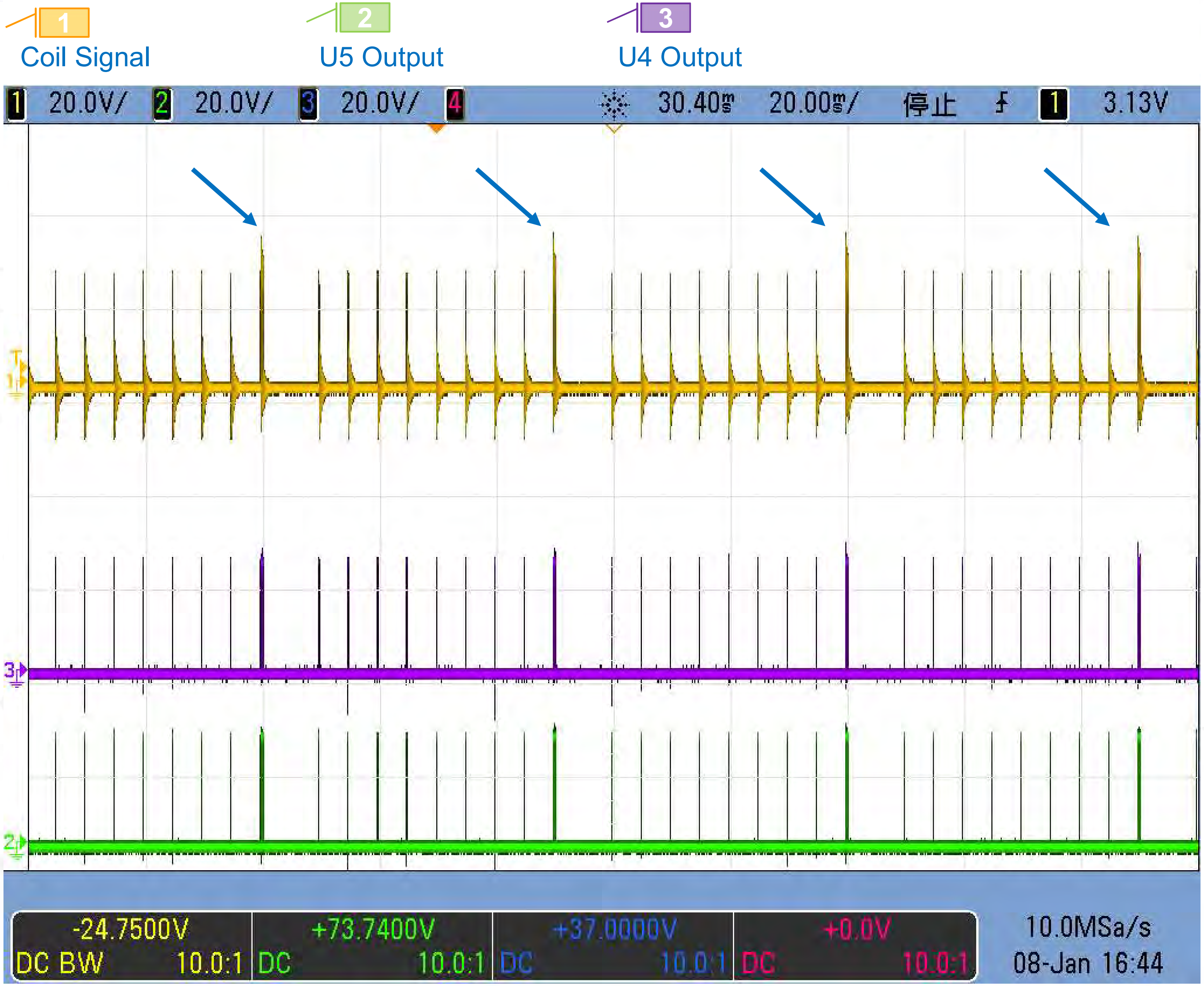
In the A6 software, the critical line of [4] can be set by a button.

Z13. Irregular Signal Attenuation



This is an extreme example.
Absorption of electromagnetic power by a normal metal body causes the resonance signal to attenuate faster.
Make the atteunation of the coil signal liner.
However, when the RX is placed for a short time, the action of the rectifier and the capacitor behind it will quickly absorb the power irregularly, so that the resonant signal on the coil shows an irregular attenuation.
According to the aforementioned technology
This condition is misjudged as having a metalic foreign object.
Do not start normal operation of RX.

Z14. RX End is Suspected to Get Close, Insert Precharge Program

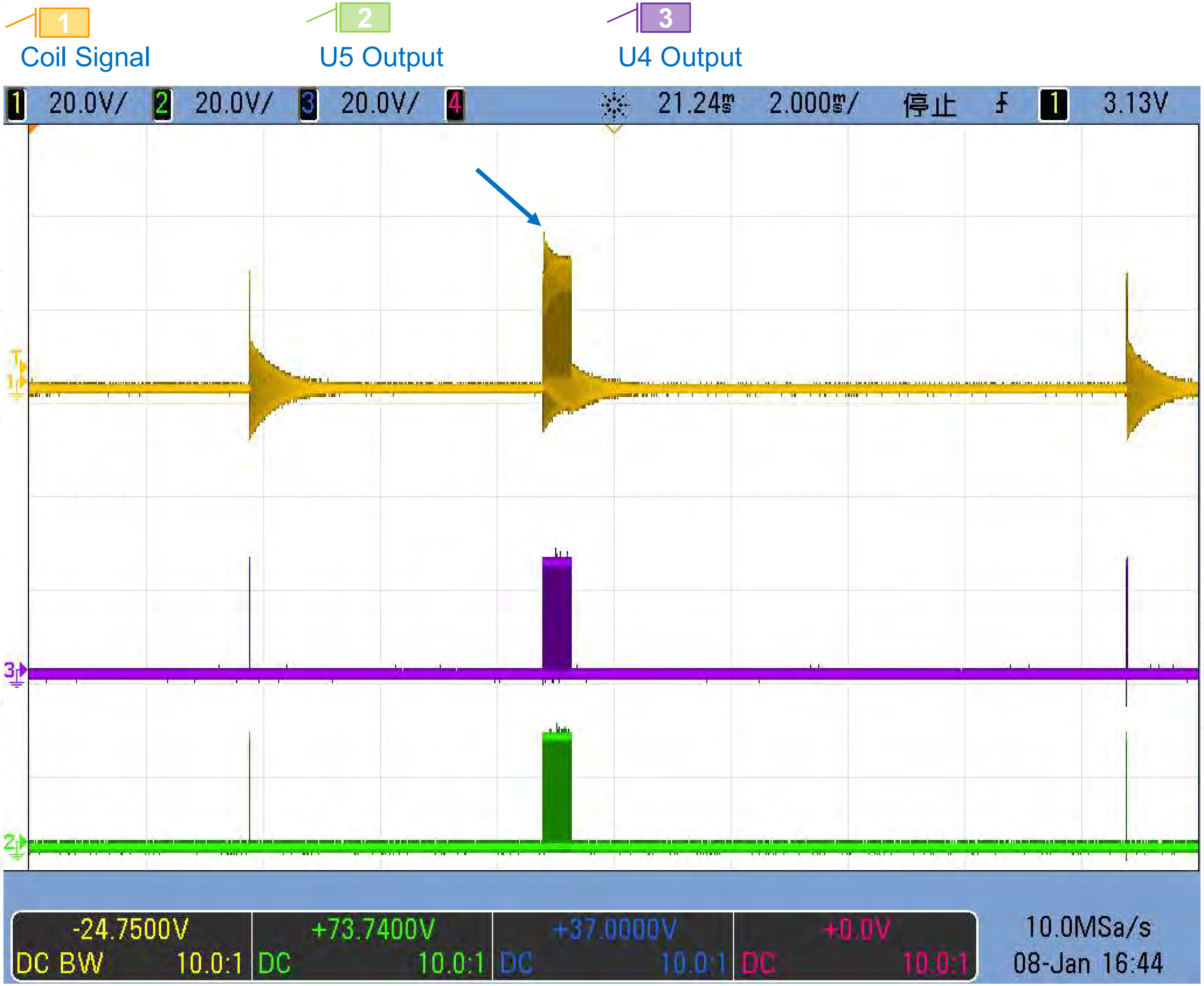


As mentioned above, because the capacitor on the normal working RX is empty, the signal on the abnormal absorption coil maybe judged as having a metalic foreign object. The single driving signal used for detection cannot charge the large capacitor on the RX, so it will not start.

Therefore, another design should be added. When it is suspected that the RX end is close, insert a pre-charged drive in the interval of multiple detection cycles.

The purpose is to charge the capacitor on the RX but the drive time is still very short. It will not start the B3 IC on the RX for data communication.

Z15. Precharge Program

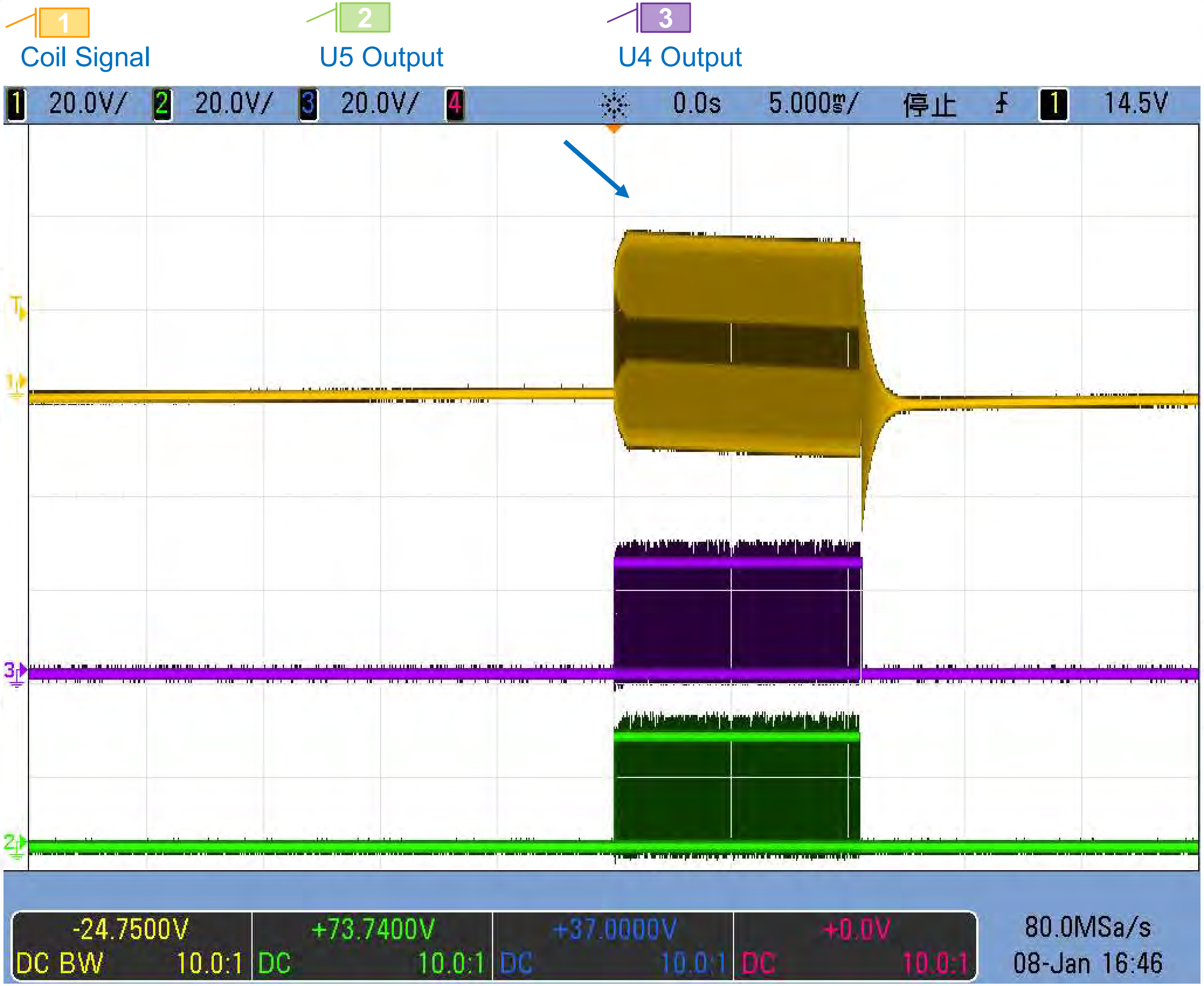


Pre-charge drive is only about 0.5ms which is a very short drive time. Even if there is a metalic foreign object between RX and TX, there will be no heat.

The pre-charge can fully charge the capacitor on the RX. After the power of the capacitor is full, the resonant signal for detection will not be absorbed.

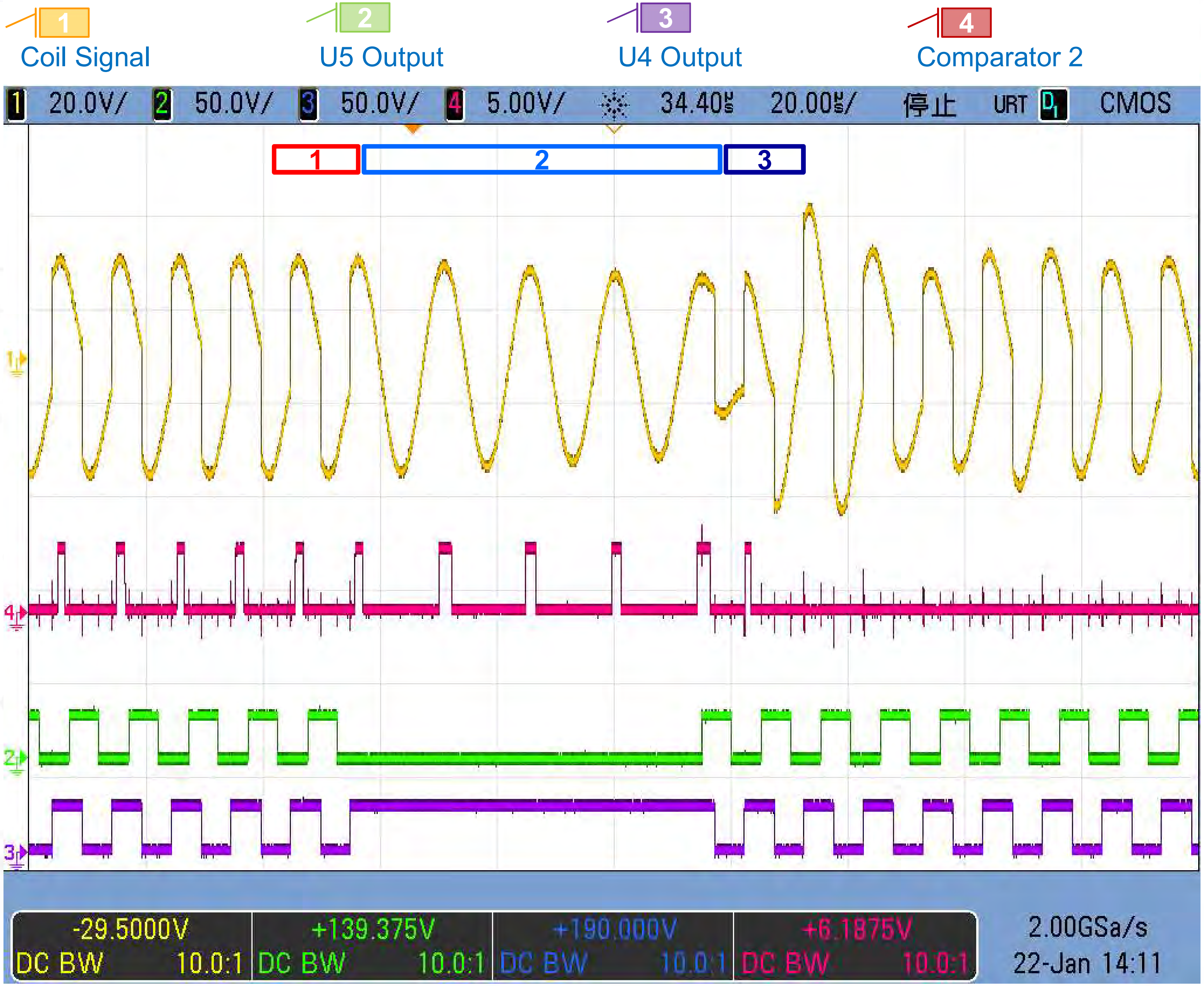
If you still find that the resonant attenuation rate is faster, it means that there is a metalic foreign object. Do not start power transmission.

Z16. Start the RX Feedback Data Program



After confirming that there is no metalic foreign object and determing the resonant frequency, it is known that there may be a RX and a drive signal will be sent.
If the RX receives this signal, it will start to feed back the data. As long as the data is correct, the power transmission will start.

Z17. The Measurement Signal Attenuation State after the PWM Drive is Paused

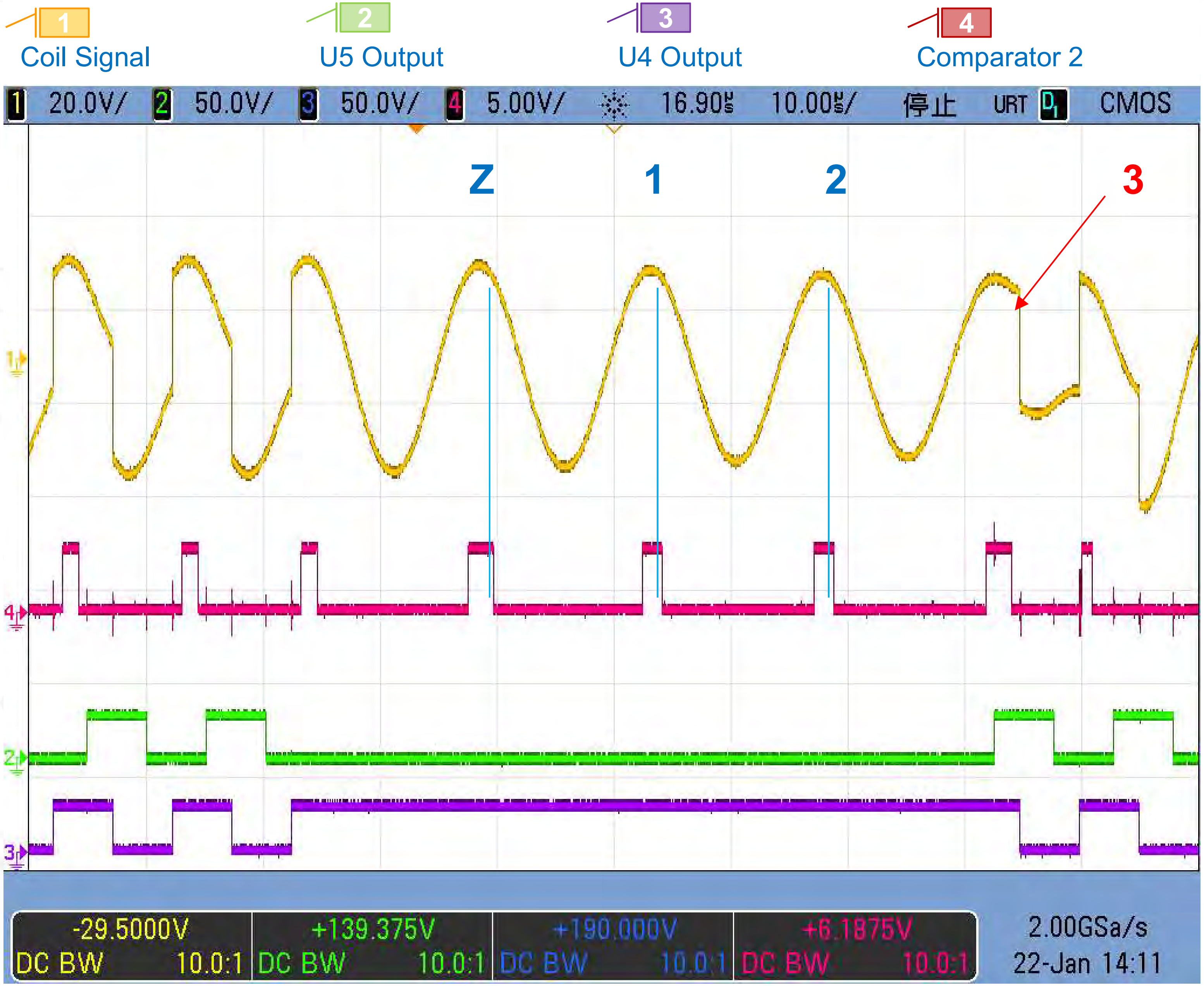


In the process of power transmission, FOD dection requires to suspend the driving of the PWM output to observe the resonant signal attenuation state. This method is quite difficult to implement and the higher the power, the more likely it is to be rushed during the bonding phase. The hardware damage will be caused.

[1] PWM stop procedure
[2] Detection procedure
[3] Joining procedure

Set [1] as IOCON1 to stop the PWM in a high-low state. The coil signal for detection circuit is close to the U4 output. Therefore, the U4 terminal is kept at a high potential for convenience of measurement.

Z18. Measure the Peak Height by Using the Comparator Trigger State



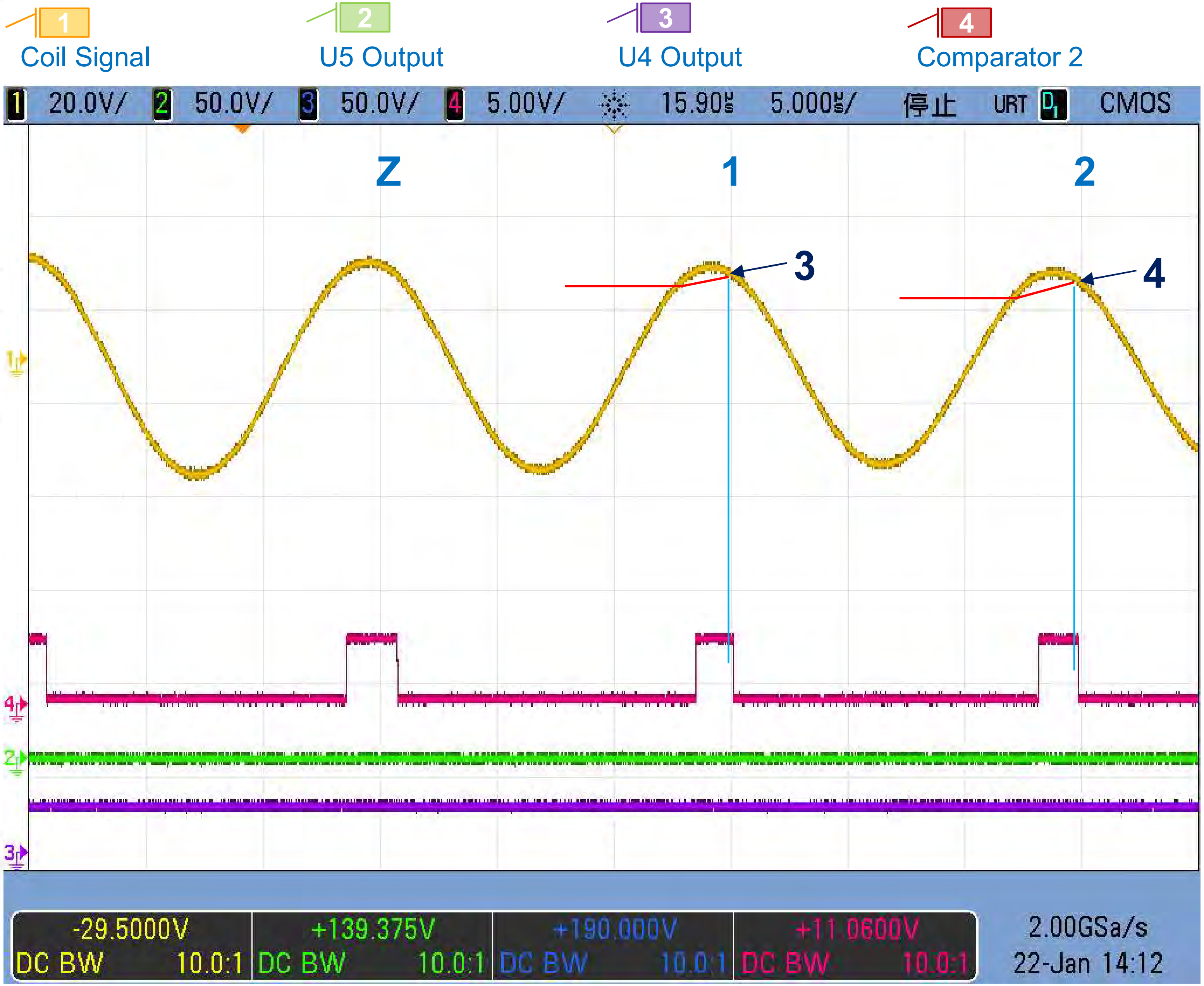
[Z]The first peak after stopping the drive
[1] Measuring the first peak
[2] Measuring the second peak

The first peak after the drive is paused is not within the complete and natural resonance period, so it should not be measured [Z]

The DAC2 is used to adjust the voltage to monitor the comparator output state to determine the height of the peak.

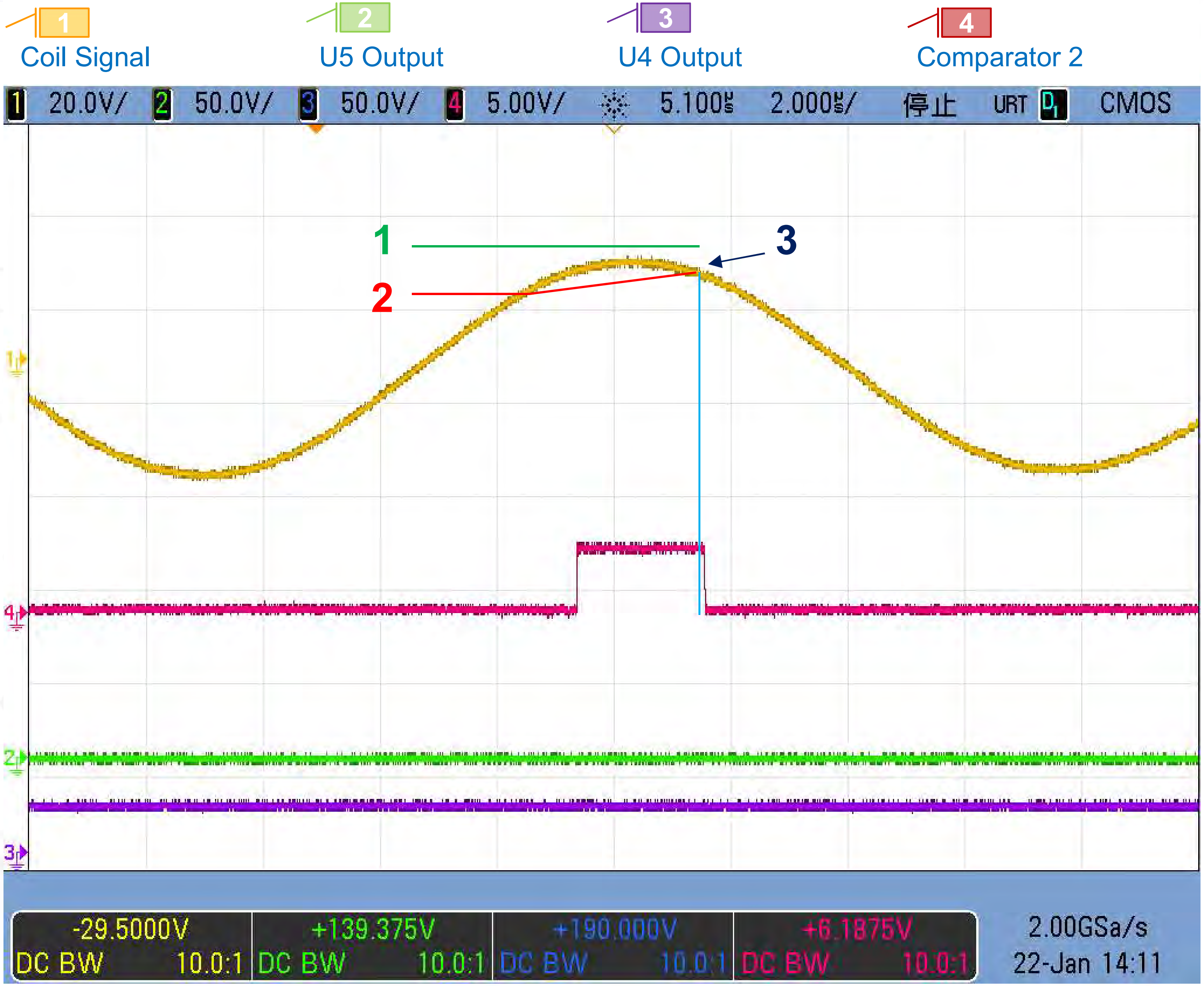
The last re-joining [3] is the switching time point at which the resonant signal is captured by the comparator 1. The time point at which the PWM is re-joining is calculated.
Match the wave pattern as smoothly as possible

Z19. Quickly Adjust the DAC Voltage after Trigger, Find the Relative Height



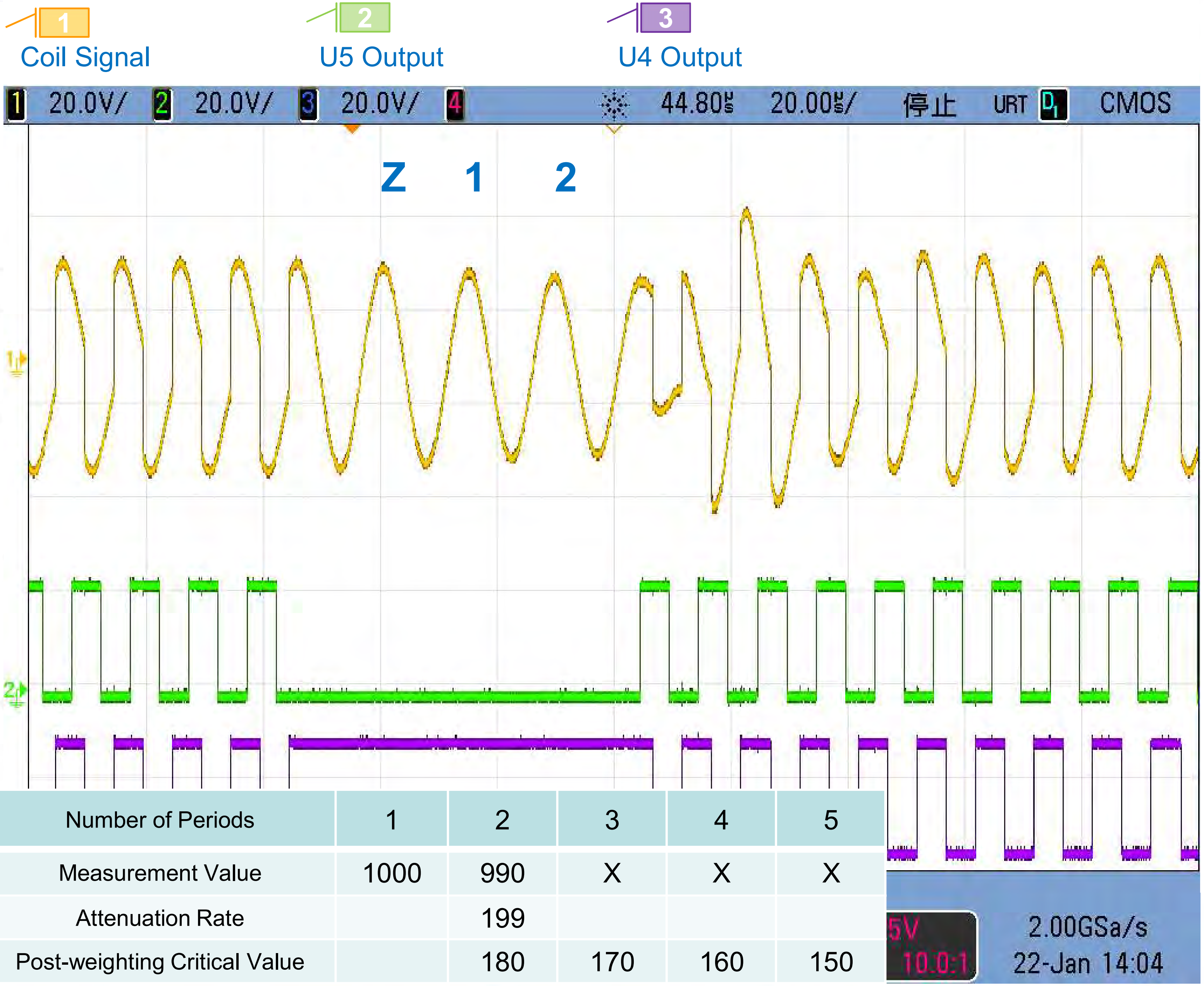
[Z]does not need to be measured
The measurement method for [1] and [2]: largely reduce the measurement starting point from the previous measurement result or the previous time without triggering.
The red line represents the DAC2 voltage. It enters the Comparator 2 interrupt service program as soon as the trigger occurs. Circulatively increase DAC2 voltage until the comparator output is at low potential. It indicates that the DAC2 voltage is greater than the peak of the resonant signal. Finally, the DAC2 voltage [3][4] is the measured value of the peak. Each of the subsequent measurements is performed like that, because the target is to calculate the slope by taking the relative values, so there is no need to obtain the actual peak maximum voltage point.

Z20. Pre-drop of Voltage and Trigger Result



The original method of measuring the voltage using the DAC is to firstly set a DAC voltage and then wait for a trigger. Increase the voltage if there is a trigger. Reduce the voltage if there is no trigger.
[1] is the value after the previous measurement voltage
[2]is the pre-drop by the previous measurement voltage
[3] is the final measurement result
In the early design, if [1] is used to detect the voltage firstly, then the current measurement will not capture the trigger. This cycle requires many checks to actually measure the voltage.
The new design is to firstly reduce the voltage to [2] in advance and start to increase the DAC2 voltage value quickly until the trigger is out.
This design can still capture the value required for FOD discrimination in the state of unstable wireless charging.

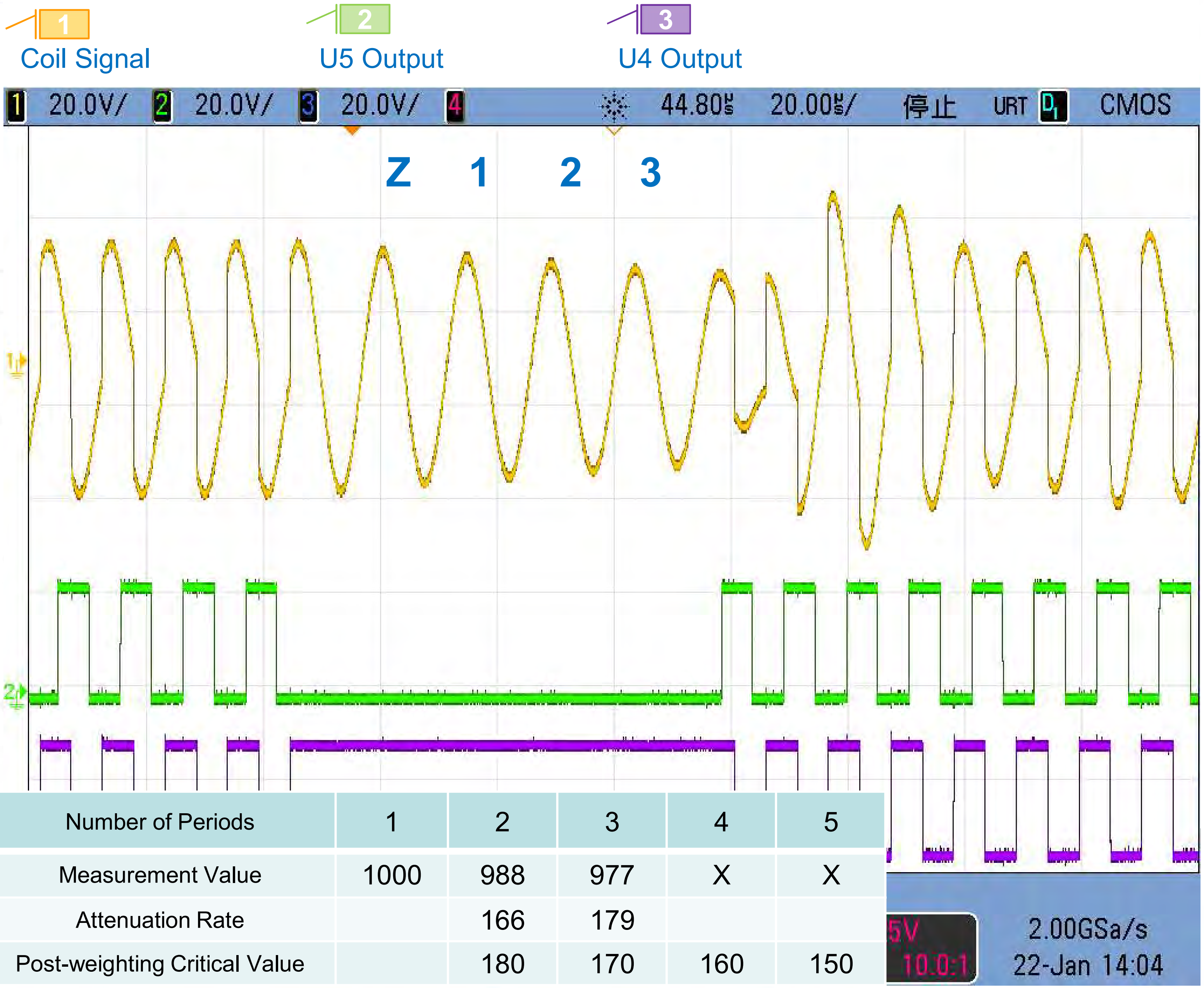
Z21. Suspend Driving 3 Resonant Periods



Number of Periods	1	2	3	4	5
Measurement Value	1000	990	X	X	X
Attenuation Rate		199			
Post-weighting Critical Value		180	170	160	150

Waveforms: the following are examples of calculation methods.
Measuring slope requires two peak heights.
The calculation method of [1]+[2] / [1]-[2] requires the slope of this section. In the design, a discriminant threshold should be firstly defined. The example is the last stage 150.When the slope is lower than 150, it is judged to have metalic foreign objects.And the criticality is increased by 10 at each stage.After the second peak measurement, the calculated value 199 is still higher than the critical value of 180, indicating that in the safe state of no metalic foreign object, it is unnecessary to continue measuring.

Z22. Suspend Driving 4 Resonant Periods



Number of Periods	1	2	3	4	5
Measurement Value	1000	988	977	X	X
Attenuation Rate		166	179		
Post-weighting Critical Value		180	170	160	150

The examples are as follows: During the FOD signal measurement, some erroneous readings due to some interference noise are often produced. However, if the power output is turned off because of a wrong judgement, the reliability of the system will be reduced, but the signal suspecting having metalic foreign objects cannot be ignored. So the judgement requires multi-stage analysis. Calculation resulr of [1][2]: the slope 166 is lower than the critical line 180, so it is necessary to continue to detect the slope of the next [2][3]. Calculation result shows that 179 is greater than 170, then it can be judged that there is no metalic foreign object. Leave this measurement.

Z23. Suspend Driving 5 Resonant Periods

Number of Periods	1	2	3	4	5
Measurement Value	1000	986	974	962	X
Attenuation Rate		142	163	161	
Post-weighting Critical Value		180	170	160	150

Examples

Calculation result of [1][2] the slope of 142 is lower than the critical line of 180, so continue the measurement

Calculation result of [2][3] the slope of 163 is lower than the critical line of 170, so continue the measurement

Calculation result of [3][4] the slope of 161 is lower than the critical line of 180, so it can be judged that there is no metalic foreign object.

Measurement ends