Yamaha XS650 TCI Timing

(or my theory of how it works)

The TCI ignitor board receives two pickup pulse inputs and produces a single output to the Ignition coil. The pickup pulses are 25 degrees. For the sake of my explanation, I have labelled them P1 and P2. All of the ignition will happen between P1 and P2. If the engine is running at < 1900 rpm then the ignition coil will fire at P2 time. If the engine is running between 1900 and 3300 rpm then the ignition coil will fire between the P1 and P2 pulses. If the engine is running at >3300 rpm, then the ignition coil will fire at P1 time. *See the Yamaha timing chart fig. 1*. *A simple analogy would be the mechanical advance in the standard points type ignition, where the centrifugal force pushes the weights from a resting position at low rpm to a maximum advance at high rpm. The resting position would be represented by P2 and the fully advanced determined by P1.* Each pickup pulse generates an integrator or ramp-type waveform, one long waveform started by P2 and one short waveform started by P1. These two ramp waveforms voltages are compared to produce a signal that fires the ignition coil.

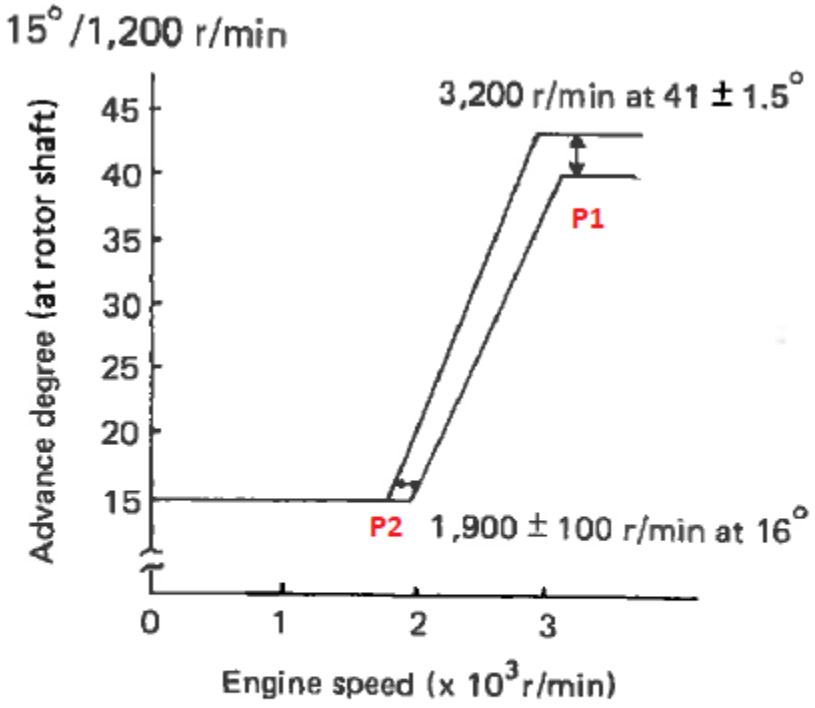
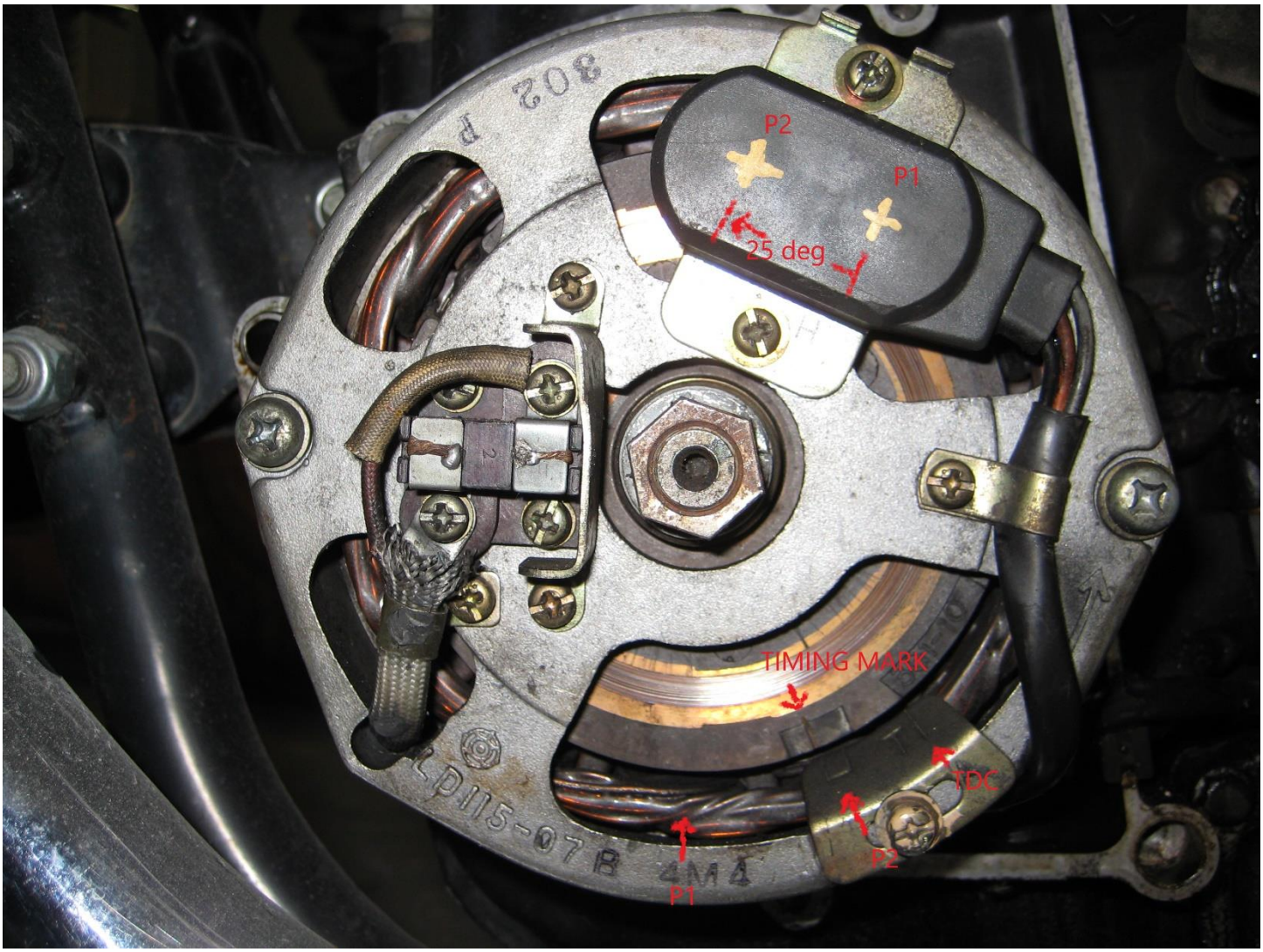


fig 1 - extracted from the XS650SJ/K shop manual. Strangely it shows some tolerance of 1.5 degrees at the top of the advance curve. There really is no way of adjusting this. Note the 25 degree spread from 16 to 41 degrees. The transition rpms are 1900 and 3200

A picture of the rotor, pickup coils and timing marks is provided. I have indicated approximately where the rotor timing mark is during the revolution, as the pickup coils pulse. For example, as the rotor magnet passes under P1 pickup the timing mark would be at the P1 mark at the bottom. Note that P2 pickup coil is pulsing just prior to the recommended timing mark on the chassis (about 16 deg +/- a bit). Rotation is ccw.



Refer to the timing diagram and schematic for the following description.

1) - The timing begins with the P2 pulse. If the Ignition coil has not already fired, it will fire it now. This is at around 16 degrees BTDC and 1900 rpm. At the same time, a long ramp waveform is started. This waveform is created using components C9, R20 and R21.

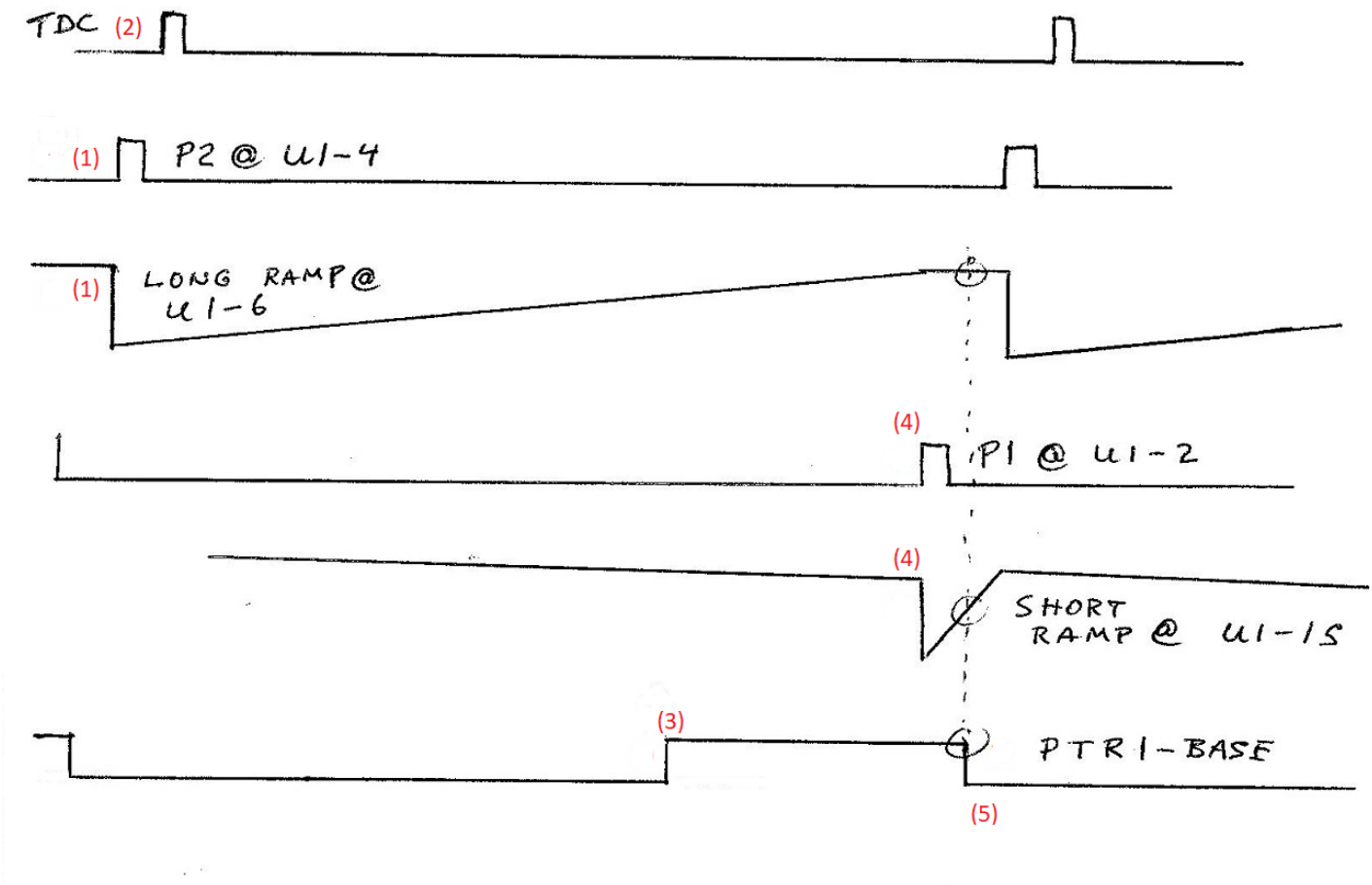
2) - Next, the engine passes through TDC. This is not generated on the ignitor. It is generated on my test jig.

3) - Next, the coil is energized, by switching the output transistor PTR1 on.

4) - As we get to P1 (41 degrees BTDC) , a short ramp waveform is started using components C13, R22 and R23. The long waveform generated in step (1) is latched at whatever voltage it has charged to at this point in time. If the rpm is >3300 then the long waveform will not have charged that much and the short waveform will quickly exceed the value of the long waveform causing the ignition coil to fire.

5) - At rpms between 1900 and 3300, the circuitry compares the two waveforms looking for the time when the short ramp exceeds the latched long ramp to fire the ignition coil.

- Back to step (1) - at below 1900 rpm (P2 time) the short waveform will exceed the value of the long waveform because the long waveform is reset to 0 volts at this time.



The above timing diagram is not to scale.

By varying the resistive and capacitive components that make up the two ramp waveforms, one can adjust the rpm start and end times on the timing curve. The degrees BTDC will not change (these are fixed at a 25 degree spread), but the rpms at which they occur at, will vary. For example, prior to repairing my TCI board the low and high rpm transition points were 2300 and 3500 rpms. *See fig 2.* After replacing the capacitors and adjusting the resistors, the timing curve more closely resembles the Yamaha curve. *See fig 3.*

I am not certain what circuitry is causing the coil to energize (step 3). There is a slight discharge of the short ramp after P2. It is possible this may be used to switch this waveform. No way of knowing how this works without digging up and re-animating the Hitachi engineers who designed the ignitors.

Some of the functionality on this board can be inferred from examining the design of the early 1980 ignitor (12-01 version). The early ignitor uses an-off-the-shelf quad op-amp IC. By tracing out the 12-01 board you can see where the two ramp waveforms are compared.

I will include a picture showing the waveforms as seen on the oscilloscope.

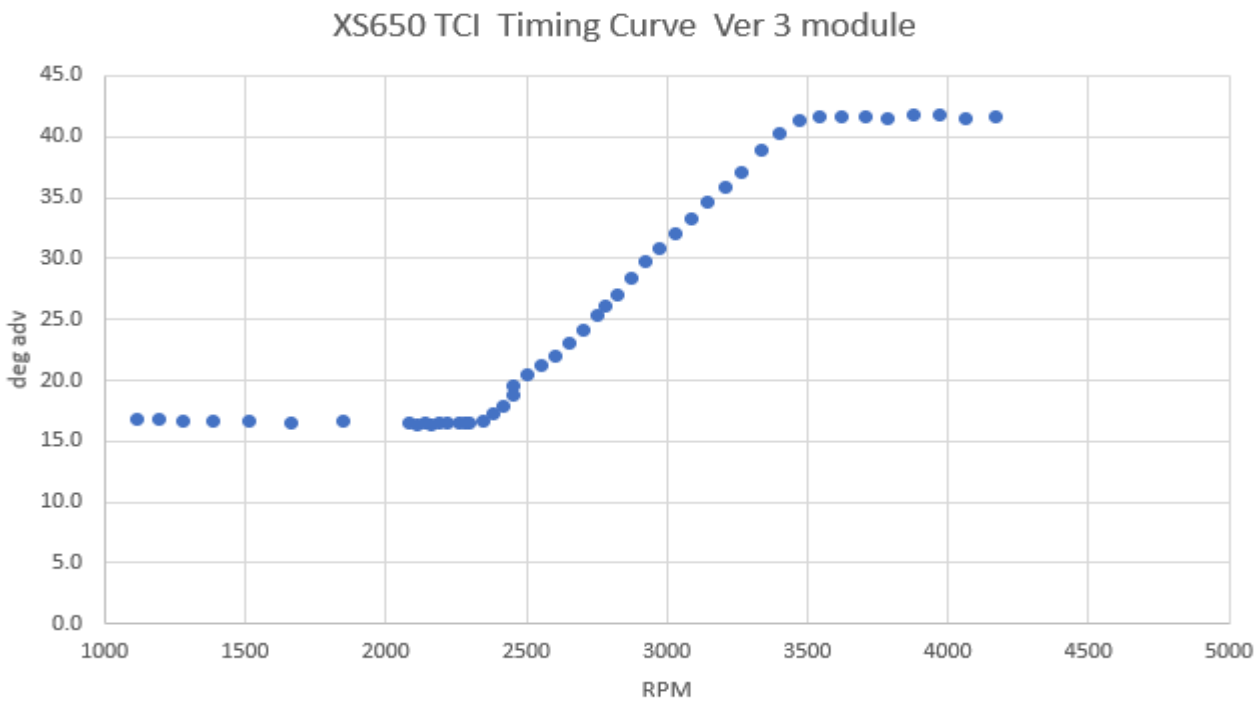
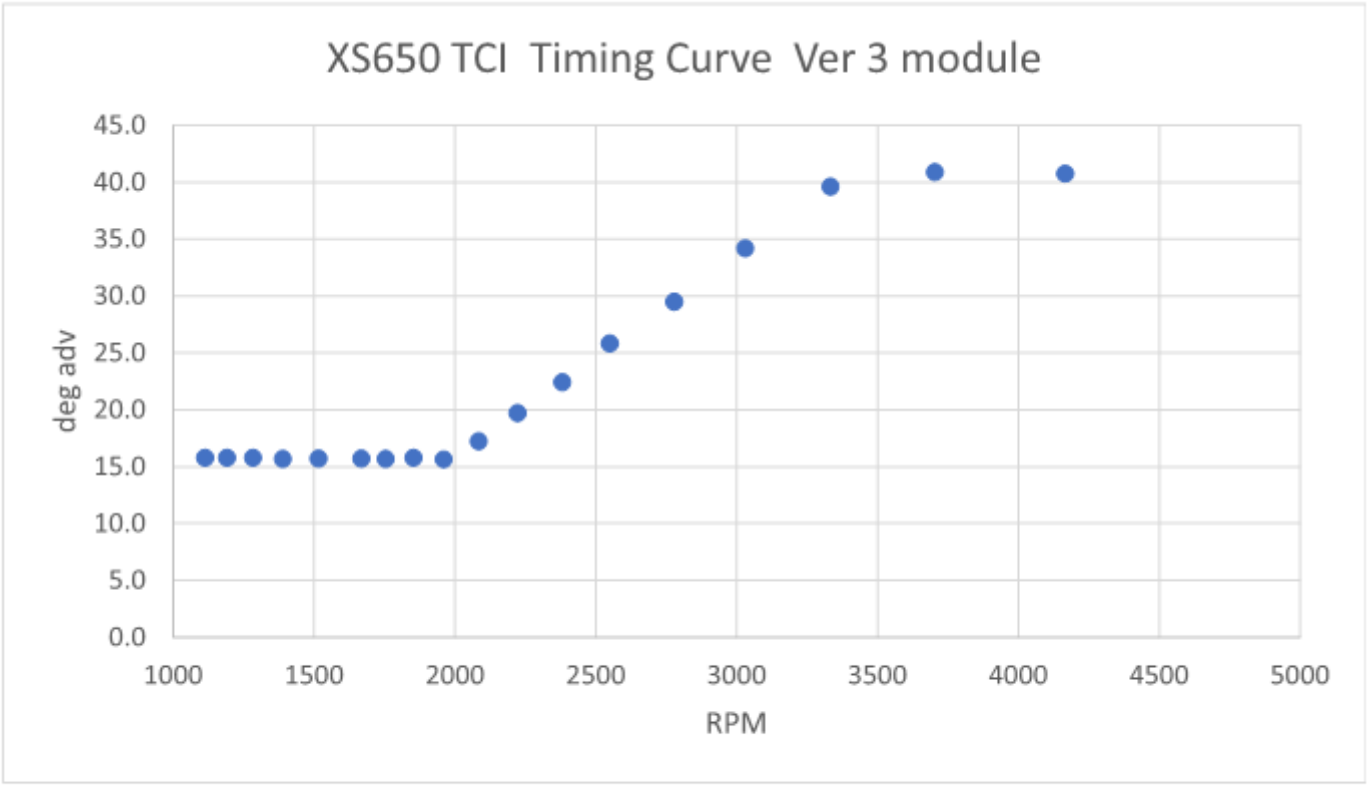
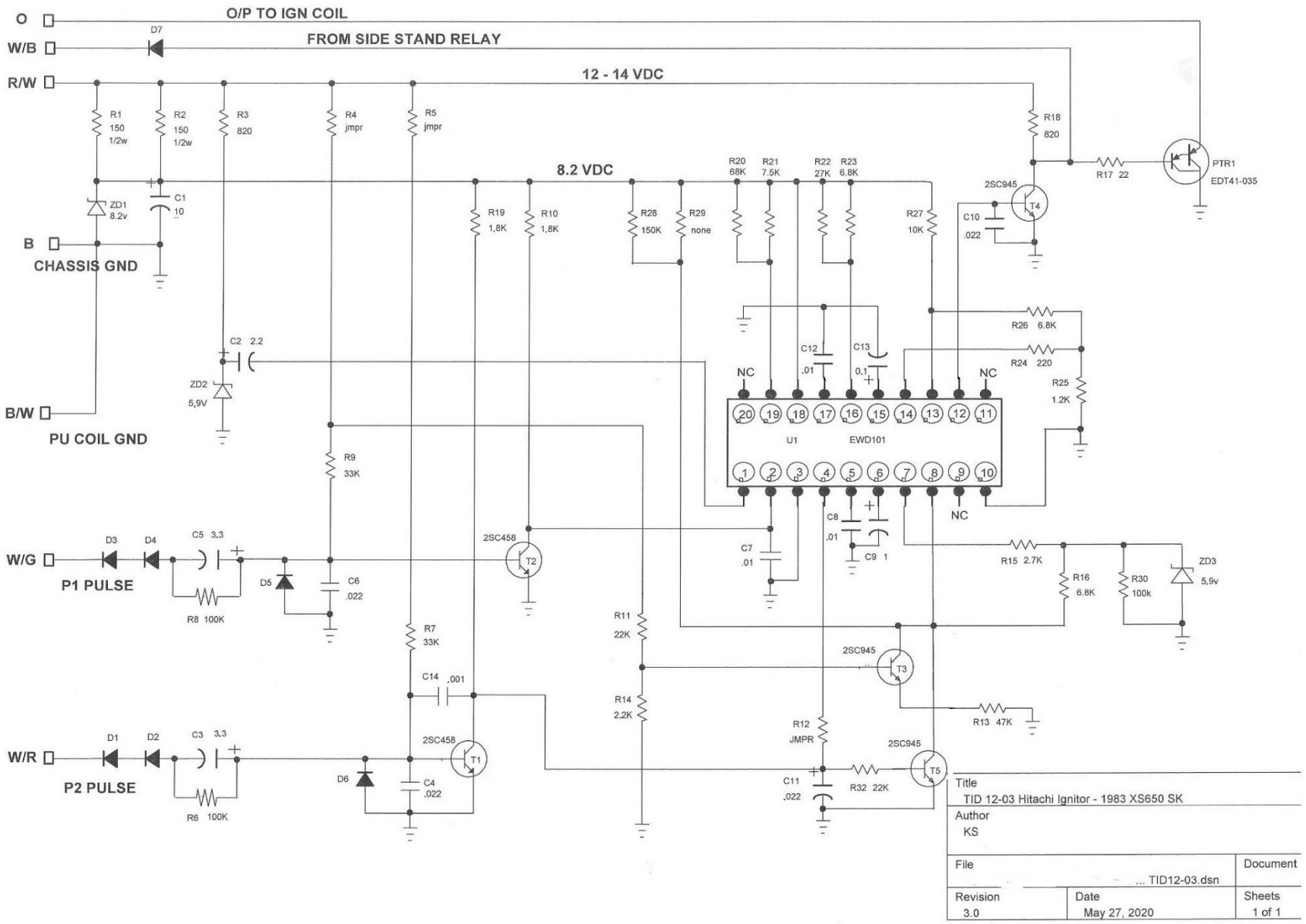


fig. 2 12-03 ignitor before adjustment. Advance switching at 2300 and 3500 rpms. Degree spread is fixed at 25 degrees. Measurements done using test jig and oscilloscope.

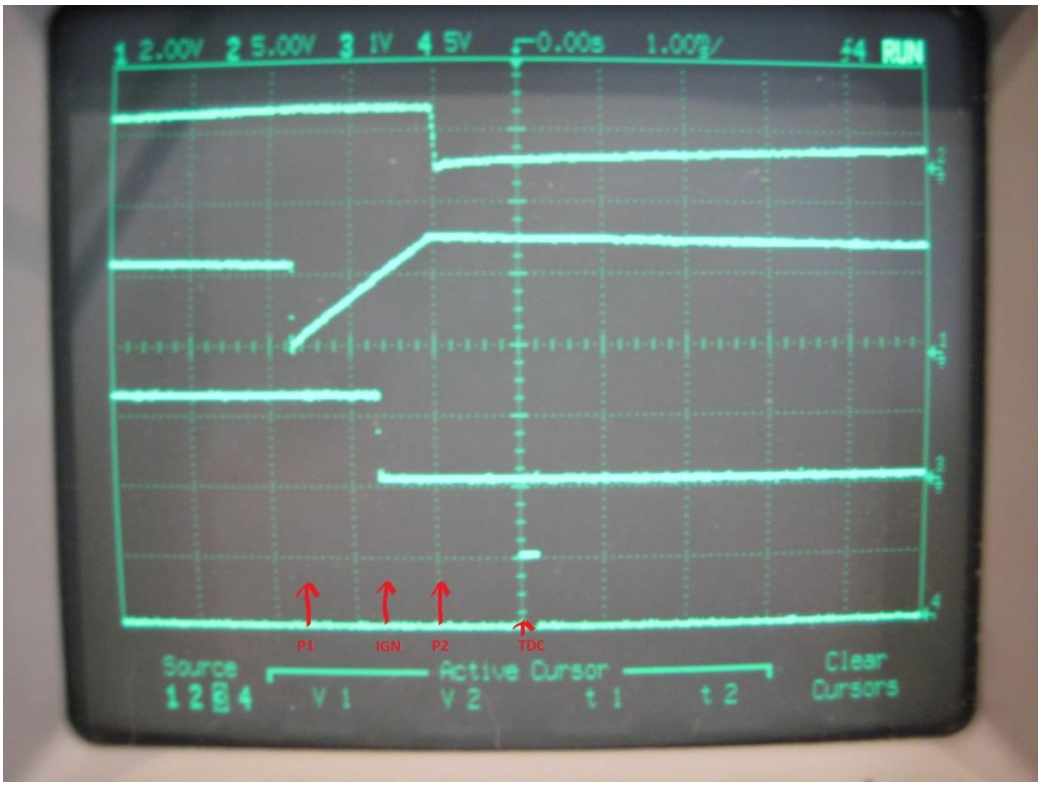


·fig. 3 Ignitor timing after adjustment. Transition points on timing curve at 1950 and 3400 rpm. Smaller sampling rate.

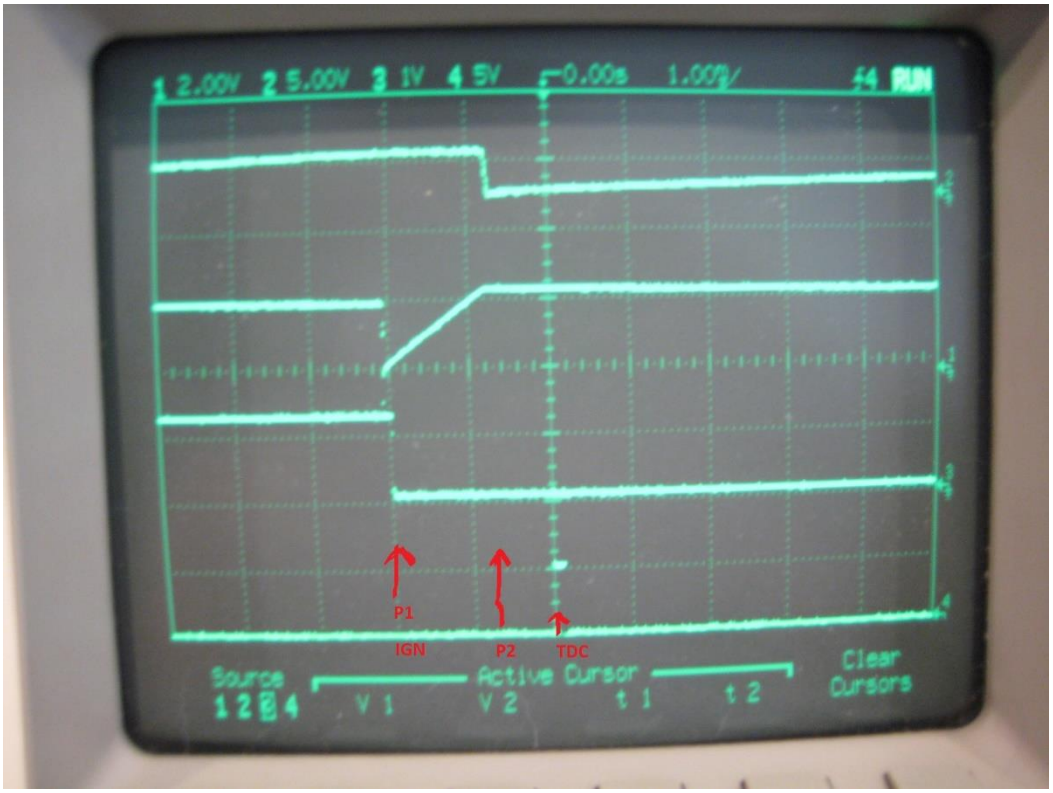


Title: TID 12-03 Hitachi Ignitor - 1983 XS650 SK		
Author: KS		
File: ... TID12-03.dsn		Document
Revision: 3.0	Date: May 27, 2020	Sheets: 1 of 1

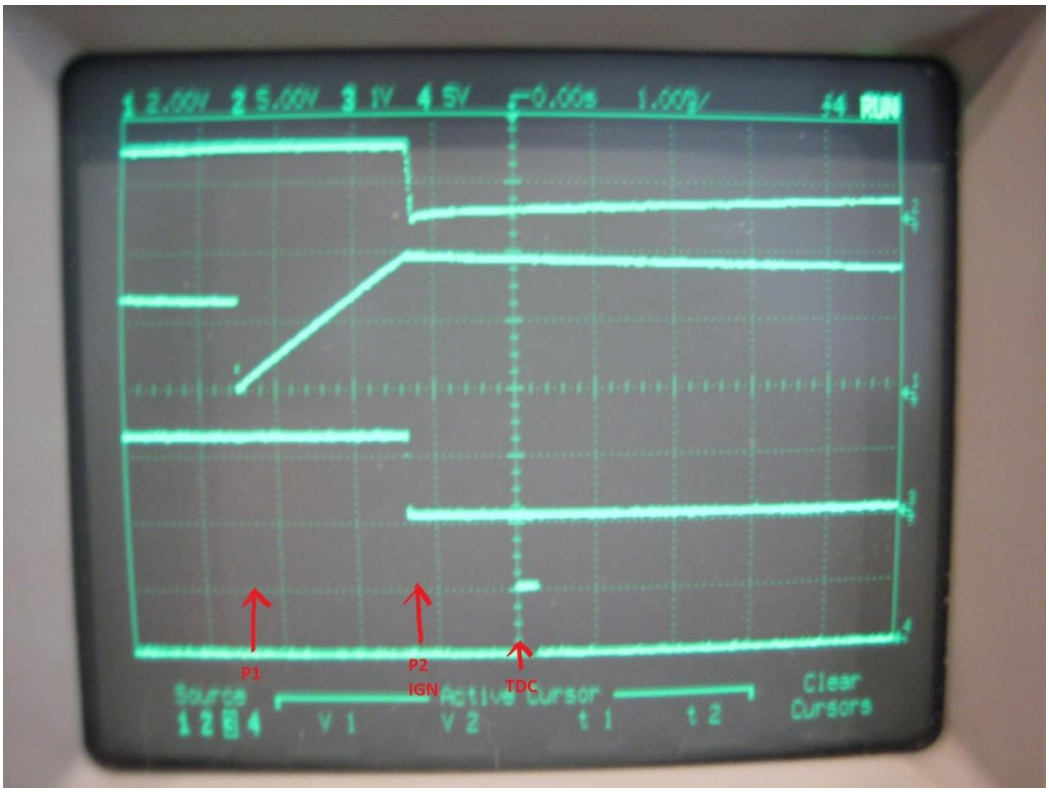
Oscilloscope image. Top trace is long ramp, second trace is short ramp, third is base of output transistor and bottom is TDC pulse. This one is showing an rpm somewhere in the middle of the advance curve.



Ignition at P1 … higher end of advance curve.



Ignition near P2 …low end of advance curve.



Test setup.