MSD-6A MULTIPLE SPARK DISCHARGE IGNITION

A Technical Report

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May 6, 1997
Rev 0.2

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1. Introduction

1.1 Scope

This document provides technical details of the MSD-6A ignition. Most of this information is electrical in nature, based on actual measurements and the schematic of my unit (reversed engineered). I am in no way affiliated with the makers of the MSD products (Autotronic Controls Corp.).

1.2 General

Autotronic Controls offers a wide range of MSD ignitions. This report focuses on the model MSD-6A which is their ignition for "street and race" applications. The various MSD-6A models are described in Table 1. The MSD-6T models are also listed as they are electrically identical. The are minor differences between the ignitions designed for 8 cylinder applications and those designed for 4 and 6 cylinder applications.

Table 1 MSD-6A and MSD-6T Models

Model	Part Number	Application	Features
MSD-6A	6200	High Performance - Street/Race	Standard model, 8 cylinder.
MSD-6A	6246	High RPM Race, 4 & 6 Cylinder	Same as 6200, for 4&6 cylinder.
MSD-6T	6400	High Performance - Circle Track	Heavy duty, rev limiter interface, 8 cylinder.
MSD-6T	6446	High RPM Race - 4 & 6 Cylinder	Same as 6400, for 4&6 cylinder.

Information based on MSD Ignition Catalog (1989-1990), reference [1].

1.3 Sample Unit

All unit specific measurement data, descriptions, schematic, etc. are based on the model MSD-6A Multiple Spark capacitive Discharge ignition, part number 6200, with serial number 100273. This unit is referred to as the "sample unit."

The unit was manufactured sometime between the 32nd week of 1987 (8732) and May 1988, based on the date code printed on some of the diodes.

I purchased this unit in May, 1988, for $255.60 retail (with the "Blaster 2" coil). More recent prices are much lower; Summit Racing Equipment (reference [2]) and Jeg's High Performance (reference [3]) sell it for $120 (less coil), quoted April 11, 1995.

The coil used was the MSD "Blaster 2," part number 8203. This coil is the typical cylindrical type coil (metal canister, oil filled). Summit Racing Equipment and Jeg's High Performance sell it for $28, quoted April 11, 1995.

2. Published Specifications

2.1 MSD-6A Specifications

The published specifications for the MSD-6A as listed in the MSD Ignition 1989-1990 catalog [1] are summarized in Table 2. Also included are specifications from the MSD web page (reference [4]) which was accessed on March 26, 1997.

Table 2 MSD-6A Published Specifications

Parameter	**Specification** (1989-1990 Catalog) [1]	**Specification** (from web page, March 1997) [4]
Operating Voltage	+12 VDC, negative ground	+10 to +18 VDC (full power) "will run down to 5 volts"
Current Requirements	10 A at 10,000 RPM	-
Voltage Output, Primary	450 volts	470 volts
Voltage Output, Secondary	40 kV (stock coil) 45 kV (Blaster coil)	- -
RPM Range	10,000 RPM (8 cylinder)	-
Energy Output Max	600 mJ per sequence	110 mJ per spark
Multi-Spark Duration	20 deg crankshaft rotation	20 deg crankshaft rotation
Weight and Size	2.75 lbs; 8”L, 3.5”W, 2.25”H	-

2.2 "Blaster 2" Coil Specifications

The relevant specs for the “Blaster 2” coil are: 100:1 turns ratio; 0.7 ohms primary resistance; 10.5 K ohm secondary resistance; 45 kV maximum output voltage.

3. Input and Output Interface

3.1 Main Power and Ground (Red and Black Wires)

The main power wires are the heavy gauge (approximately 10 AWG) red and black wires. These are connected to a continuos source of +12V (battery). The current drain is in the micro amp range (i.e. practically nothing) except when the units fires.

3.2 Ignition (Switched) Power (Red Wire)

This is connected to a source of switched power, such as the key ignition switch. It should be electrically disconnected from the battery when the engine is not running. This powers most of the electronics in the unit. The current drain is probably less than an amp (based on the schematic - I didn't measured it).

3.3 Output to Coil Primary and Ground Return (Orange and Black Wires)

The orange wire connects to positive terminal of the coil primary. The black wire connects to the coil negative terminal, and is the return path. The black wire is connected to the large black wire in the unit (ground).

3.4 Trigger Inputs

The MSD-6A has separate trigger inputs for conventional points or magnetic pickup.

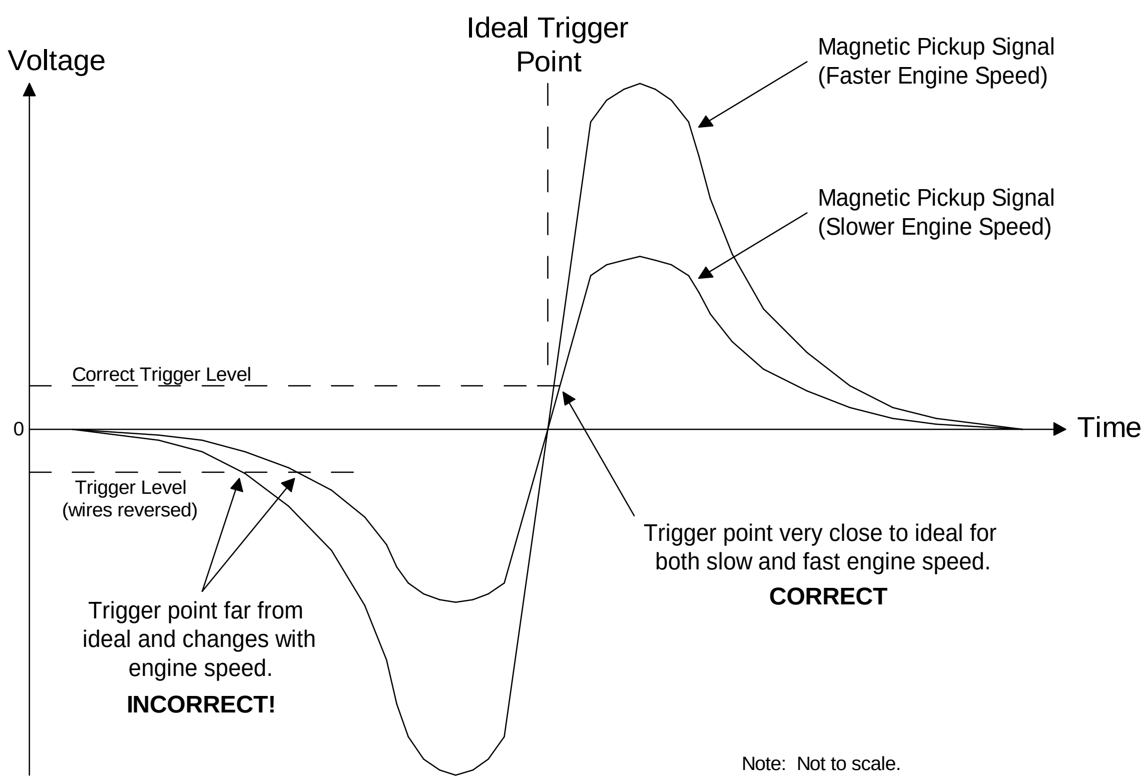
3.4.1 Input for Mechanical Points (White Wire)

The white wire is connected to the points (if used). When the points in the distributor close, the signal is grounded. As the points open, the unit fires. The current that flows through the points is limited by a 40 ohm, 5 watt resistor in the unit. This is 350 mA at 14 V (engine running). This is low compared to the current that the points must switch in a conventional system (many amps), so the points should last much longer. However, 350 mA is still quite a lot of current for the function being performed; perhaps the engineers wanted to ensure a fast risetime of the signal when the points open. This input can be used to inject your own trigger signal, using a transistor switch to ground. Make sure that the transistor power rating is sufficient to handle the current.

3.4.2 Magnetic Pickup Input (Violet and Green Wires)

The magnetic pickup inputs are the violet and green wires. The green wire is grounded internally to the unit. My unit fired when the voltage on the violet wire reached about +0.3 V, and it triggered on the rising edge of the signal. This is important information, as it will affect the timing depending on the polarity of the signal from the magnetic pickup. In the correct case: as the rotor in the distributor approaches the magnetic pickup, the voltage will go negative to some max value, then swing positive. It will pass through 0V as the rotor is exactly lined up with the pickup (this is where you want the ignition to fire); the voltage will continue to go positive to some max value, and then return to 0V as the rotor rotates away from the pickup. It is the negative to positive transition that you want as the trigger reference. If the wires are reversed so that the signal goes positive first, the unit will trigger early (as the rotor approaches the pickup). This will cause early timing. Even worse, the trigger point will change depending on RPM, as higher RPM will create higher voltages. This is illustrated in Figure 1.

Figure 1 Magnetic Pickup Signal Waveform



3.5 Tachometer Output and Connector (Internal Yellow Wire)

Note that if a tachometer was connected previously to the stock coil, it will probably not function correctly with the MSD-6A. The tachometer is expecting one pulse for each combustion cycle, whereas the MSD will deliver multiple pulses. Because of this, MSD units have a separate tachometer output. On the MSD-6A, it is a connector (the internal wire is yellow). This output is driven by an open collector NPN transistor with a 270 ohm, 1 watt pull-up resistor to the supply voltage (12V). This output could easily be used as an input to an EFI computer if a level translation to +5V is performed.

4. MEASUREMENTS

The following measurements were performed in order to verify the published specifications.

4.1 Current Consumption

The 10 amp spec appears low; I recall seeing more than this when I was doing my testing. When installed in an automobile, the battery and charging system must be able to supply high current with little voltage drop. The use of heavy gauge wire (the same or larger gauge as on the unit itself) is recommended.

4.2 Unit Output (Coil Primary)

4.2.1 Primary Output Voltage

The open circuit output voltage when the unit fires was -500V. The voltage is negative with respect to ground (the schematic verifies this).

4.2.2 Multiple Spark

The number of spark discharges from the unit was measured as a function of input frequency. This was performed by feeding a square wave signal into the trigger input (violet/green wires). The output of the unit was loaded with the 0.8 ohm, 50 watt, wire wound ballast resistor that is provided with the “Blaster 2” coil. This resistance is almost the same as the resistance of the "Blaster 2" coil, but has significantly less inductance. It is assumed that this load will not damage the unit. (When installed in the car, I did not use this ballast resistor.)

The data is presented in Table 3.

The spark duration is specified as “20 deg crankshaft rotation.” I assume that this means that the unit will fire multiple sparks over a 20 deg rotation. When multiple discharges occur, the time interval between the discharges is 1 mS. Based on this, the duration was calculated and is listed in Table 3.

The actual duration of an individual spark was not measured.

Table 3 Multiple Sparks vs. Input Frequency (engine RPM)

Measured Data - Model 6200

Input Frequency (Hz)	Equivalent Engine Speed (RPM)[1]			Number of Discharges	Spark Duration[2] 8 cylinder (deg)
	4 cylinder	6 cylinder	8 cylinder		
10	300	200	150	10	8.1
12	360	240	180	9	8.6
15	450	300	225	8	9.5
18	540	360	270	7	9.7
24	720	540	360	6	10.8
31	930	620	465	5	11.2
39	1170	780	585	4	10.5
55	1650	1100	825	3	9.9
85	2550	1700	1275	2	7.7
170	5100	3400	2550	1	n/a

[1] The 4 and 6 cylinder engine speeds are listed for reference only. The model 6200 is designed for 8 cylinder applications. The engine speed is based on a four stroke engine and is calculated as follows:

Engine speed (RPM) = (120 * freq) / (number of cylinders).

[2] The spark duration is defined as the time interval from the first to the last spark in a multiple spark discharge sequence, based on a time interval of 1 mS between sparks. The spark duration is calculated as follows:

Duration (deg) = 360 * (Number of sparks - 1) * (interval between sparks) / (period of one revolution)

Duration (deg) = 360 * (Number of sparks - 1) * (1 mS) * (engine RPM) / 60

4.3 Energy

The capacitor that discharges into the coil is 1 uF, rated at 400V. Apparently the 400V rating is conservative since it is being exceeded by 100V based on my measurements. At 500V, the energy stored in the capacitor is 125 mJ, calculated with the following equation.

$$E = \frac{1}{2} C V^2$$

The spec listed in the 1989-1990 catalog [1] is 600 mJ which is more than my calculation. It appears that this spec applies to the sum of all multiple discharges. If this is the case, then it will depend on engine RPM, varying from 1250 mJ (10 discharges) to 125 mJ (one discharge) as RPM increases. This is clarified by the MSD web page [4] which states, "All sparks, including each multiple spark, is 110 milliJoules of spark energy."

4.4 Coil Output Voltage (Coil Secondary)

I did not verify the secondary output voltage from the coil. However, I do not doubt the spec of 45 kV. With the "Blaster 2" coil, the spark will jump from the coil output (center electrode) to one of the coil primary connections. This is distance of at least 1.5 inches! Be careful! It will not kill you, but it will not feel too good either.

4.5 Tachometer Output

The duty cycle of the tachometer output was measured as a function of input frequency. The input signal was a TTL level squarewave applied to the violet and green wires (magnetic pickup input). The data is presented in Table 4.

The time delay between the trigger input and the tachometer output was measured to be 6 uS.

Table 4 Tachometer Output Duty Cycle vs. Input Frequency

Measured Data - Model 6200

Input Frequency (Hz)	Tachometer Output Duty Cycle (%) [1]
10	10.7
20	14.7
50	18.0
100	19.6
200	20.6
400	22.3

[1] The duty cycle (%) is defined as the time that the signal is at +12V relative to the period of the signal.

5. Schematic

5.1 Generated Schematic

The schematic was generated by "reverse engineering" the sample unit. This is achieved by the tedious task of tracing the PWB connections from one component to the next and then drawing a logical schematic. Resistor values are identified by color code and other components by part value and part number markings. I completed this task in late 1988.

The generated schematic is shown in Figures 2 through 4. The schematic was drawn using Orcad Capture for Windows, version 6.11. This schematic represents the sample unit.

5.2 Patent References

The multiple spark ignition system was patented in 1975 [5] and 1978 [6], and have since expired. These patents contain many technical details of the MSD system, including schematics.

Figure 2 Generated Schematic (page 1 of 3)

UNLESS OTHERWISE SPECIFIED:

1. RESISTORS ARE IN OHMS, 5%, 0.25W.
2. CAPACITORS ARE IN MICROFARADS.
3. UNIT SERIAL NUMBER IS 100273.
4. UNIT PURCHASED MAY, 1988.
5. PWB PART NUMBER MARKING IS 47540886 MSD6A.

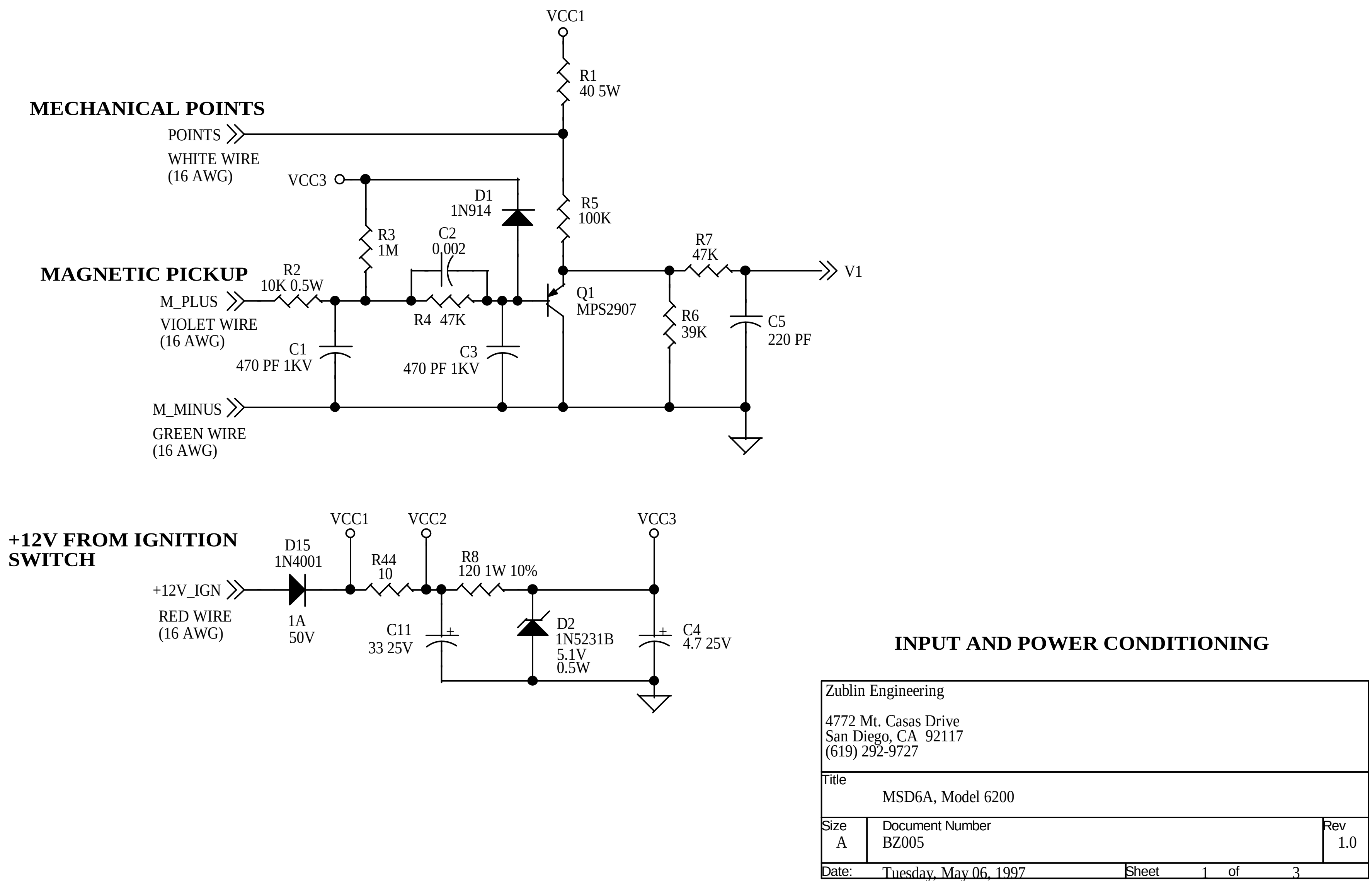


Figure 3 Generated Schematic (page 2 of 3)

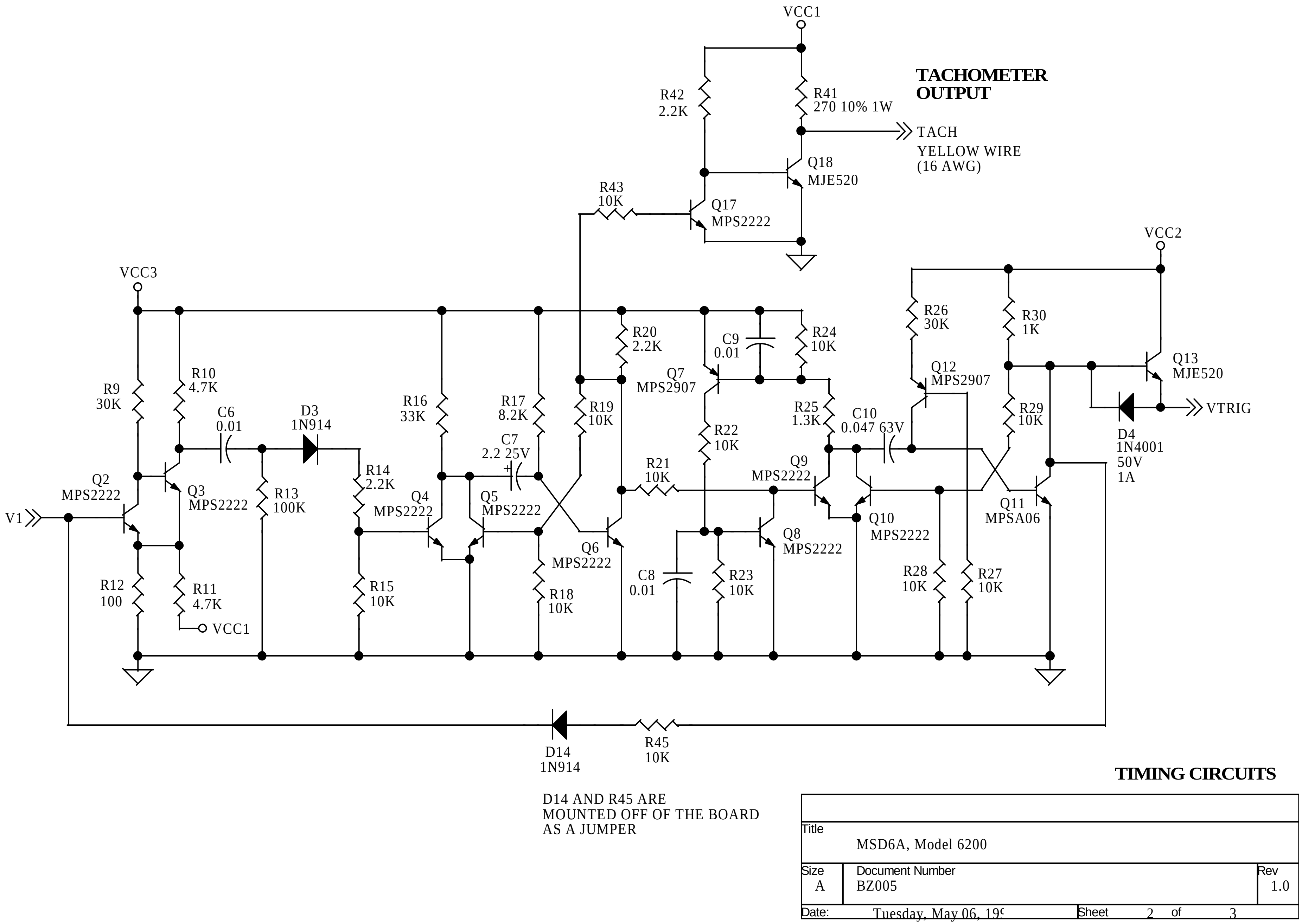
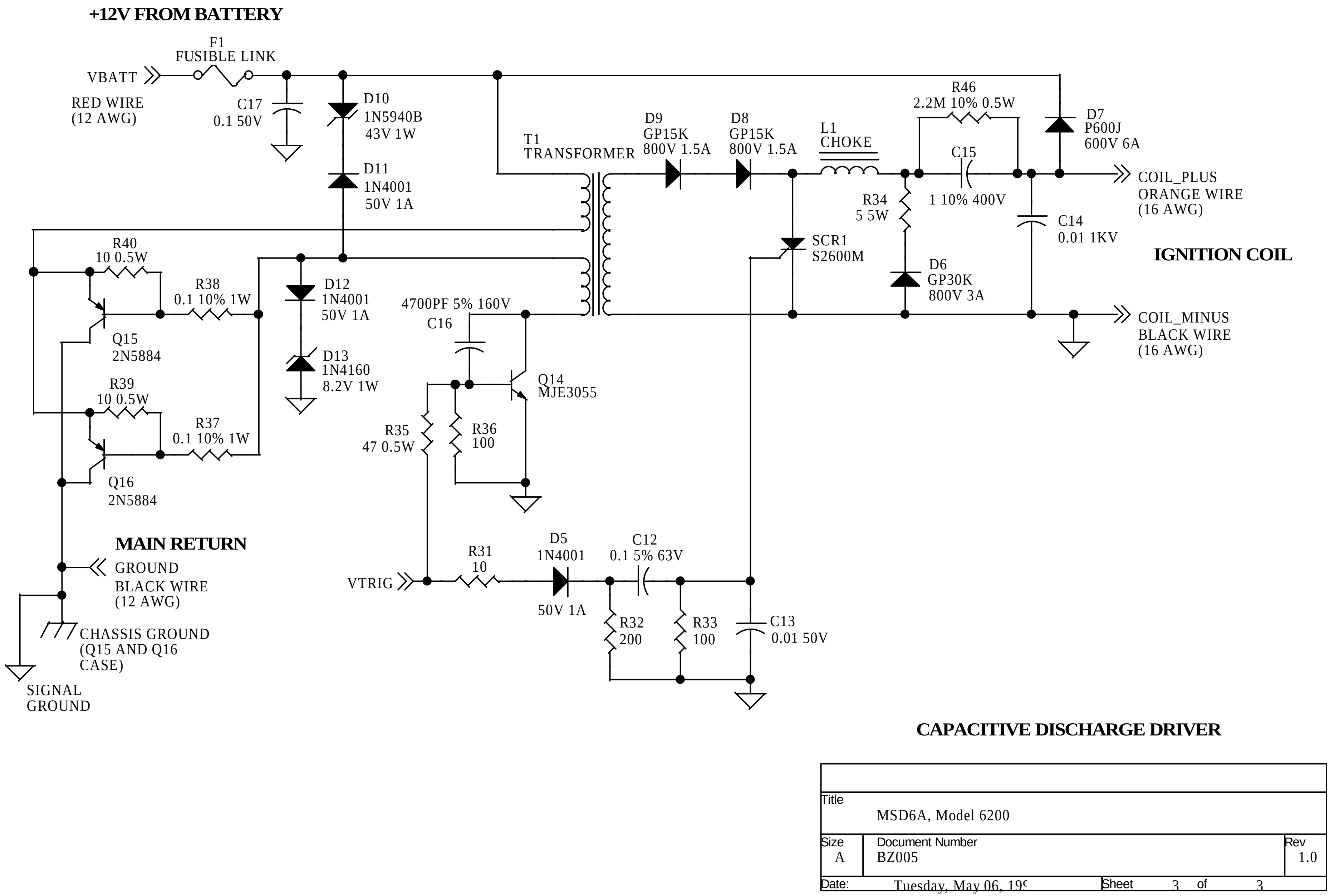


Figure 4 Generated Schematic (page 3 of 3)



6. Parts List

Table 5 Transistors

Ref Desig.	Part Number	Polarity	Case Style	Manuf.
Q1	MPS2907	PNP	TO-92	MOT
Q2	MPS2222	NPN	TO-92	MOT
Q3	MPS2222	NPN	TO-92	MOT
Q4	MPS2222	NPN	TO-92	MOT
Q5	MPS2222	NPN	TO-92	MOT
Q6	MPS2222	NPN	TO-92	MOT
Q7	MPS2907	PNP	TO-92	MOT
Q8	MPS2222	NPN	TO-92	MOT
Q9	MPS2222	NPN	TO-92	MOT
Q10	MPS2222	NPN	TO-92	MOT
Q11	MPSA06	NPN	TO-92	MOT
Q12	MPS2907	PNP	TO-92	MOT
Q13	MJE520	NPN	TO-126	SGS
Q14	MJE3055	NPN	TO-127	MOT
Q15	2N5884	PNP	TO-3	SGS
Q16	2N5884	PNP	TO-3	SGS
Q17	MPS2222	NPN	TO-92	MOT
Q18	MJE520	NPN	TO-126	SGS

Table 6 Diodes

Ref Desig.	Part Number	Type	Voltage	Wattage (watts)	Current (amps)	Part Marking
D1	1N914	Switch	-	-	-	
D2	1N5231B	Zener	5.1	0.5	-	5231B
D3	1N914	Switch	-	-	-	
D4	1N4001	Rect.	50	-	1	1N4001
D5	1N4001	Rect.	50	-	1	1N4001
D6	GP30K	Rect.	800	-	3	GP30K GI 8732
D7	P600J	Rect.	600	-	6	P600J GI 8705
D8	GP15K	Rect.	800	-	1.5	GP15K GI 8724
D9	GP15K	Rect.	800	-	1.5	
D10	1N5940B	Zener	43	1	-	1N5940B
D11	1N4001	Rect.	50	-	1	1N4001
D12	1N4001	Rect.	50	-	1	1N4001
D13	1N4160	Zener	8.2	1	-	
D14	1N914	Switch	-	-	-	
D15	1N4001	Rect.	50	-	1	1N4001
SCR1	S2600M	SCR	-	-	-	S2600M RCA 8728
Abbreviations: Rect = rectifier; SCR = silicon controlled rectifier.						

Table 7 Other Parts

Ref Desig.	Part Description
F1	Fusible link, approximately 0.4 inches of 28 or 30 AWG wire.
L1	Choke, toroid, 35 turns, 20 or 22 AWG enameled wire
T1	Transformer, "MSD6A WABASH 4946 524 8730"

Table 8 Capacitors

Ref Desig.	Value	Tol. (%)	Voltage	Type	Part Color	Part Marking
C1	470 pF	-	1000	Disk	tan	470K Z5F
C2	0.002 uF	-	-	Disk	tan	.002K X5F
C3	470 pF	-	1000	Disk	tan	470K Z5F
C4	4.7 uF	-	25	Tant.	orange	
C5	220 pF	-	-	Disk	tan	220K
C6	0.01 uF	-	-	Disk	green	.01M Y5P
C7	2.2 uF	-	25	Tant.	orange	
C8	0.01 uF	-	-	Disk	green	.01M Y5P
C9	0.01 uF	-	-	Disk	green	Y5P
C10	0.047 uF	-	63	-	red	WIMA
C11	33 uF	-	25	Elec.	tan	
C12	0.1 uF	5	63	-	red	WIMA
C13	0.01 uF	-	50	Disk	green	Y5P
C14	0.01 uF	-	1000	Disk	tan	.01K Z5P
C15	1 uF	10	400	-	red	WIMA MKP10
C16	4700 pF	5	160	-	yellow	4700 WIMA
C17	0.1 uF	-	50	Ceramic	blue	104M
Abbreviations: Elec = electrolytic; Tant = tantalum; Disk = ceramic disk.						

Table 9 Resistors

Ref Desig.	Value (ohms)	Tol. (%)	Wattage (watts)	Type	Part Marking
R1	40	5	5	WW	PW5
R2	10K	5	0.5	-	-
R3	1M	5	0.25	-	-
R4	47K	5	0.25	-	-
R5	100K	5	0.25	-	-
R6	39K	5	0.25	-	-
R7	47K	5	0.25	-	-
R8	120	10	1	CC	-
R9	30K	5	0.25	-	-
R10	4.7K	5	0.25	-	-
R11	4.7K	5	0.25	-	-
R12	100	5	0.25	-	-
R13	100K	5	0.25	-	-
R14	2.2K	5	0.25	-	-
R15	10K	5	0.25	-	-
R16	33K	5	0.25	-	-
R17	8.2K	5	0.25	-	-
R18	10K	5	0.25	-	-
R19	10K	5	0.25	-	-
R20	2.2K	5	0.25	-	-
R21	10K	5	0.25	-	-
R22	10K	5	0.25	-	-
R23	10K	5	0.25	-	-
R24	10K	5	0.25	-	-
R25	1.3K	5	0.25	-	-
R26	30K	5	0.25	-	-
R27	10K	5	0.25	-	-
R28	10K	5	0.25	-	-
R29	10K	5	0.25	-	-
R30	1K	5	0.25	-	-
R31	10	5	0.25	-	-
R32	200	5	0.25	-	-
R33	100	5	0.25	-	-
R34	5	5	5	WW	PW5
R35	47	5	0.5	CC	-
R36	100	5	0.25	-	-
R37	0.1	10	1	CC	-
R38	0.1	10	1	CC	-
R39	10	5	0.5	-	-
R40	10	5	0.5	-	-
R41	270	10	1	CC	-
R42	2.2K	5	0.25	-	-
R43	10K	5	0.25	-	-
R44	10	5	0.25	-	-
R45	10K	5	0.25	-	-
R46	2.2M	10	0.5	CC	-
Abbreviations: CC = carbon composition; WW = wire wound.					
All other types are probably carbon film.					

7. Image Files

Color image files (jpeg format) of the printed wiring board are available from the author as listed in Table 10. They were generated by scanning color photographs of the sample unit. The “a” and “b” versions are identical except for the resolution. Hopefully these files will be posted in the same location as this document file.

Table 10 PWB Image Files

File	Date & Time	Size (bytes)	Description
pic1a.jpg	03/27/97 08:00p	23,824	Bottom view.
pic1b.jpg	03/27/97 08:01p	157,424	
pic2a.jpg	03/27/97 08:01p	15,808	End view, transformer and power transistors (Q15 and Q16).
pic2b.jpg	03/27/97 08:01p	72,298	
pic3a.jpg	03/27/97 08:01p	16,572	Side view, power resistor (R1) and power transistor (Q14).
pic3b.jpg	03/27/97 08:01p	73,406	
pic4a.jpg	03/27/97 08:01p	27,865	End view, diode (D7), misc. TO-92 transistors, power resistor (R1).
pic4b.jpg	03/27/97 08:02p	74,387	
pic5a.jpg	03/27/97 08:02p	45,202	Side view, transformer (T1), toroid (L1), capacitor (C15).
pic5b.jpg	03/27/97 08:02p	79,619	
pic6a.jpg	03/27/97 08:02p	48,348	Top view.
pic6b.jpg	03/27/97 08:02p	85,262	

8. References

[1] MSD Ignition 1989-90 Catalog, catalog PN 9600, published by Autotronic Controls Corp., 1490 Henry Brennan Drive, El Paso, TX, 79936, USA, (800) 392-2842. WWW page at Internet address http://www.msdignition.com/

[2] Summit Racing Equipment, P.O. Box 909, Akron, OH 44309-0909, USA, (800) 230-3030. Mail order supplier. WWW page at Internet address http://www.summitracing.com/

[3] Jeg's High Performance, 751 East 11th Avenue, Columbus, OH, 43211, (800) 345-4545. Mail order supplier. WWW page at Internet address http://www.jegs.com/

[4] MSD Ignition web page, Internet address http://www.msdignition.com.

[5] Multiple Spark Discharge Circuitry, United States Patent 3,926,165, December 16, 1975. Inventor: James Walter Merrick. Assignee: Autotronic Controls Corporation.

[6] Multiple Spark Discharge Circuitry, United States Patent 4,131,100, December 26, 1978. Inventor: James W. Merrick. Assignee: Autotronic Controls, Corp.