Simulator for an Antique Telephone System circa 1915

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I was recently inspired by a publication from http://www.telephonearchive.com/ for Kellogg Magneto Switchboards to find a way to demonstrate what it was like to use the telephone back in "the old days".

Assumptions:

1. Operation of this simulator is based on my limited understanding of the operation of Kellogg switchboards and phone networks circa 1915.
2.

Compromises:

1. Instead of each phone having a magneto to crank, to produce the ring voltage, I installed a toggle switch in each phone that supplies a signal to the switchboard that represents the customer cranking the magneto. This means that there is no need to detect the ring voltage within the switchboard nor generate (or supply) ring voltage to these modern phones. There is ring voltage, however, used to cause the phones to ring.
2. Instead of mechanical “drops” I used LEDs and latching relays.
3. Instead of each phone supplying DC current, each switchboard circuit supplies the DC current to the (two connected) phones.
4. The ring-off drops (LEDs) do not have a manual reset, but instead are reset when the corresponding circuit phone plug is removed from the line jack.
5. The switchboard implements a common-ground system whereby there is only one wire that is used to make connections between circuits and lines. This was done so that the two-conductor phone plug could be used to carry the voice/ring signals on one conductor and the ring-off signal on the other.
6. 1/4” phone plugs and jacks are too difficult/expensive to come by and so I used 2.5mm plugs and jacks.

Operational Basis:

On original equipment, a phone call proceeded as follows:

1. Subscriber cranks magneto.
2. Ring voltage from subscriber phone causes line drop to trip on switchboard, creating a visual indicator to the operator of which line is active, also optionally activating an audible alarm.
3. Operator chooses a free circuit and takes the “call” cord and plugs it into the active subscriber line.
4. Operator pushes the chosen circuit's “listen” switch to the on position.
5. Operator converses with subscriber to determine how to direct the call.
6. Operator takes the “answer” cord and plugs it into the desired line.

7. Operator pushes the “ring thru/ring back” switch to the “ring through” position and cranks their magneto, causing the phone to ring at the end of the “answer” line.
8. When “answer” line subscriber lifts receiver and talks, operator turns off “listen” switch effectively disconnecting from the circuit.
9. When subscribers are finished with their call, one or both (?) crank their magnetos causing the “ring-off” drops corresponding to the circuit in-use to trip. This provides a visual indicator to the operator the one or both of the subscribers are finished (or need operator assistance?). There may also be an optional audible indicator that the drops have tripped.
10. The operator then either unplugs the subscriber lines from the circuit or turns on the “listen” switch and converses with the subscriber(s) to see what else is needed.

Other scenarios or variations of this scenario are possible. For example, the operator may have to have the calling subscriber wait until and uplink is free and thus may “ring-back” the subscriber at a later time.

Unanswered questions:

1. Do the “ring-off” drops indicate completion of the call or simply that a subscriber needs more service?
2. Was there a dedicated (half-)circuit for the operator to use to talk to subscribers when all full-circuits were in-use? Or did an Operator simply reserve one circuit for that purpose? Or even simply let the subscriber's calls go unanswered in case all circuits were busy?
3. It seems obvious that the “ring-off” drops had to be reset manually, and that the line drops were (mechanically) reset by insertion of the phone plug into the line jack.
4. It appears that the operator had no indication when the subscriber went “off hook”. Only the ring voltage produced by the magneto cause any indication at the switchboard.

Equivalents on the simulator:

1. The subscriber phone magneto is replaced by a toggle switch. Activating this switch will cause an indicator on the switchboard. Depending on whether a circuit is plugged into the line, the indicator will either be the line drop or the “ring-off” drop.
2. The line drops are replaced by LEDs. The operator sees an LED light and will service that line. The LED will latch ON until the operator inserts a circuit plug into the line jack, and which time the LED will turn OFF. If a “night alarm” is connected that audible alarm will also be silenced (if there are no other line drops active).
3. The “ring-off” drops are also latching LEDs but have no manual reset. They are turned OFF by removal of the corresponding circuit plug from the line jack.

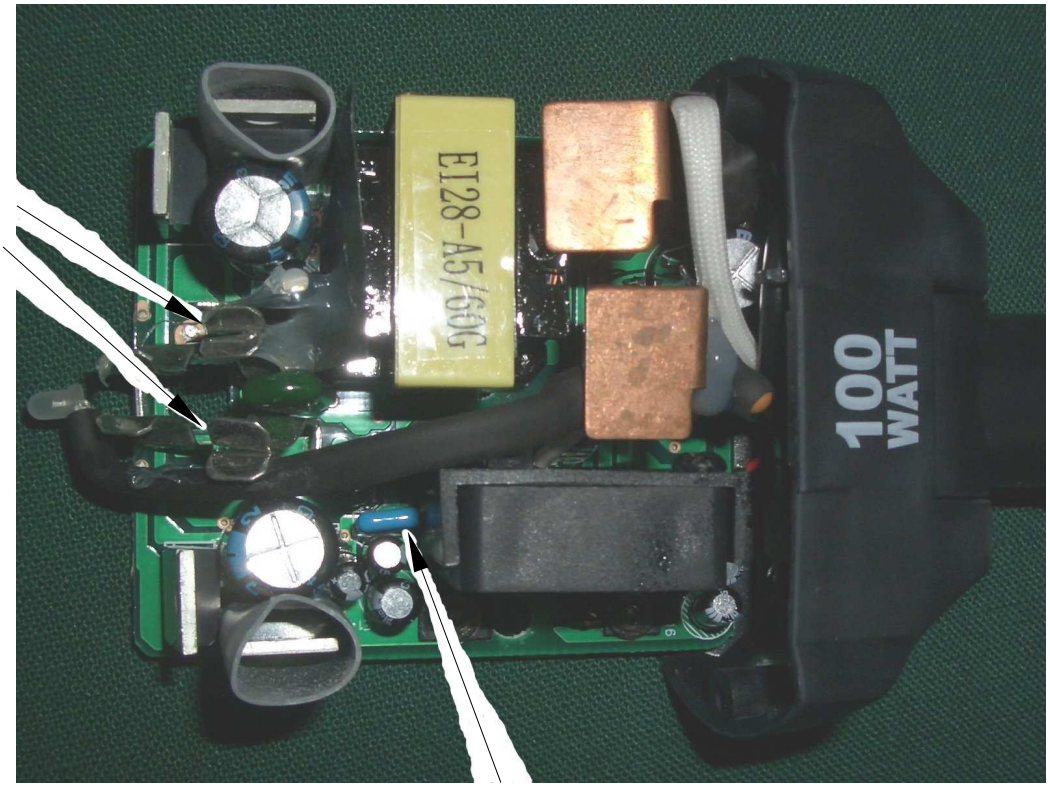
Technical Information:

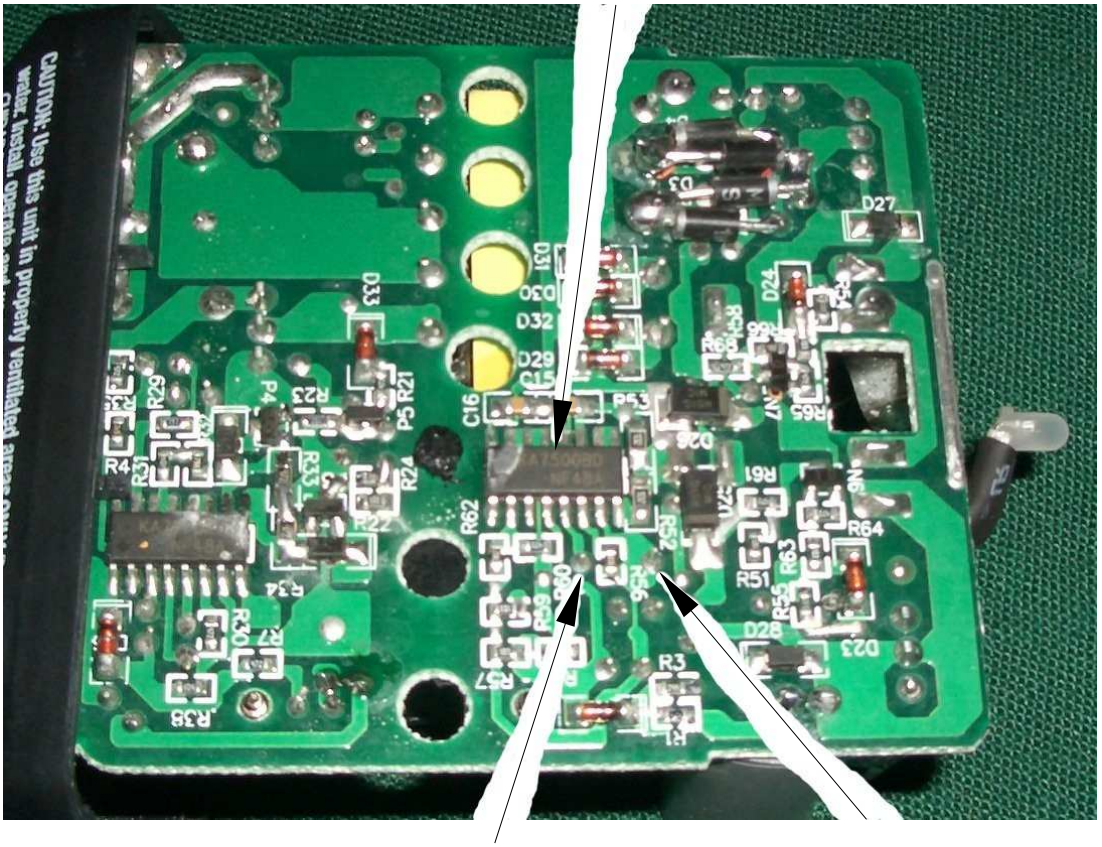
No power is supplied to subscriber lines until a circuit is plugged in. This design decision simplified wiring.

Ring Voltage:

Ring voltage is supplied through a commodity inverter (12vdc to 120vac) which has been modified to output 20Hz instead of 60Hz and also has a capacitive voltage divider to reduce the voltage presented to the circuits and phones.

I found “Husky” simple inverters for $9.95 (Home Depot). These inverters use a KA7500 series Pulse Width Modulator chip in the output stage, and its oscillator uses a capacitor with through-hole leads (i.e. is not surface mount, so easier to replace). The capacitor value for 60Hz is 0.1uF and so the value needed to produce 20Hz is 0.3uF. I was able to find a “0.33uF +/-10%” capacitor (with the right form factor to fit on the board) with an actual value of 0.307uF which produced 20.08Hz.

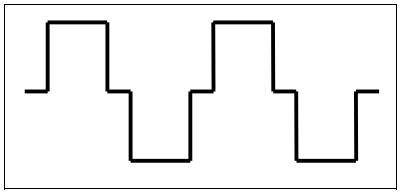




The remaining problem with using an inverter is supplying it with 12vdc. Simple 7812 series regulators are unable to supply the startup current needed, so I had to go with an old PC power supply. Had I known that earlier in my prototype I'd

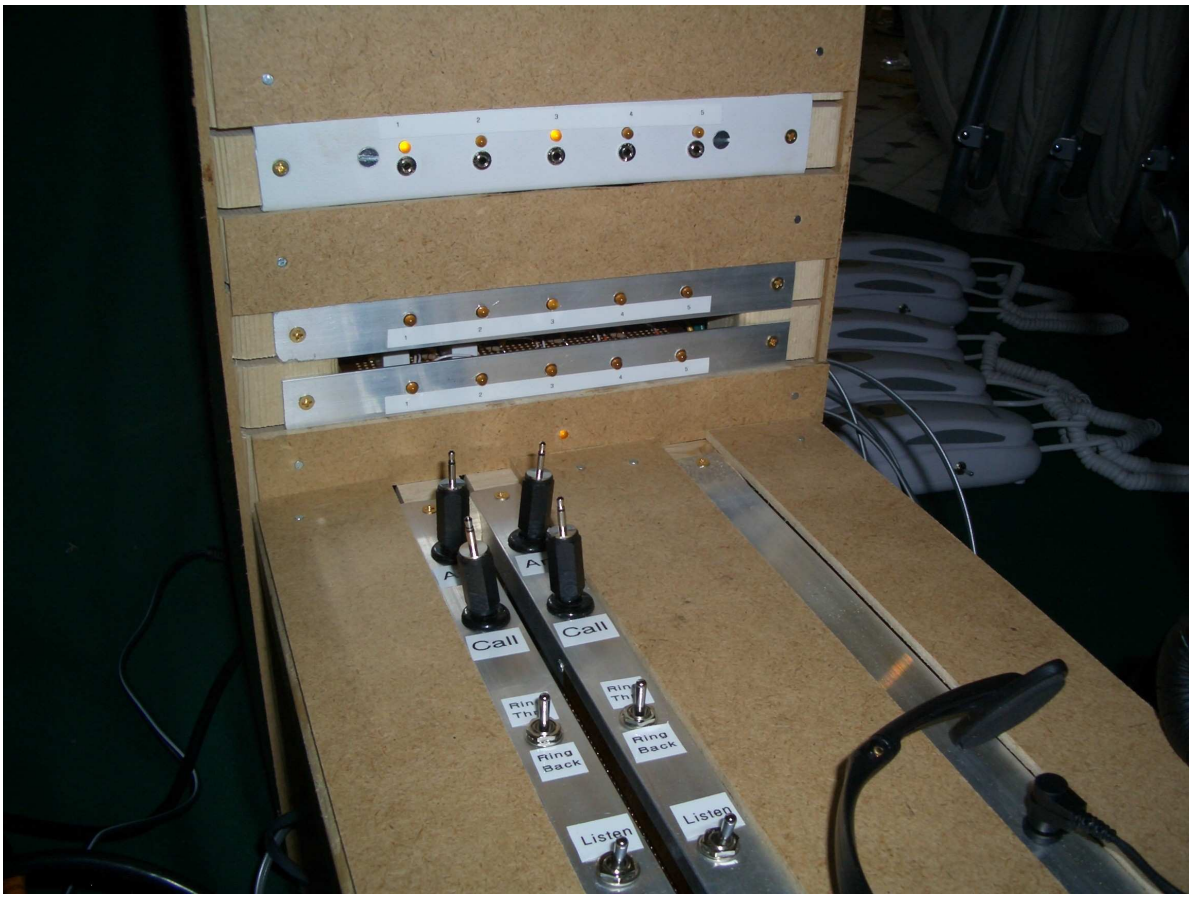
have gotten 12vdc relays and used the PC power supply for everything. But since I already have 24vdc relays I'll stay with my original power supply and use the PC power supply solely for the inverter, and producing ring voltage.

The inverter output is not a sine wave. It is more of a squarewave as shown right, with an amplitude of over 150v (300v p-p) and so reducing this voltage is important when using it for ring voltage. I was able to burn out a cheap telephone by supplying full output of the inverter to it while off-hook.



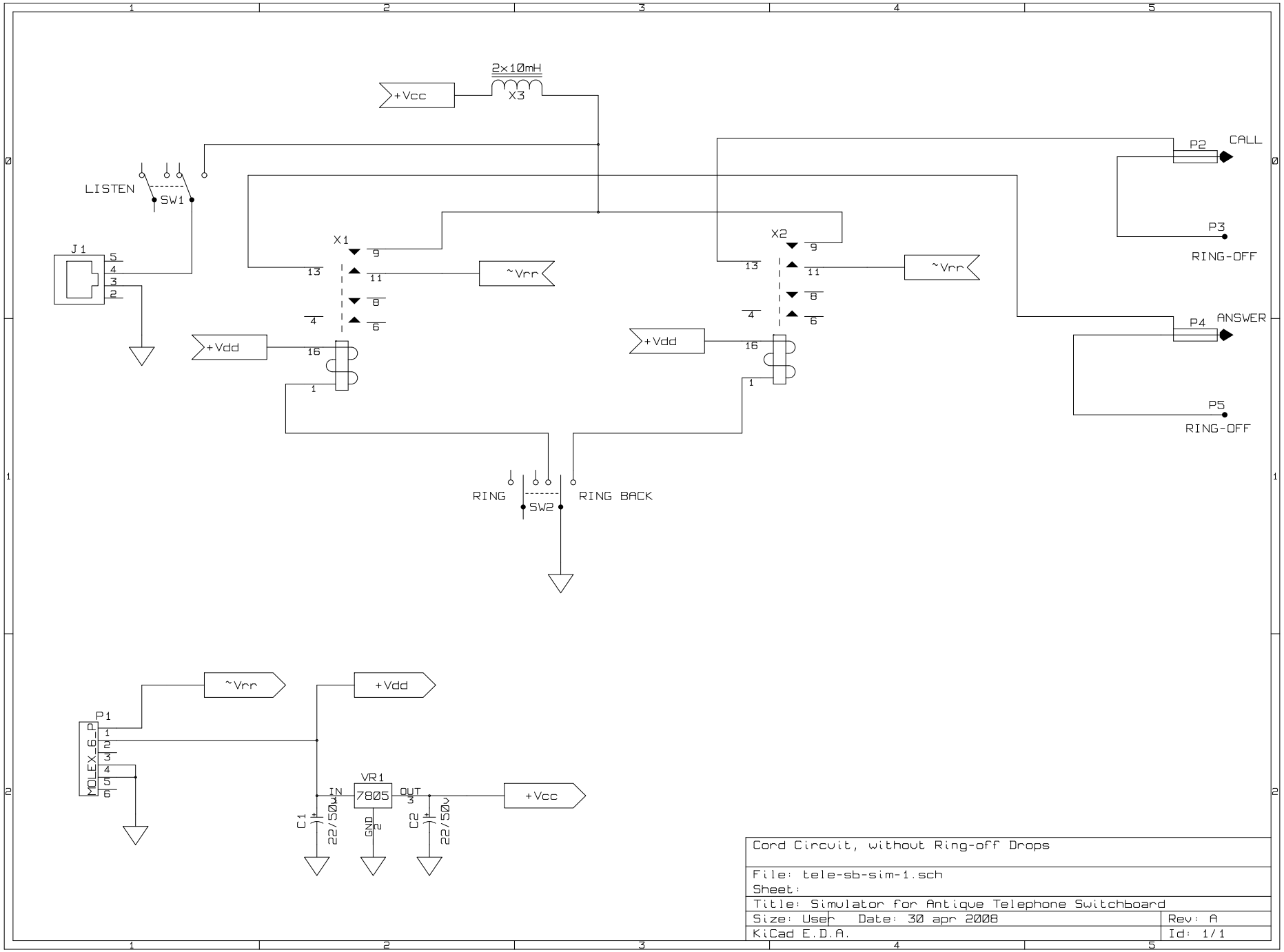
The reason for testing off-hook ringing is that this switchboard, like the originals, does not prevent ring voltage from being sent while the phone is off-hook. I needed to know not only if the phones would stand up to it but also how ear-splitting the audio affect was. With a 2/3 voltage divider (1.0uF + 0.47uF) the no-load voltage read (DVM) as under 80vac (rms) and was below 40vac when under load of a phone. The results is an annoying, but not deafening, sound from the ear piece.

The following pages show photos of my first prototype, and schematics.


Call
Call
Ring Back
Ring Back
Listen
Listen


Emerson.


Emerson.


2x10mH
X3
+Vcc
LISTEN
SW1
J1
X1
X2
~Vrr
+Vdd
P2
CALL
P3
RING-OFF
P4
ANSWER
P5
RING-OFF
RING
SW2
RING BACK
P1
MOLEX_6_P
VR1
7805
IN
OUT
GND
C1
C2
22/50v
Cord Circuit, without Ring-off Drops
File: tele-sb-sim-1.sch
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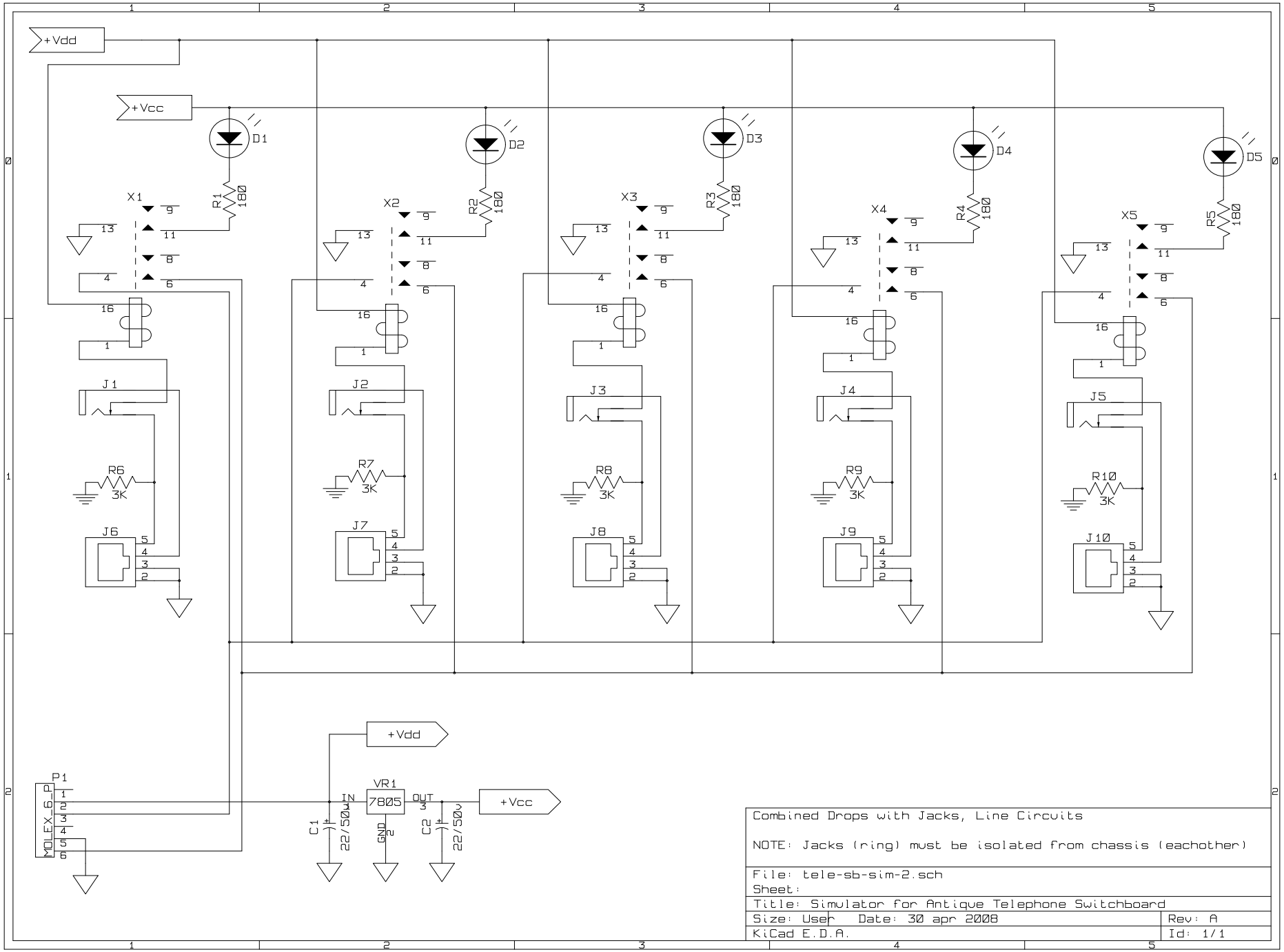
Size: User
Date: 30 apr 2008
Rev: A
KiCad E.D.A.
Id: 1/1


+Vdd
+Vcc
D1
D2
D3
D4
D5
R1 180
R2 180
R3 180
R4 180
R5 180
X1
X2
X3
X4
X5
J1
J2
J3
J4
J5
J6
J7
J8
J9
J10
R6 3K
R7 3K
R8 3K
R9 3K
R10 3K
P1
MOLEX_6_P
VR1
7805
IN
OUT
GND
C1 22/50v
C2 22/50v
+Vdd
+Vcc
Combined Drops with Jacks, Line Circuits
NOTE: Jacks (ring) must be isolated from chassis (eachother)
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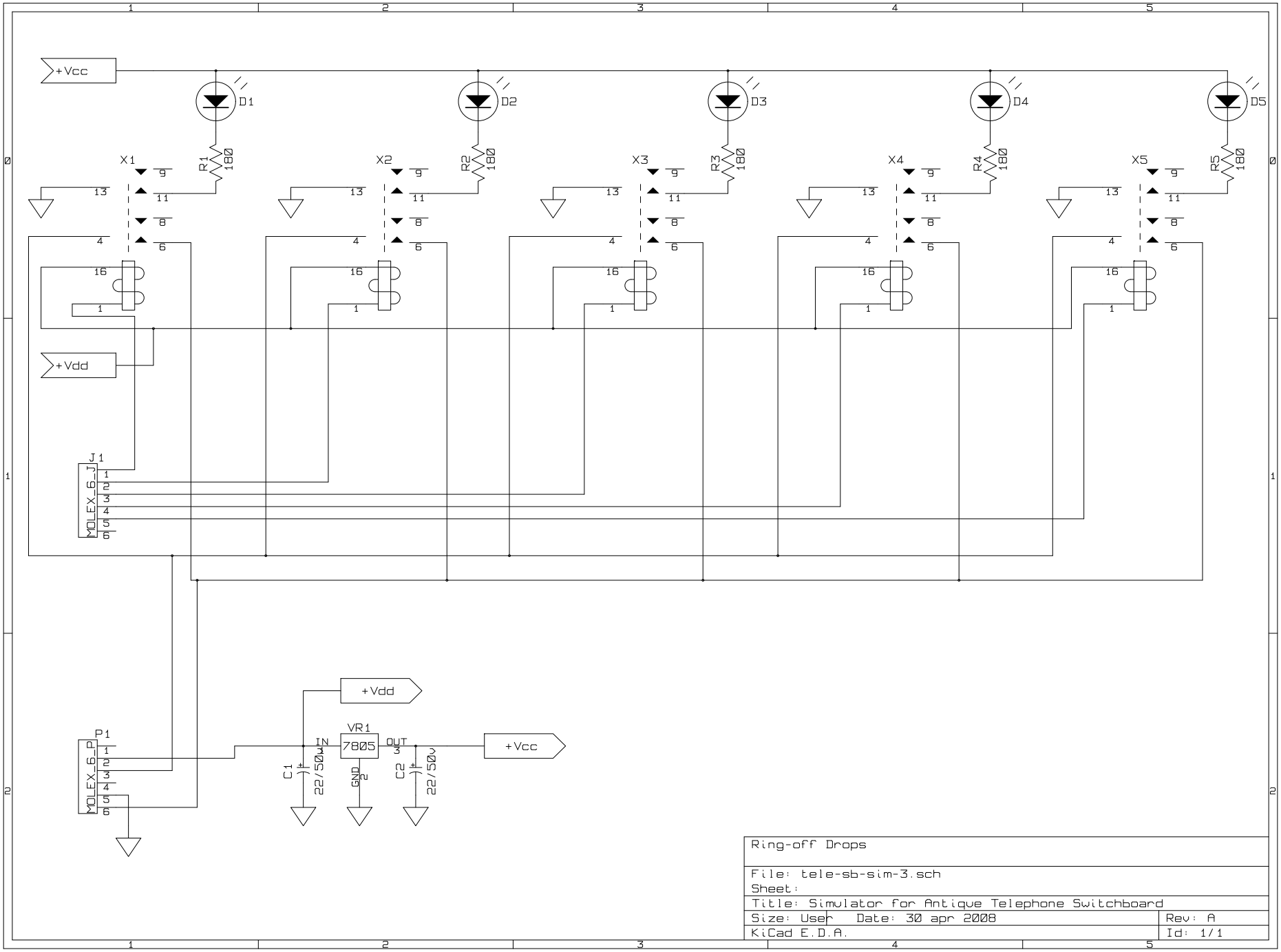
Size: User Date: 30 apr 2008 Rev: A
KiCad E.D.A. Id: 1/1


+Vcc
D1
D2
D3
D4
D5
R1 180
R2 180
R3 180
R4 180
R5 180
X1
X2
X3
X4
X5
+Vdd
J1
MOLEX_6_J
P1
MOLEX_6_P
VR1
7805
IN
OUT
GND
C1 22/50v
C2 22/50v
+Vdd
+Vcc
Ring-off Drops
File: tele-sb-sim-3.sch
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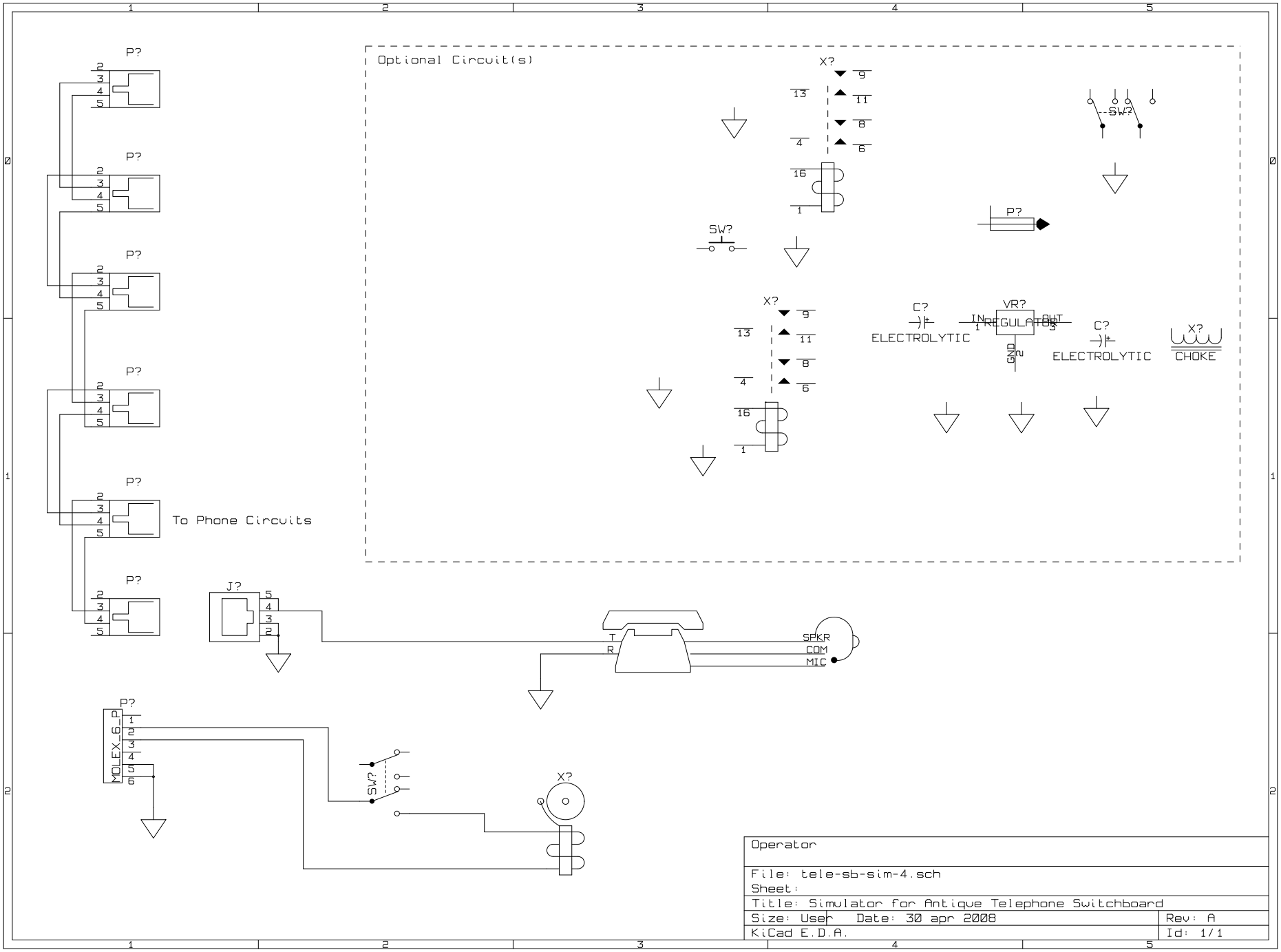
Size: User Date: 30 apr 2008
Rev: A
KiCad E.D.A.
Id: 1/1


P?
P?
P?
P?
P?
P?
To Phone Circuits
Optional Circuit(s)
X?
SW?
P?
X?
C?
ELECTROLYTIC
VR?
REGULATOR
IN
OUT
GND
C?
ELECTROLYTIC
X?
CHOKE
J?
T
R
SPKR
COM
MIC
P?
MOLEX_6_P
SW?
X?
Operator
File: tele-sb-sim-4.sch
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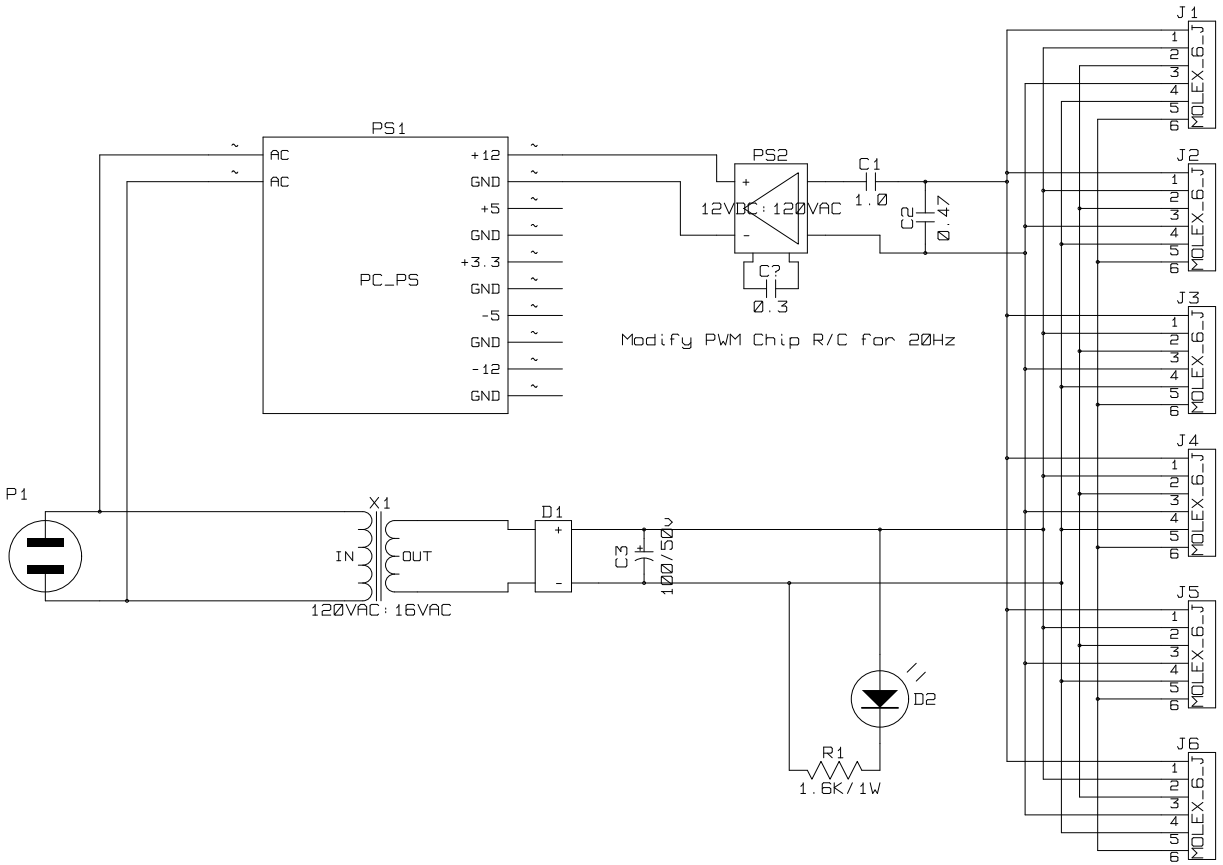
Size: User
Date: 30 apr 2008
Rev: A
KiCad E.D.A.
Id: 1/1



Power Supply	
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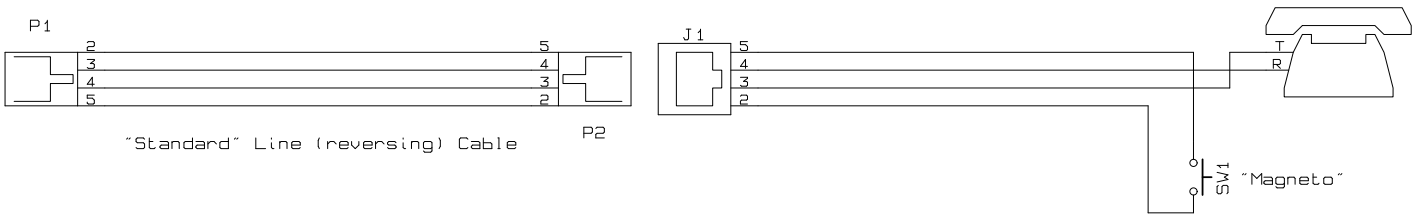

Subscriber Phone		
File: tele-sb-sim-6.sch Sheet:		
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KiCad E.D.A.		Id: 1/1