Battery Condition Monitoring: Battery Temperature Sensing Methods

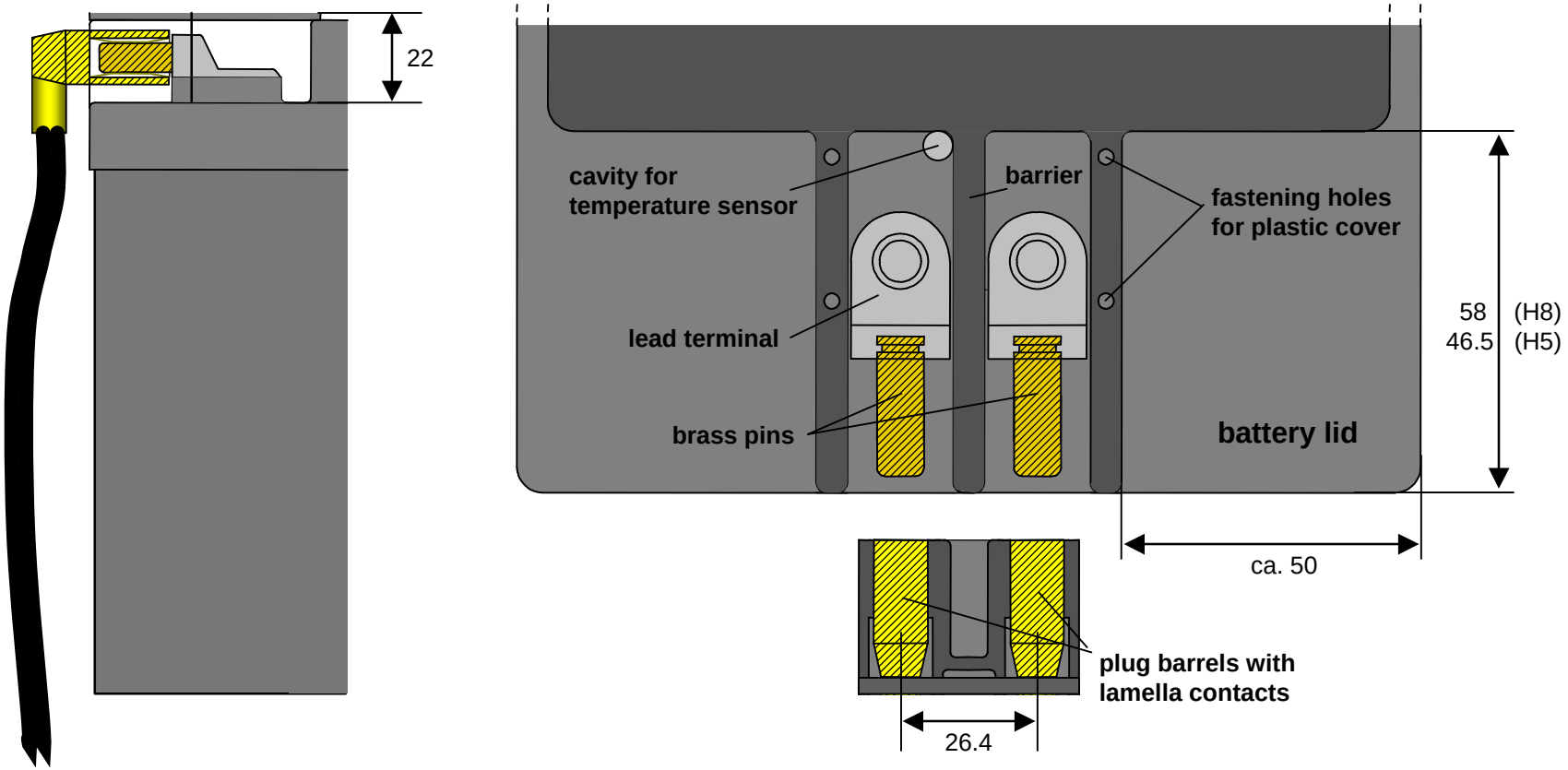
Dr. Hans-Peter Schöner & Dr. Roustiam Chakirov
DaimlerChrysler Research and Technology
Actuators and Mechatronics (FT2/SA)
Frankfurt / Main
Tel.: +49-69-6679-578 Fax: -412
peter.schoener@daimlerchrysler.com

Battery Temperature Sensing

- New design of 36V battery contacts is under way
- Provisions are made to integrate an optional temperature sensor into the battery
- Compare different implementations with respect to functionality, reliability and cost
- Due to main contact current, voltage drops up to 600A * 0,5mΩ = 300mV at main contact are possible

36V Battery Connector Concept

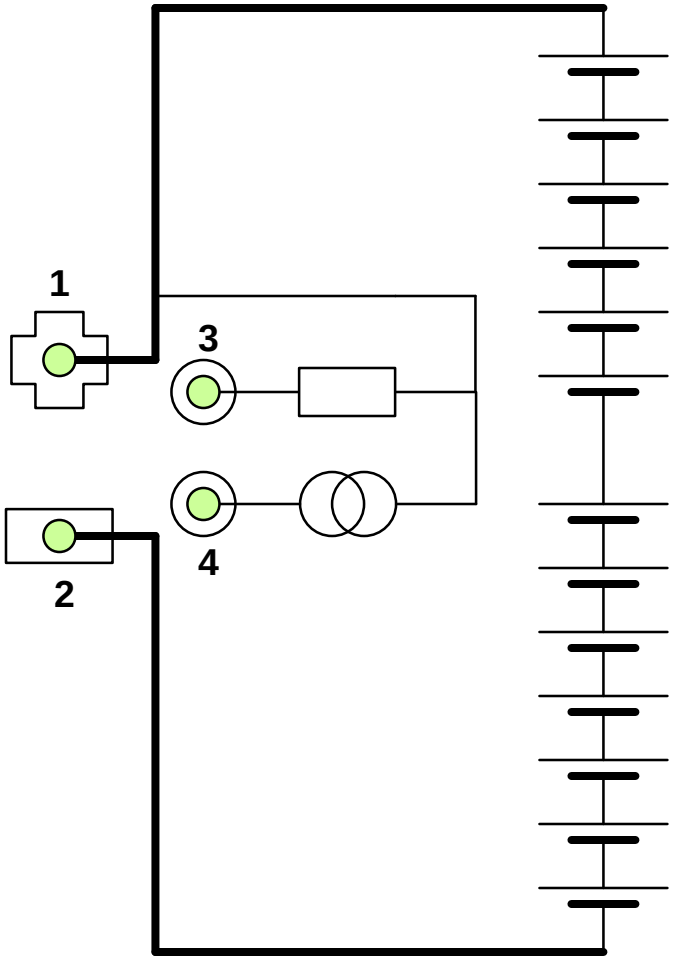
(general idea, under redesign)



- **pins or blades under consideration for main contacts**
- **extra 2 contacts for disconnect and temperature sensing (not shown here)**

Temperature-Dependent Current Source

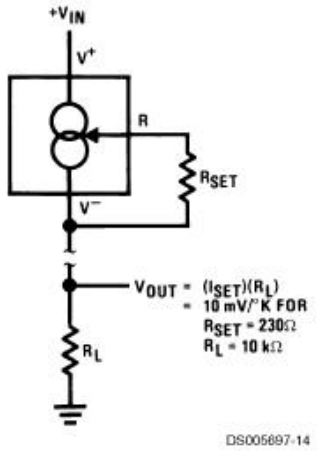
- Current source is insensitive to voltage drops at main contacts
- very linear behaviour
- measure temperature by adding an external switch and a resistor
- current source available with 2 or 3 terminals
- current typically 1µA/K
- leave pin 4 open or away if temperature sensor not needed



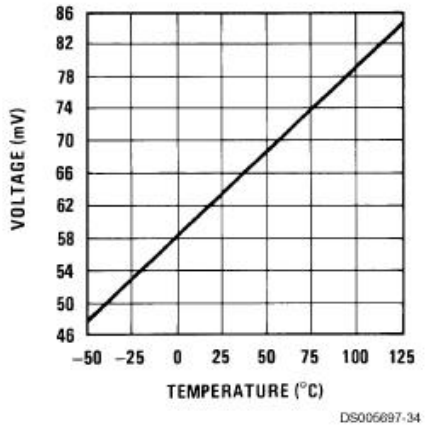
Current Sources as Temperature Transducer

LM134,LM334 - *National Semiconductor*
TMP17 - *Analog Devices*
(all have 3 terminals; 2 terminal devices also available)

Terminating Remote Sensor for Voltage Output



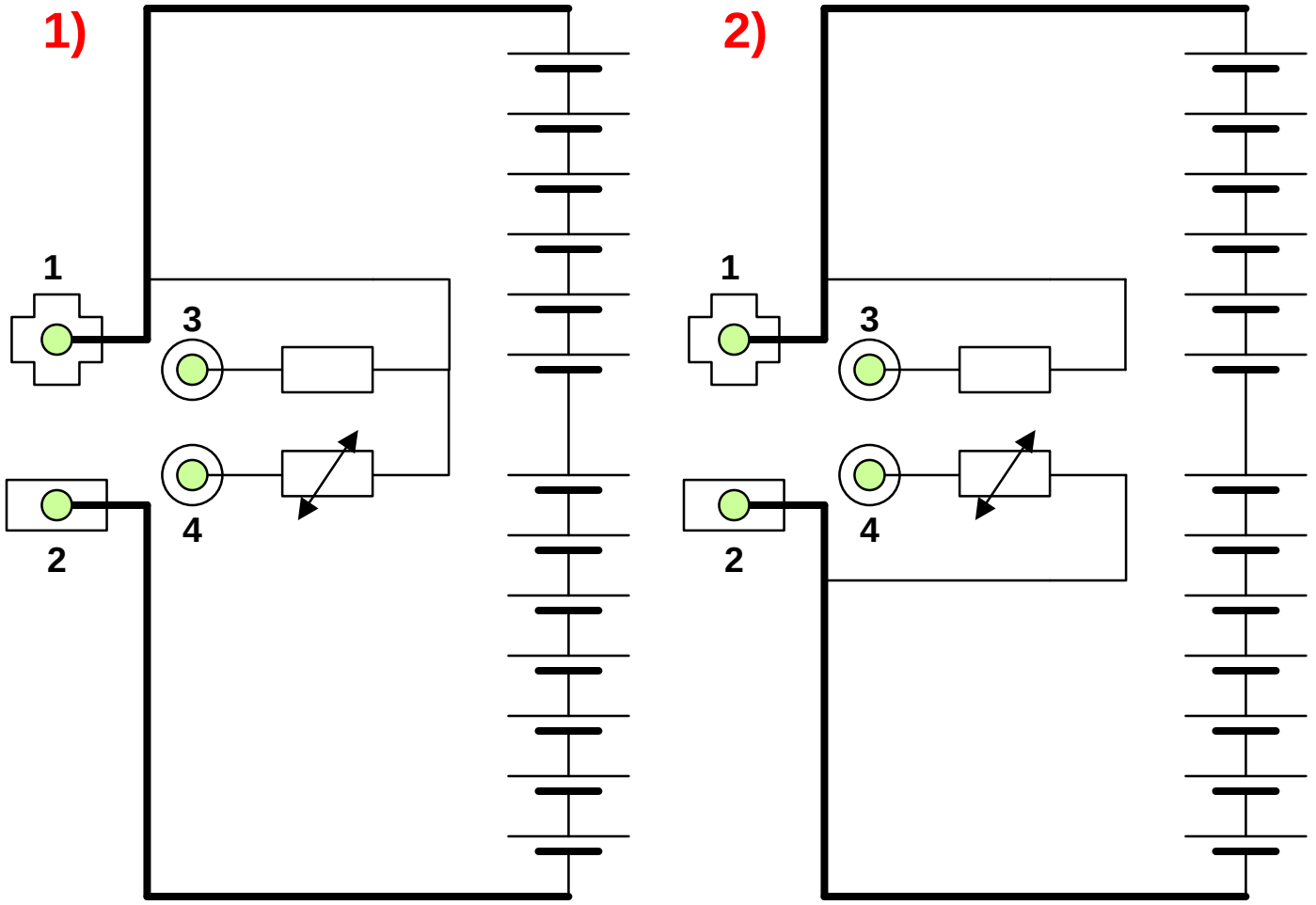
Voltage Across R_{SET} (V_R)



Supply voltage +4V to 40V (60V not available ?)

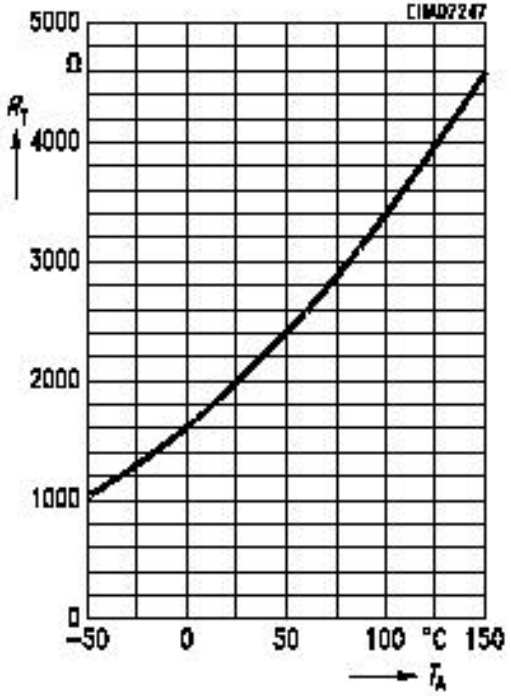
Accuracy: +/-1% (+/-1.25K)
Sensor cost: less than 2$

Battery Temperature Sensing with Thermistor

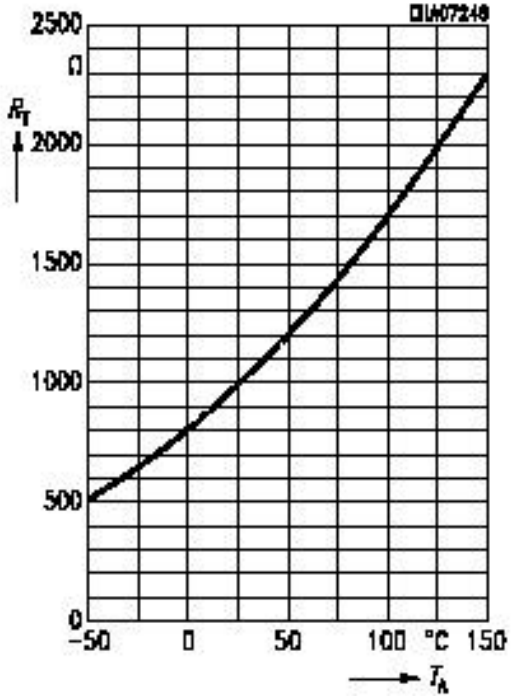


Silicon Temperature Sensor - KTY (Infineon, Philips)

Sensor Resistance $R_T = k_T \times R_{25} = f(T_A)$
I_B = 1 mA; Example: R_{25} = 2000 Ω



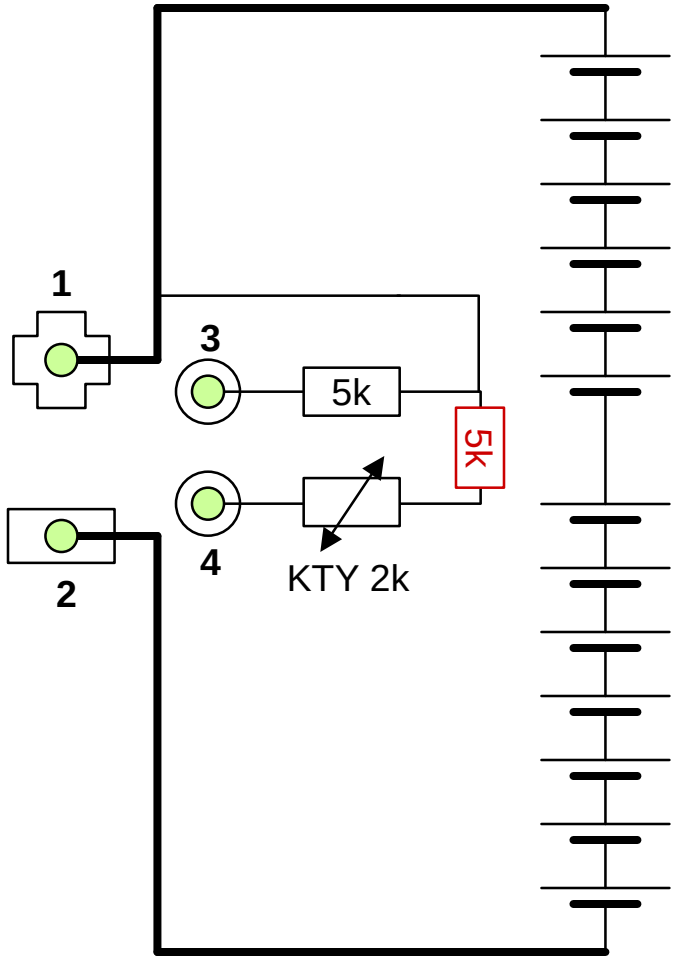
Sensor Resistance $R_T = k_T \times R_{25} = f(T_A)$
I_B = 1 mA; Example: R_{25} = 1000 Ω



maximum error: +/-1.2K
Sensor cost: less than 0.35$

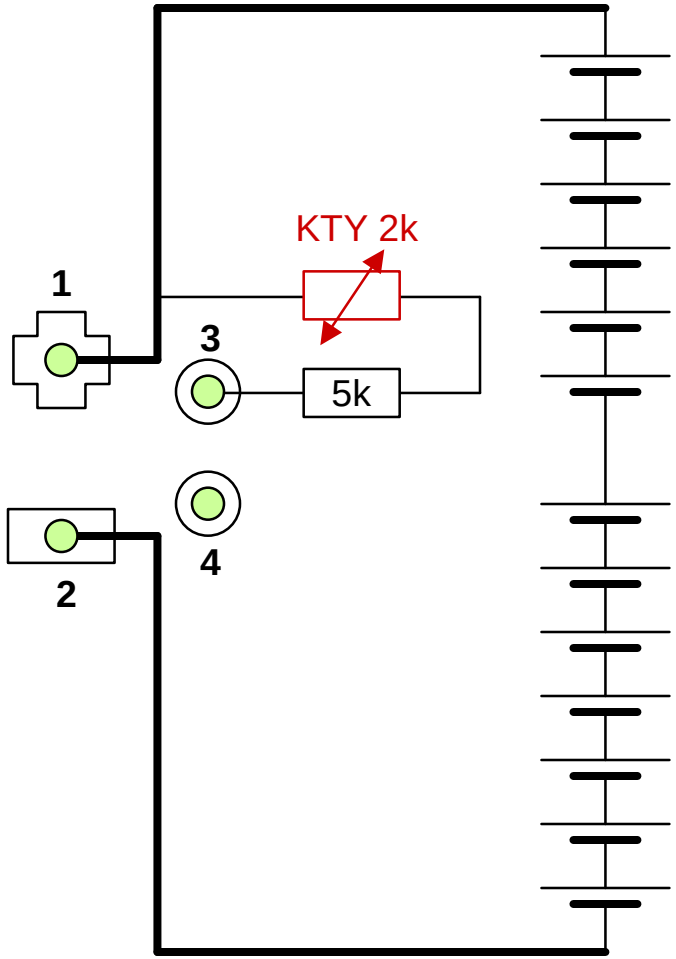
1) Thermistor at Positive Pole

- additional resistor needed for short circuit protection
- reduces relative variation in resistance due to temperature, but still can be measured with enough resolution
- pin 3 and pin 4 behave equivalent with respect to disconnect detection
- reference KTY voltage drop to o/c voltage at pin 3 to compensate for voltage drop
- leave pin 4 open or away if temperature sensor not needed



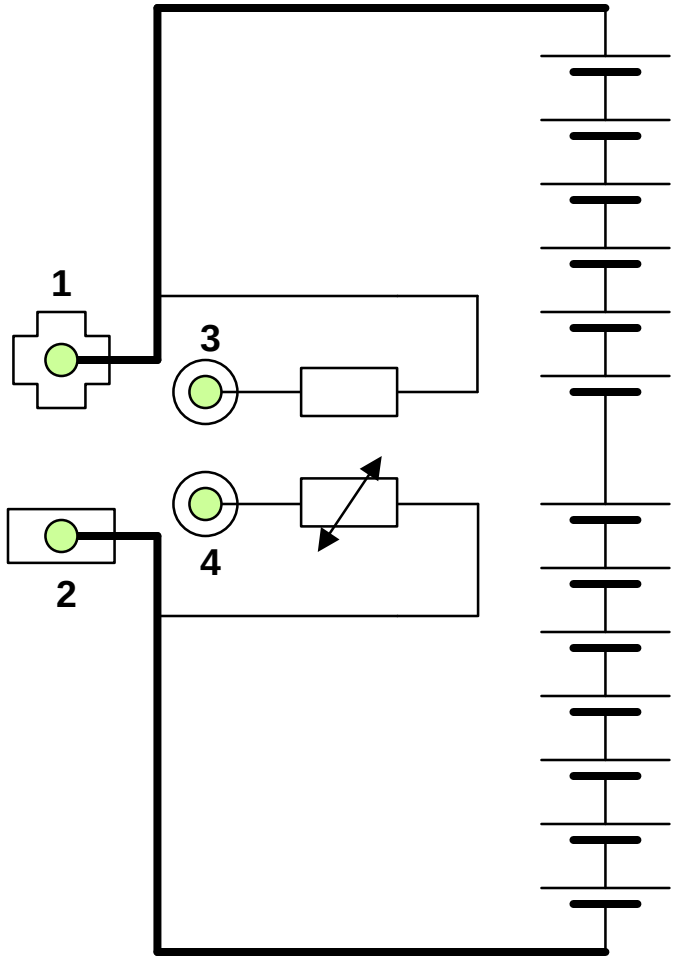
2) Thermistor in Series to Pull-up

- use KTY only if required
- test for KTY by resistance (if >6kΩ, then KTY is present)
- compensate for voltage drop by alternating measurements with high impedance (i=0) and measurement current (1mA)
- leave pin 4 for future use, or save its space and cost
- reliability of disconnect sensing decreases with sensor (is this significant ?)



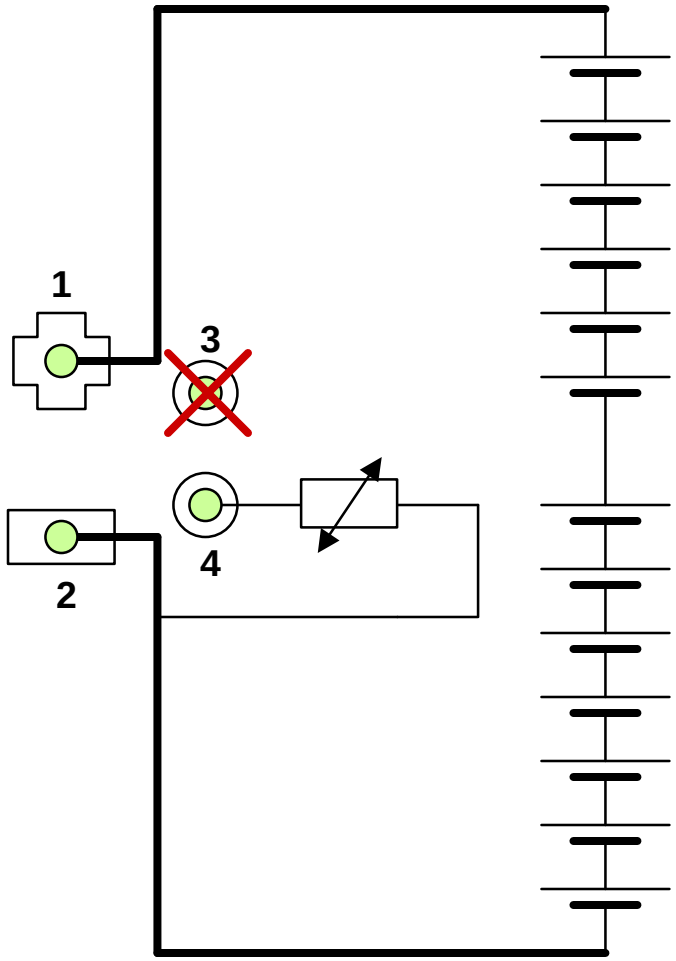
3) Thermistor - Symmetrical Solution

- identical contacts
- no problem of shorts or corrosion between power contact and adjacent sense contact
- without temperature sensor connect pin 4 directly to ground (and let pin 3 away ?)
- measure battery voltage between sense pins; contact resistance may be checked
- both sense pins may be used for redundant disconnect sensing (increased availability)



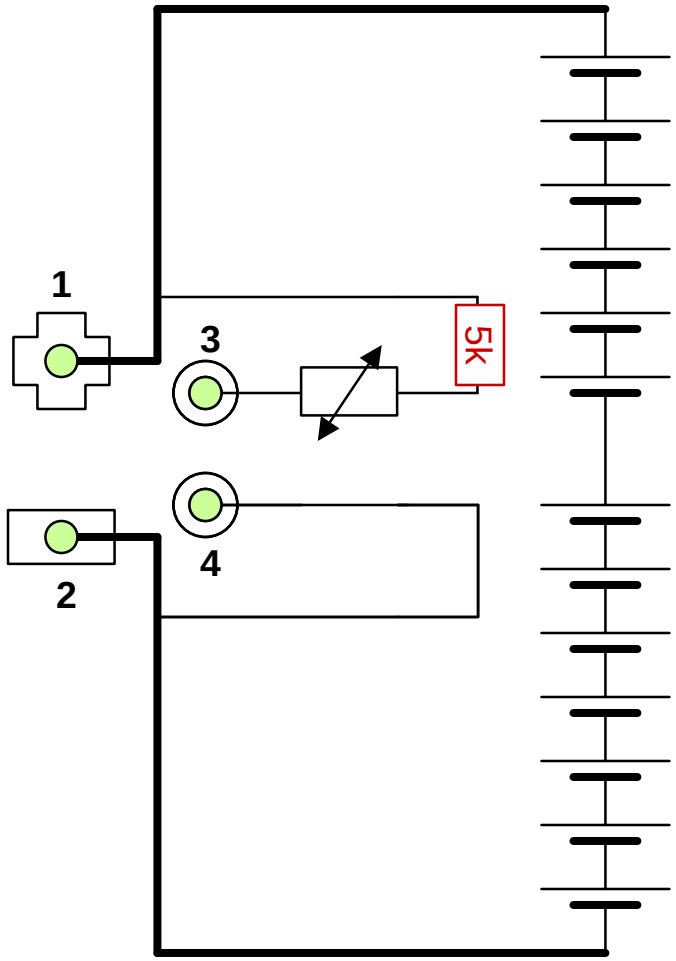
4) Thermistor at Negative Pole, 3 Pins

- A resistor is not needed if disconnect sense pin is at negative pole (but in harness !)
- save cost and space of one pin
- without temperature sensor connect pin 4 directly to ground
- reliability of disconnect sensing decreases with a sensor (is this significant ?)
- reliability of disconnect sensing without temperature sensor is better than with previous solutions



5) Thermistor at Positive Pole, no Pull-up

- A resistor is not needed at negative pole (but in harness !)
- cost compared to symmetrical solution (same parts) ?
- reliability same for disconnect sensing only, worse for temperature measurement
- without temperature sensor leave pin 3 open or away; better reliability than with a resistor at positive pole
- measure battery voltage between sense pins (with temperature sensor)



Failure Rates per Million Units

	GM	*GB*
	10^6 miles	*10^6 hours*
Resistor, Fixed	0.0015	0.0068
Resistor, Thermistor	0.0060	0.0065
Diode, Zener	0.0033	0.0204
Diode, Zener, Voltage Regulator		0.1648
IC Plastic Voltage Regulator		0.1721

Failure rate of additional contact ?

GM - Ground Mobile Equipment

GB/GBC - Ground non-Mobile Equipment

Conclusions

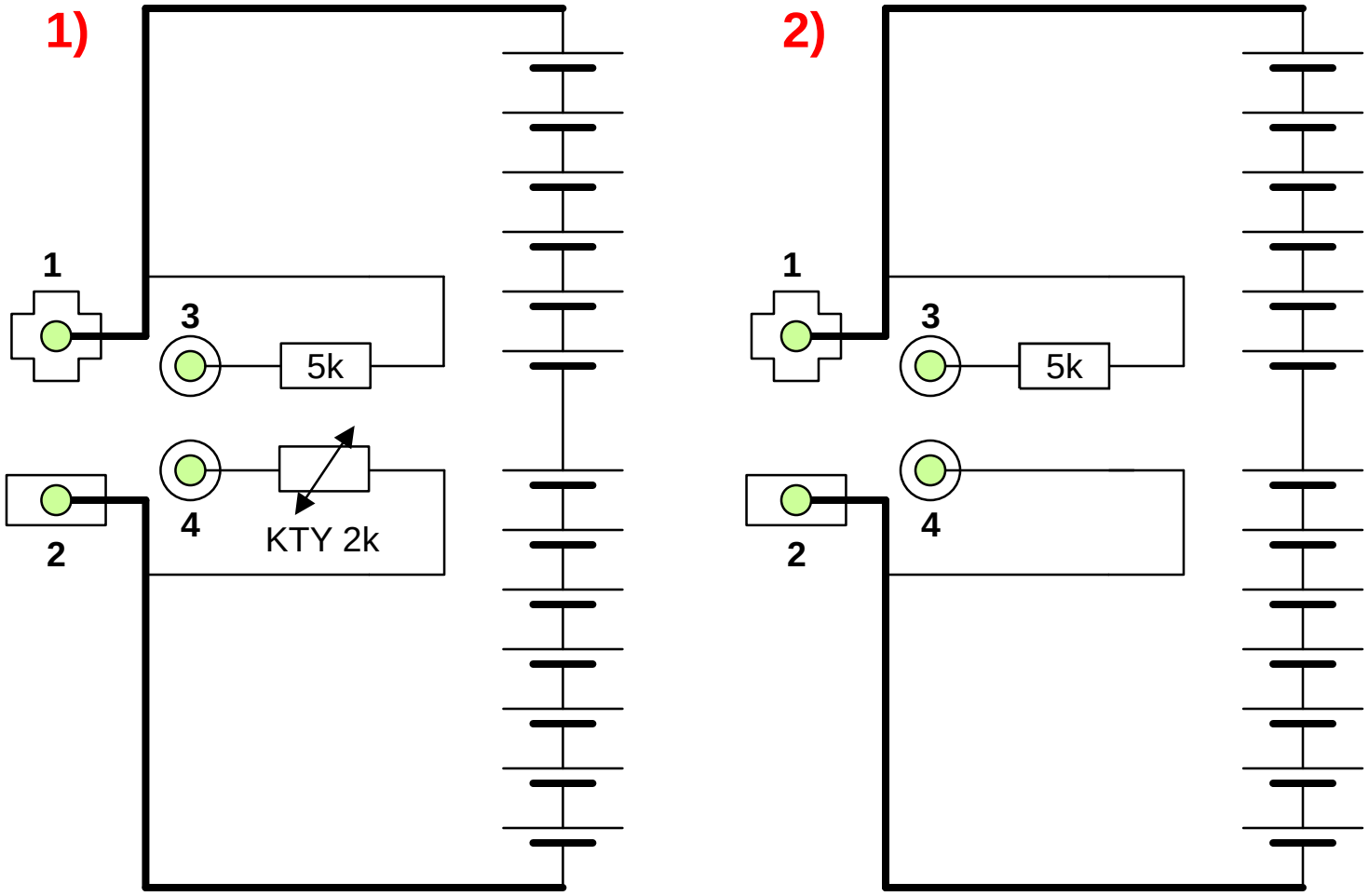
- Thermistor is cheaper and more reliable than current source
- Sensitivity of thermistor is good enough (+/-1.2K)
- Current source sensor not available (?) for 60V
- Voltage drop of main contacts can be compensated (even with measurement on only one sense pin)

➔ Thus use a thermistor as temperature sensor !

- 2k thermistor needs a series resistor (5k), if on positive pole
- Disconnect sensing and temperature sensing can be measured at one single sense contact, but reliability is reduced
- Using third and forth contact for redundant disconnect sensing, reliability can be improved
- With solution #3 and #5, the main contact resistances can be checked

➔ The symmetrical solution (#3) shows the best overall performance

Battery with and without Temperature Sensing



Potential Extension with IC

- For future extensions an IC might be designed, which starts to operate when the voltage across the KTY sensor exceeds a certain limit (>5V)

- This IC could provide data on battery parameters and save data on battery cycle data or on battery condition or age