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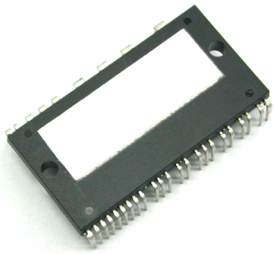
May, 2003

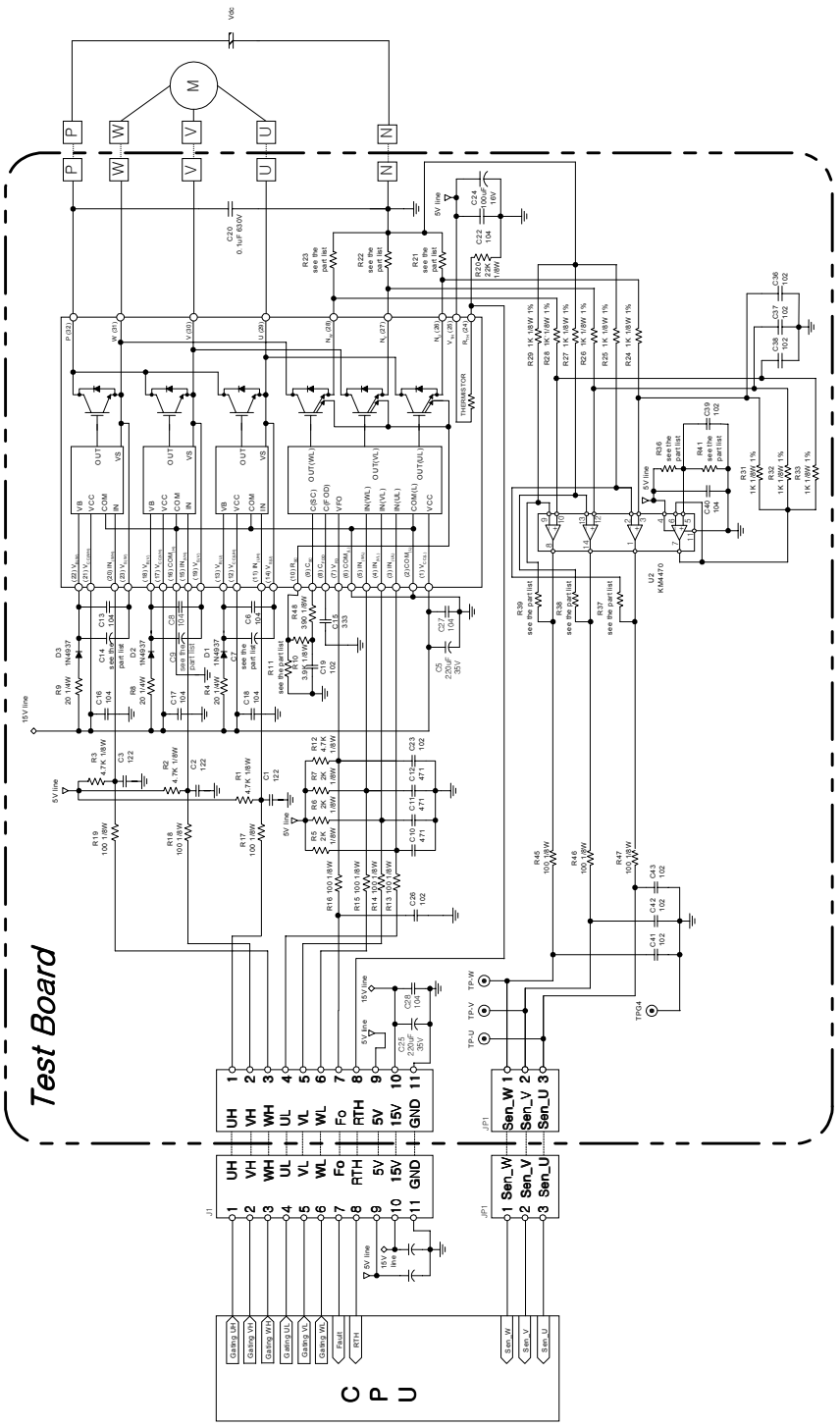
Application Note 9029

DIP-Smart Power Module Test Board I

SPM™ TEST BOARD for use in Direct Interface with CPU (using 3-Shunt Resistor)



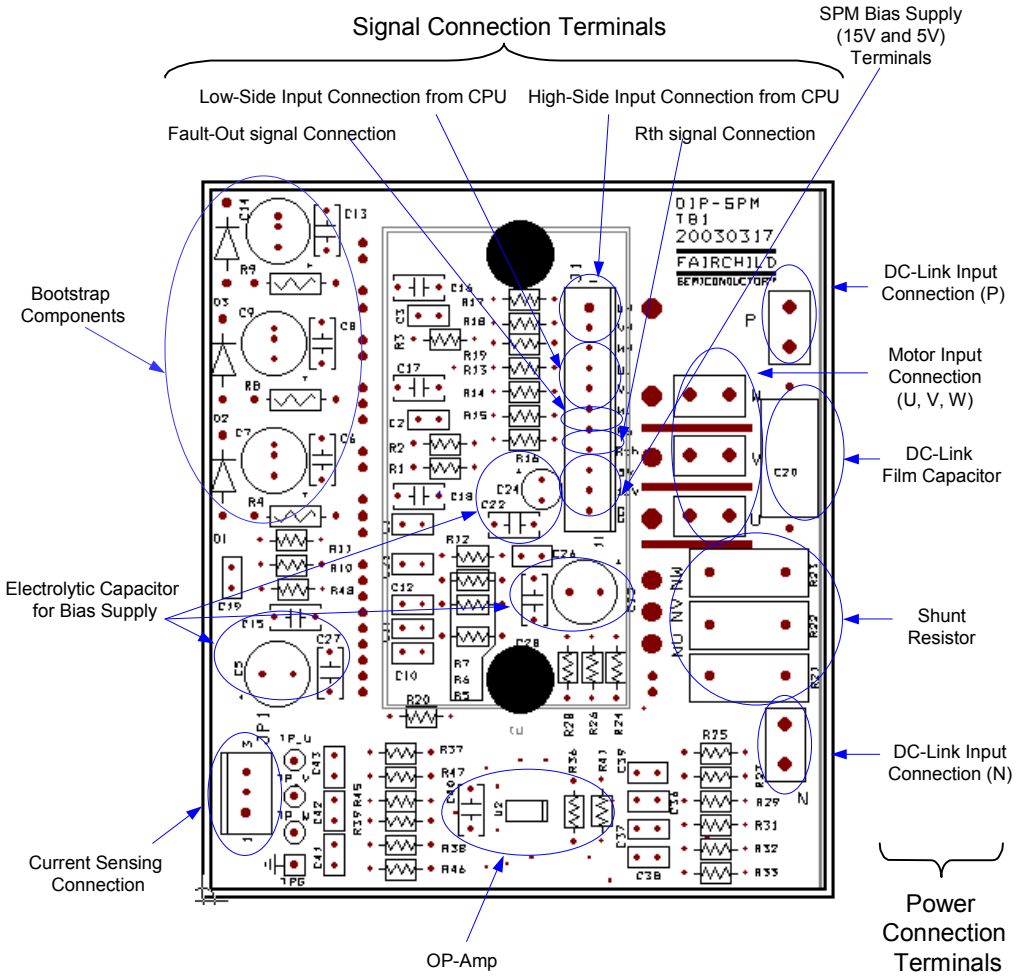
Schematics and External Interface Diagram



Note)

1. Common-grounded power supplies of +5V and +15V are used for CPU and DIP-SPM operation.
2. For further details, see the datasheet and application note.

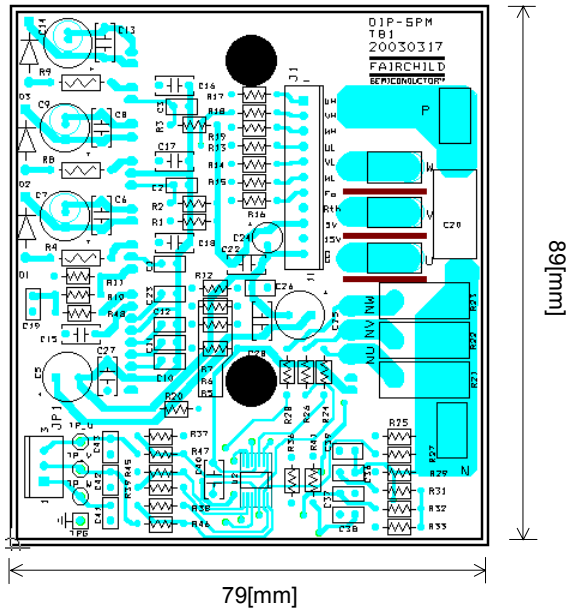
PCB Layout


Signal Connection Terminals
SPM Bias Supply (15V and 5V) Terminals
Low-Side Input Connection from CPU
High-Side Input Connection from CPU
Fault-Out signal Connection
Rth signal Connection
Bootstrap Components
DC-Link Input Connection (P)
Motor Input Connection (U, V, W)
DC-Link Film Capacitor
Electrolytic Capacitor for Bias Supply
Shunt Resistor
DC-Link Input Connection (N)
Current Sensing Connection
OP-Amp
Power Connection Terminals
DIP-SPM
TB1
20030317
FAIRCHILD
P
N
U
V
W

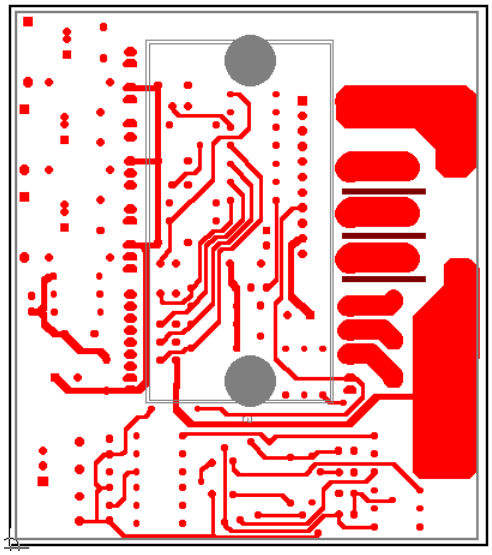
External Connection

Signal	1	High-Side Input Signal from CPU (Phase U)
	2	High-Side Input Signal from CPU (Phase V)
	3	High-Side Input Signal from CPU (Phase W)
	4	Low-Side Input Signal from CPU (Phase U)
	5	Low-Side Input Signal from CPU (Phase V)
	6	Low-Side Input Signal from CPU (Phase W)
	7	Fault-Out Signal CPU
	8	Thermistor Out Signal to CPU
	9	SPM Bias Supply +5V Terminal
	10	SPM Bias Supply +15V Terminal
	11	SPM Bias Supply Ground Terminal
Signal Interface (JP1)	1	Current Sensing (Phase W)
	2	Current Sensing (Phase V)
	3	Current Sensing (Phase U)
Power Connection	P	Positive DC Link Input Connection
	N	Negative DC Link Input Connection
	U	Motor Input Connection (Phase U)
	V	Motor Input Connection (Phase V)
	W	Motor Input Connection (Phase W)

Photograph of Assembled PCB



(a) Top Side View



(b) Bottom Side View

Part List 1

Part No.	Rating	Characteristics	Definition
R1	4.7kΩ, 1/8W	Carbon Film Resistor (5%)	Pull-Up Resistor (UH)
R2	4.7kΩ, 1/8W	Carbon Film Resistor (5%)	Pull-Up Resistor (VH)
R3	4.7kΩ, 1/8W	Carbon Film Resistor (5%)	Pull-Up Resistor (WH)
R4	20Ω, 1/4W	Carbon Film Resistor (5%)	Bootstrap Resistor (Phase U)
R5	2kΩ, 1/8W	Carbon Film Resistor (5%)	Pull-Up Resistor (UL)
R6	2kΩ, 1/8W	Carbon Film Resistor (5%)	Pull-Up Resistor (VL)
R7	2kΩ, 1/8W	Carbon Film Resistor (5%)	Pull-Up Resistor (WL)
R8	20Ω, 1/4W	Carbon Film Resistor (5%)	Bootstrap Resistor (Phase V)
R9	20Ω, 1/4W	Carbon Film Resistor (5%)	Bootstrap Resistor (Phase W)
R10	3.9kΩ, 1/8W	Carbon Film Resistor (5%)	Low-Pass-Filter for Current Sensing
R11	1/8W	Carbon Film Resistor (5%)	Current Sensing Resistor - **refer to the datasheet or Note2**
R12	4.7kΩ, 1/8W	Carbon Film Resistor (5%)	Pull-Up Resistor (Fault-Out)
R13	100Ω, 1/8W	Carbon Film Resistor (5%)	Series Resistor for Signal Interface (UL)
R14	100Ω, 1/8W	Carbon Film Resistor (5%)	Series Resistor for Signal Interface (VL)
R15	100Ω, 1/8W	Carbon Film Resistor (5%)	Series Resistor for Signal Interface (WL)
R16	100Ω, 1/8W	Carbon Film Resistor (5%)	Series Resistor for Signal Interface (Fault-Out)
R17	100Ω, 1/8W	Carbon Film Resistor (5%)	Pull-Up Resistor (UH)
R18	100Ω, 1/8W	Carbon Film Resistor (5%)	Pull-Up Resistor (VH)
R19	100Ω, 1/8W	Carbon Film Resistor (5%)	Pull-Up Resistor (WH)
R20	22kΩ, 1/8W	Carbon Film Resistor (5%)	Voltage Divider Resistor for Thermistor
R21	5W	Non-inductive Resistor (5%)	Shunt Resistor for Current Sensing (Phase U) - **refer to Note1**
R22	5W	Non-inductive Resistor (5%)	Shunt Resistor for Current Sensing (Phase V) - **refer to Note1**
R23	5W	Non-inductive Resistor (5%)	Shunt Resistor for Current Sensing (Phase W) - **refer to Note1**
R24	1kΩ, 1/8W	Carbon Film Resistor (1%)	Op-amp's (+) Input Resistor (Phase U)
R25	1kΩ, 1/8W	Carbon Film Resistor (1%)	Op-amp's (-) Input Resistor (Phase U)
R26	1kΩ, 1/8W	Carbon Film Resistor (1%)	Op-amp's (+) Input Resistor (Phase V)
R27	1kΩ, 1/8W	Carbon Film Resistor (1%)	Op-amp's (-) Input Resistor (Phase V)
R28	1kΩ, 1/8W	Carbon Film Resistor (1%)	Op-amp's (+) Input Resistor (Phase W)
R29	1kΩ, 1/8W	Carbon Film Resistor (1%)	Op-amp's (-) Input Resistor (Phase W)
R31	1kΩ, 1/8W	Carbon Film Resistor (1%)	Op-amp's (+) Input Biase Resistor (Phase U)
R32	1kΩ, 1/8W	Carbon Film Resistor (1%)	Op-amp's (+) Input Biase Resistor (Phase V)
R33	1kΩ, 1/8W	Carbon Film Resistor (1%)	Op-amp's (+) Input Biase Resistor (Phase W)
R36	1/8W	Carbon Film Resistor (1%)	Voltage Divider Resistor for Oo-amp's Input - **refer to Note1**
R37	1/8W	Carbon Film Resistor (1%)	Op-amp's Feedback Resistor (Phase U) - **refer to Note1**
R38	1/8W	Carbon Film Resistor (1%)	Op-amp's Feedback Resistor (Phase V) - **refer to Note1**
R39	1/8W	Carbon Film Resistor (1%)	Op-amp's Feedback Resistor (Phase W) - **refer to Note1**
R41	1/8W	Carbon Film Resistor (1%)	Voltage Divider Resistor for Oo-amp's Input - **refer to Note1**
R45	100Ω, 1/8W	Carbon Film Resistor (5%)	Op-amp's Output Series Resistor (Phase W)
R46	100Ω, 1/8W	Carbon Film Resistor (5%)	Op-amp's Output Series Resistor (Phase V)
R47	100Ω, 1/8W	Carbon Film Resistor (5%)	Op-amp's Output Series Resistor (Phase U)
R48	390Ω, 1/8W	Carbon Film Resistor (5%)	Series Resistor for Csc

Part List 2

Part No.	Rating	Characteristics	Definition
C1	1.2nF	Ceramic Capacitor	High-Side Pull-Up Capacitor (Phase U)
C2	1.2nF	Ceramic Capacitor	High-Side Pull-Up Capacitor (Phase V)
C3	1.2nF	Ceramic Capacitor	High-Side Pull-Up Capacitor (Phase W)
C5	220μF, 35V	Electrolytic Capacitor	+15V Bias Voltage Source Capacitor
C6	100nF	Ceramic Capacitor	Bypass Capacitor for Bootstrap Supply (Phase U)
C7	220μF, 35V	Electrolytic Capacitor	Bootstrap Capacitor (Phase U) - for washing machines
	33μF, 35V		Bootstrap Capacitor (Phase U) - for air conditioners
C8	100nF	Ceramic Capacitor	Bypass Capacitor for Bootstrap Supply (Phase V)
C9	220μF, 35V	Electrolytic Capacitor	Bootstrap Capacitor (Phase V) - for washing machines
	33μF, 35V		Bootstrap Capacitor (Phase V) - for air conditioners
C10	470pF	Ceramic Capacitor	Low-Side Pull-Up Capacitor (Phase U)
C11	470pF	Ceramic Capacitor	Low-Side Pull-Up Capacitor (Phase V)
C12	470pF	Ceramic Capacitor	Low-Side Pull-Up Capacitor (Phase W)
C13	100nF	Ceramic Capacitor	Bypass Capacitor for Bootstrap Supply (Phase W)
C14	220μF, 35V	Electrolytic Capacitor	Bootstrap Capacitor (Phase W) - for washing machines
	33μF, 35V		Bootstrap Capacitor (Phase W) - for air conditioners
C15	33nF	Ceramic Capacitor	Capacitor for Selection for Fault Out Duration
C16	100nF	Ceramic Capacitor	+15V Bias Voltage Bypass Capacitor (WH)
C17	100nF	Ceramic Capacitor	+15V Bias Voltage Bypass Capacitor (VH)
C18	100nF	Ceramic Capacitor	+15V Bias Voltage Bypass Capacitor (UH)
C19	1nF, 25V	Ceramic Capacitor	Low-Pass Fault for Current Sensing
C20	0.1μF, 630V	Film Capacitor	Snubber Capacitor to Suppress the Spike-Voltage
C22	100nF	Ceramic Capacitor	+5V Bias Voltage Bypass Capacitor
C23	1nF	Ceramic Capacitor	Pull-Up Capacitor of Fault-Out Signal
C24	100μF, 16v	Electrolytic Capacitor	+5V Bias Voltage Source Capacitor
C25	220μF, 35V	Electrolytic Capacitor	+15V Bias Voltage Source Capacitor
C26	1nF	Ceramic Capacitor	Bypass Capacitor for Fault-Out Signal
C27	100nF	Ceramic Capacitor	+15V Bias Voltage Bypass Capacitor
C28	100nF	Ceramic Capacitor	+15V Bias Voltage Bypass Capacitor
C36	1nF	Ceramic Capacitor	Bypass Capacitor for Op-amp's (+) Input (Phase U)
C37	1nF	Ceramic Capacitor	Bypass Capacitor for Op-amp's (+) Input (Phase V)
C38	1nF	Ceramic Capacitor	Bypass Capacitor for Op-amp's (+) Input (Phase W)
C39	1nF	Ceramic Capacitor	Bypass Capacitor for Op-amp's (-) Input (Phase W)
C40	100nF	Ceramic Capacitor	+5V Bias Voltage Bypass Capacitor
C41	1nF	Ceramic Capacitor	Bypass Capacitor for Op-amp's (+) Input (Phase W)
C42	1nF	Ceramic Capacitor	Bypass Capacitor for Op-amp's (+) Input (Phase V)
C43	1nF	Ceramic Capacitor	Bypass Capacitor for Op-amp's (+) Input (Phase U)
D1	1A, 600V	Fast Recovery Diode, (1N4937)	Bootstrap Diode (Phase U)
D2	1A, 600V	Fast Recovery Diode, (1N4937)	Bootstrap Diode (Phase V)
D3	1A, 600V	Fast Recovery Diode, (1N4937)	Bootstrap Diode (Phase W)
TP_U	-	Test Pin	Test Point for Op-amp's Output Signal (Phase U)
TP_V	-	Test Pin	Test Point for Op-amp's Output Signal (Phase V)
TP_W	-	Test Pin	Test Point for Op-amp's Output Signal (Phase W)
TPG4	-	Test Pin	Test Point for GND
U2	TLC2274AIN	4-Channel Op-amp	Op-amp for Phase Current Sensing
U1	-	DIP-SPM	See the datasheet.

Note 1. Circuit of Differential Aplifer

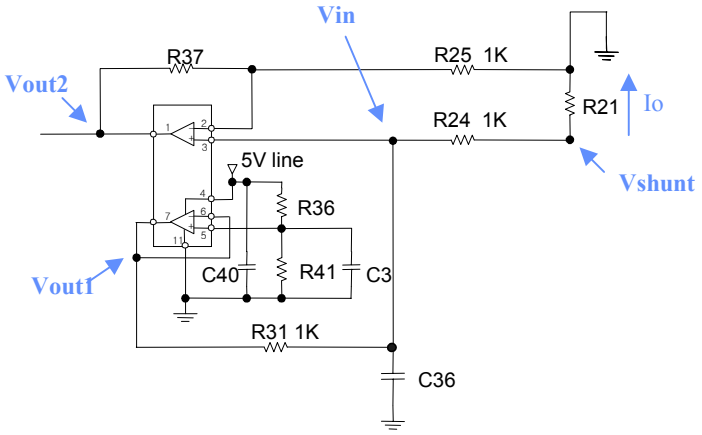


Figure 1. Circuit of Current Sensing Part (Phase U)

1. How to select component values.

   1) Choose shunt resistor (R21) value.
   2) Set the short-circuit current level.
      => It make R11 value.
         (Refer to the Fig of Rsc variation by chang of shunt resistors for
          short-circuit protection).
   3) Set the Vout2 value when Io=0.
      => typ. Vout2=2.5V when Op-amp's Vcc=5V and CPU's Vcc=5V.
   4) Set maximum Vout2 when short-circuit is happened.
      => typ. Vout2=4.5V(@ Io=150%Ic)

2. How to calculate component values.

   Where, SPM=FSAM10SH60A, R21=50mohm, short-circuit current level=15A (150%Ic),
   Vout2=2.5V (@ Io=0A), Vout2=4.4V (Io=15A),
   op-amp's offset voltage=0V

   1) $Vout1 = (R41 \times 5V) / (R41 + R36)$ --- (1-1)
   2) $Vin = (Vshunt + Vout1) / 2$ --- (2-1)
   3) $Vout2 = (1 + R37 / R25) \times Vin$ --- (3-1)
      So, $Vout2 = (1+ R37 / R25) \times ((Vshunt + Vout1) / 2)$ --- (3-2)
   4) We can get two equations from (3-2).
      First, when Io=0A & Vshunt=0V
         $2.5V = (1 + R37 / 1k\Omega) \times (Vout1 / 2)$ --- (4-1)
      Second, when Io=15A & Vshunt=0.75V
         $4.4V = (1 + R37 / 1k\Omega) \times ((0.75V + Vout1) / 2)$ --- (4-2)
      So, from equation (4-1) & (4-2)
         $R37 = 4k\Omega$, $Vout1=0.98V$
   5) If $R41=10k\Omega$, then $R36=40k\Omega$

3. Recommended values (unit : Ω)

SPM Current Rating	R21, 22, 23	R37, 38, 39	R41	R36
10A	50m	3.9k	10k	39k
15A	40m	3.3k	10k	33k
20A	30m	3.3k	10k	33k
30A	20m	3.3k	10k	33k

Note 2. Fig of Rsc Variation of Shunt Resistor for Short-circuit Protection

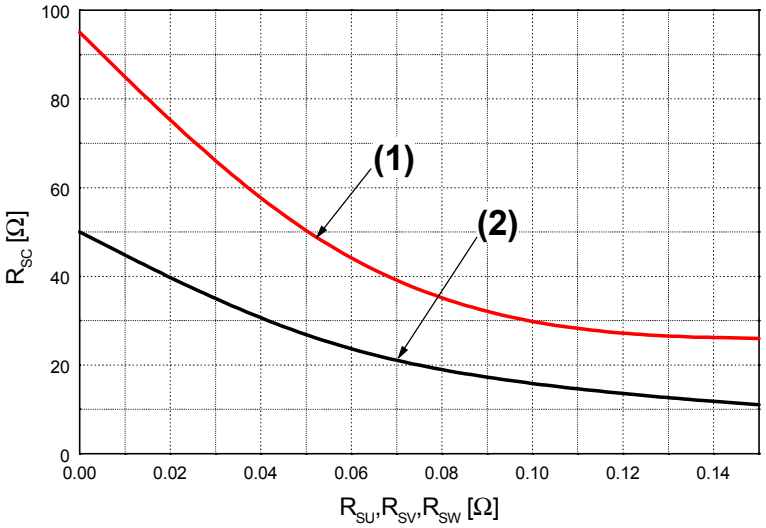


Fig. 2. 10A rated SPM
(1) @ around 100% Rated Current Trip (Ic ¨=. 10A),
(2) @ around 150% Rated Current Trip (Ic ¨=. 15A)

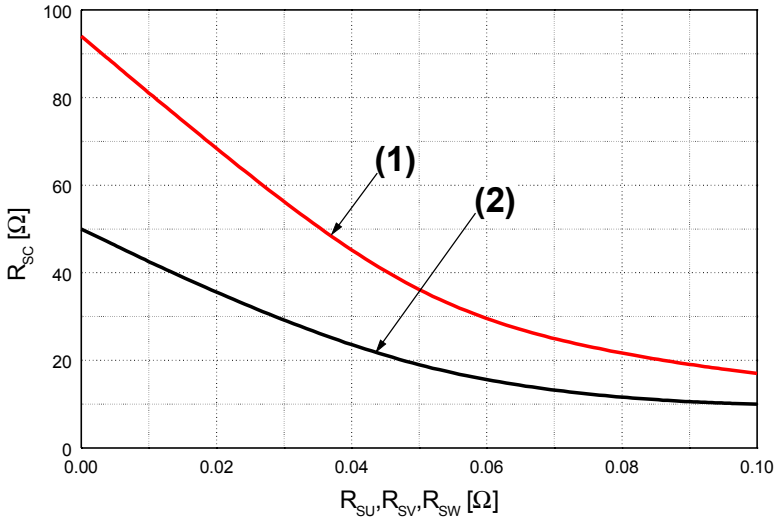


Fig. 3. 15A rated SPM
(1) @ around 100% Rated Current Trip (Ic ¨=. 15A),
(2) @ around 150% Rated Current Trip (Ic ¨=. 22.5A)

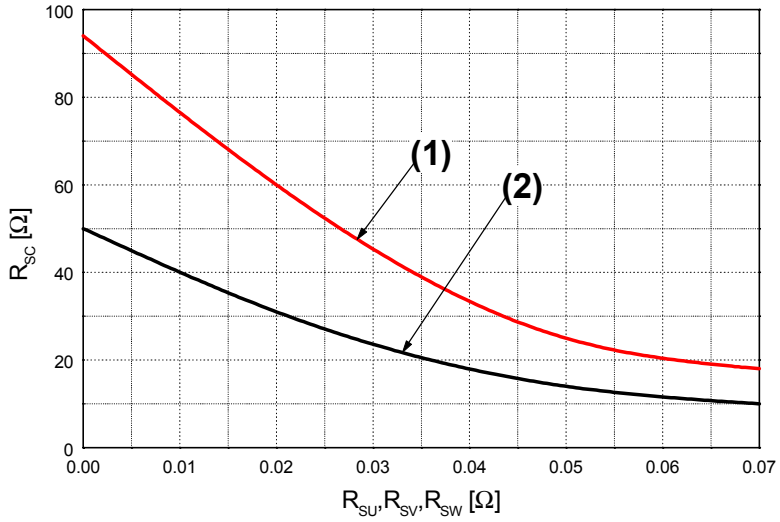


Fig. 4. 20A rated SPM
(1) @ around 100% Rated Current Trip (Ic ¨=. 25A),
(2) @ around 150% Rated Current Trip (Ic ¨=. 30A)

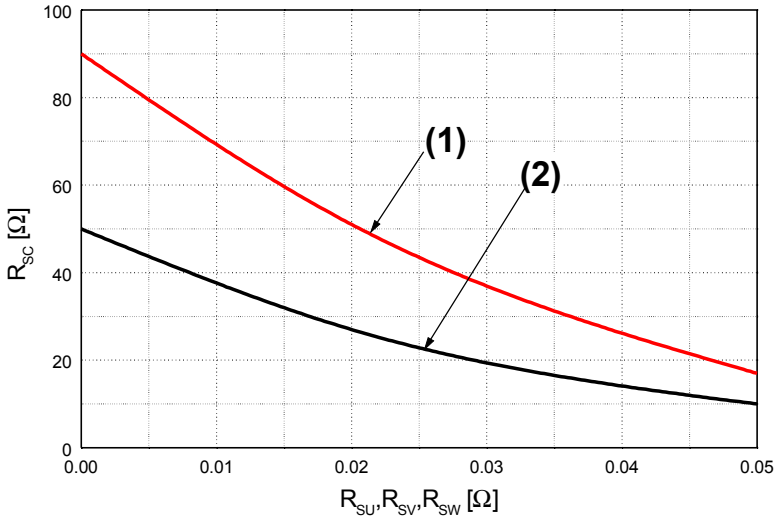


Fig. 5. 30A rated SPM
(1) @ around 100% Rated Current Trip (Ic ¨=. 30A),
(2) @ around 150% Rated Current Trip (Ic ¨=. 45A)

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