

MOS FET Relay Module

T-module

G3VM-21MT/-61MT/-101MT

Reference design report

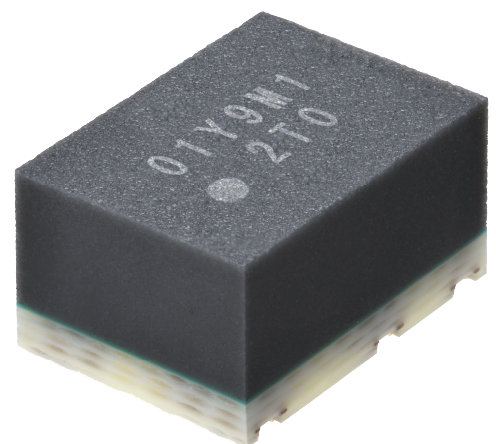


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1 Summary

In the test and measurement industry, the measurement accuracy and reliability are important and they are also required of relays which are often used to switch various measurement circuits.

For example, in the DC parametric test of automatic test equipment, minimizing leakage current at the test line is one of keys for accurate measurement result. There are multiple switching circuits to switch various DUTs and measurement pins, and mechanical relays, such as reed relays, which have physical contacts are often used. However, the contact resistance of reed relays may become unstable and regular maintenance replacements are required after exceeding their maximum cycle count. In addition, reed relay package size is not small enough to fit into advancing test and measurement equipment where higher and higher integration is being required based on increasing the number of inspection channels to meet the evolution of semiconductors.

OMRON T Module (G3VM-21MT / -61MT / -101MT) is a small semiconductor relay module with a T-switch function. It has a long life and stable ON resistance characteristics because of the semiconductor, and also minimal leakage current ($I_{LEAK} \leq 1\text{pA}$) as same level as mechanical relays. So, this product can be used in places where it was thought difficult to replace mechanical relays to semiconductor relays.

This reference design shows a result of accuracy comparison among T-module, reed relay and MOSFET relay, using an example circuit design for DC parametric test.

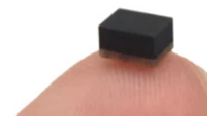
*Please contact OMRON sales for more detailed measurement methods and results.
(Prepared April 2021.)

2 Features and Benefits of the T-Module (G3VM-21MT/-61MT/-101MT)

- Very small leakage current ($I_{LEAK} \leq 1\text{pA}$) for high accurate measurement by T-switch function with 3 MOSFET relays in a single package
- Very small package for space-saving and high density integration despite complex inside circuit. (5mm x 3.75mm x 2.7mm)
- Long life due to no physical contacts
- Good linearity for low signal distortion

<Application examples>

- ATE interface board
- DC parametric measurement unit
- Switching matrix unit



2.1 Outline & Terminal Arrangement

Weight: 0.11 g

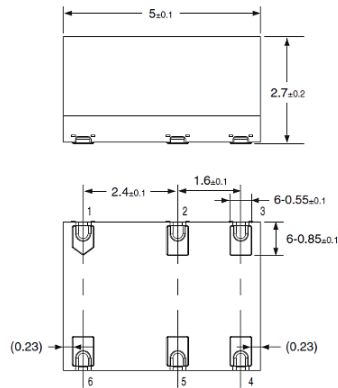


Fig.1 Outline Dimensions

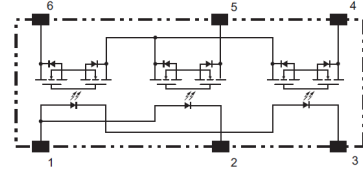


Fig.2 Terminal Arrangement (TOP VIEW)

2.2 T Switch Function of T-module

As shown in fig.3, T-module has T switch function which consists of 3 MOSFET relays and T formation circuit to minimize leakage current between output main line (between pin 4-6) by avoiding peculiar leakage current of semiconductor to pin5.

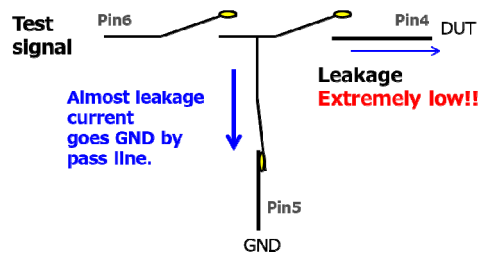


Fig.3 T switch function

2.3 T-Module Control and Operation

Pin1 is a common input LED anode terminal of 3 internal MOSFET relays. Pin 3 is LED cathode to control main line. Pin 2 is another LED cathode to control sub line. Internal MOSFET relays' operating status is controlled by LED forward current ($I_{F\text{ Main}}$, $I_{F\text{ sub}}$) control.

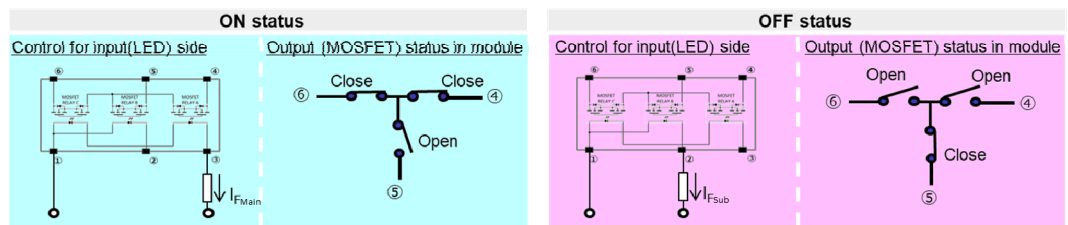


Fig.4 Operating status controlled by LED forward current control

2.4 Actual Leakage Current Performance of T-module

By T-switch function, occurred leakage current at internal MOSFET relay flows to lower impedance circuit connected to pin 5 mostly, and hardly to other pin of main line.

Fig.5 shows an example of an actual leakage current performance test when G3VM-21MT is off (Mainline: Open, Sub line: Closed.) With using 2 units of SMU, SMU1 Force inputs 0V holding to pin 4, SMU1 Guard is connected to pin 5 as alternative of GND, SMU2 Force inputs 0 – 20V sweeping voltage to pin 6. The test result shows some leakage current at SMU2 (I2), and almost zero current at SMU1 (I1) because of T switch function.

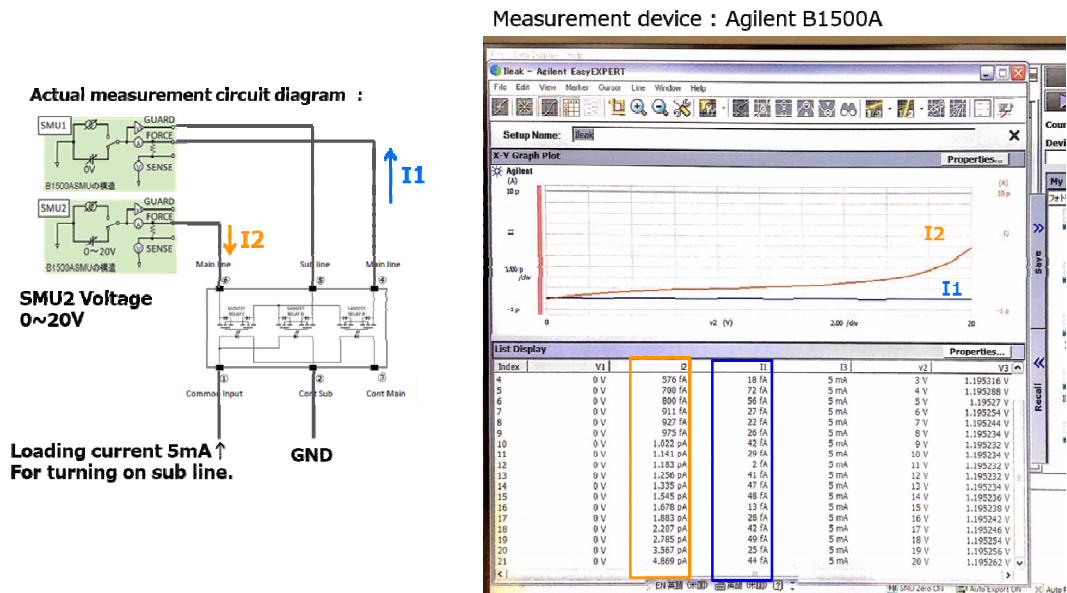


Fig.5 Actual leakage current performance example of T-module G3VM-21MT

3 Reference design board

In the DC parametric test of automatic test equipment, mechanical relays such as reed relays are often used for minimizing leakage current at the testing line. However, the contact resistance of mechanical relays may become unstable after exceeding their maximum cycle count.

OMRON T module achieves minimal leakage current ($I_{Leak} \leq 1\text{pA}$) comparable to mechanical relays, and can be used in places where it was thought difficult to replace to semiconductor relays.

This reference design, to show usefulness of T-module, evaluates and compares measurement accuracy with mechanical relays and MOSFET relays under same conditions, using DC parametric test as an example.

In addition, this reference design has input LED control circuit with inverters for controlling T-module by a single channel bit as one of the replacement cases from existing reed relays to T-modules.

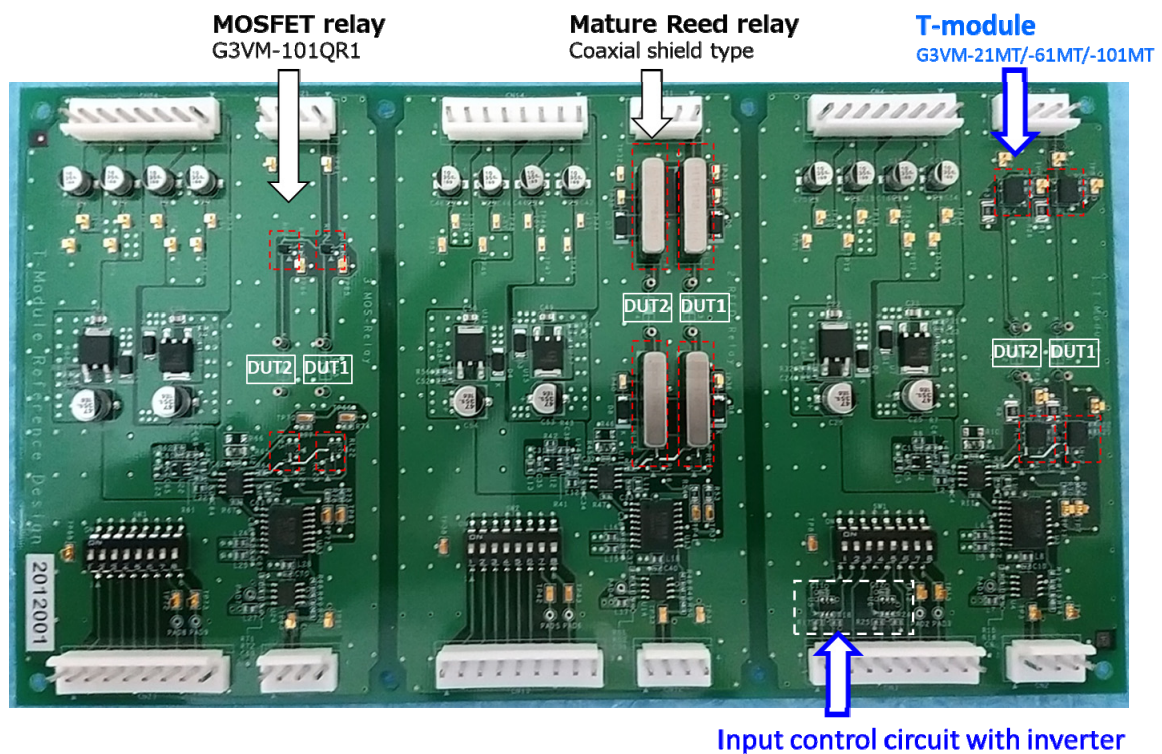


Fig.6 Reference design board

3.1 Circuit structure

1) Block diagram of measurement system

This reference design uses DC parametric test and leakage current measurement system as an example as shown in fig.7. There are 3 types of similar systems with different switching devices (T-module, Reed relay, MOSFET relay) for DUT selection switching which is indicated with blue squares in the figures.

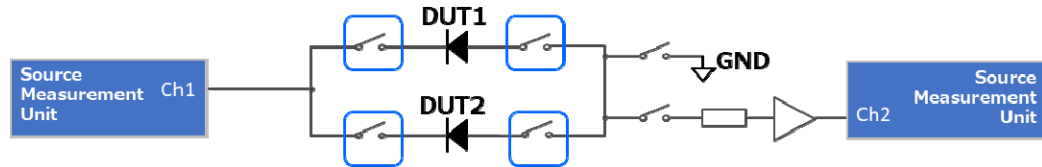


Fig.7-1 Block diagram for measurement system

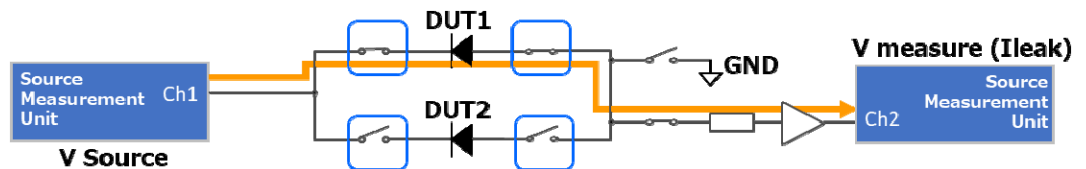


Fig.7-2 Example in case of leakage current measurement of DUT1

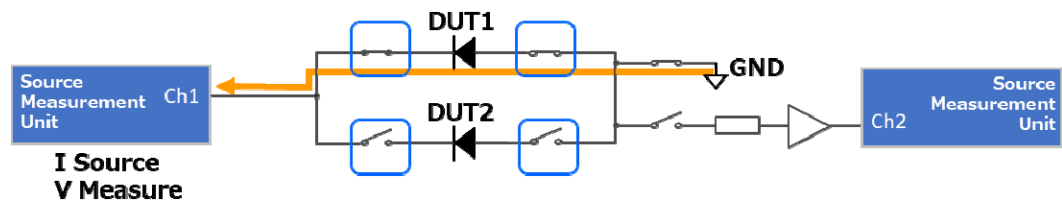


Fig.7-3 Example in case of VF characteristics measurement of DUT1

2) Circuit diagram detail

Refer to attached circuit diagram.

*There are 3 design files with each T-module model. (G3VM-21MT/-61MT/-101MT)

3) Control circuit for input (LED control) side

As explained in items 2-3, T-module output is controlled by 2 LED forward current ($I_{F \text{ Main}}$, $I_{F \text{ Sub}}$) control. These 2 LED forward currents ($I_{F \text{ Main}}$, $I_{F \text{ Sub}}$) can be controlled by a single channel bit control if using inverter on control circuit (Fig. 8) and it's adopted at this reference design.

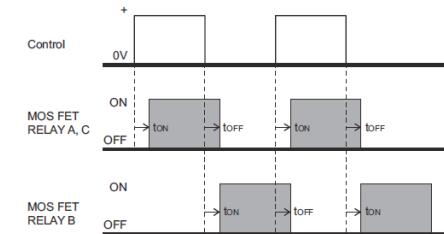
■Connection Example 1

●Device Functional Modes *

Circuit	Control	MOS FET RELAY A, C (Main line)	MOS FET RELAY B (Sub line)
ON	H	ON	OFF
OFF	L	OFF	ON
-	X	OFF	OFF

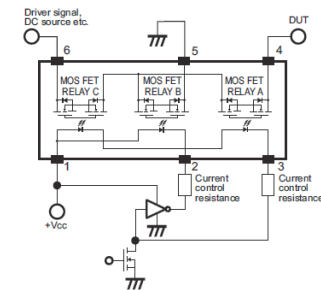
* H: Optional setting, L: 0 V, X: don't care

●Timing Diagram



* This products is recommended to use with dry switching (No Load & No Source when switching) for prevent short circuit happening.

●Measurement Circuit



Note: The number from 1 to 6 are the pin numbers in the image shown here.

Fig.8 Example of input control with an inverter

4) Short circuit prevention resistor for output side

As T-module can control mainline and sub line individually, there is a chance that both main and sub line is closed at the same time accidentally, even if utilizing a single channel bit control circuit because of its turn ON and OFF time difference between internal relays. In case of both the main and sub lines being closed at the same time, overcurrent may occur from pin 4 and 6 to GND which is connected via pin5, and it may be a cause of failure and damage to SMU, other connected equipment and T-module. To avoid this mode, a short circuit prevention resistor is recommended between GND and pin 5. This reference design uses a 68 Ohm resistor, to suppress momentary overcurrent within T-module specification.

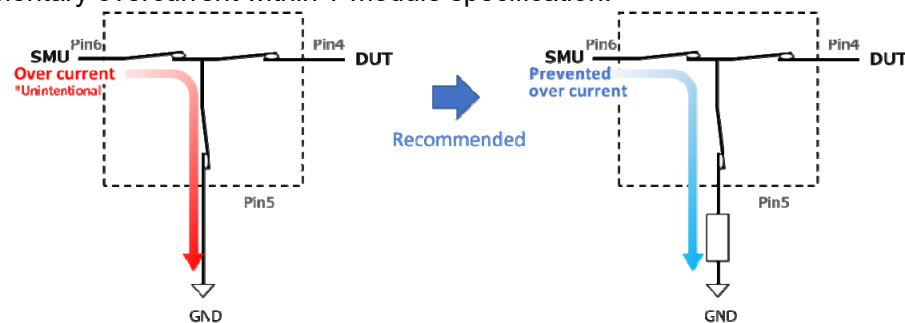


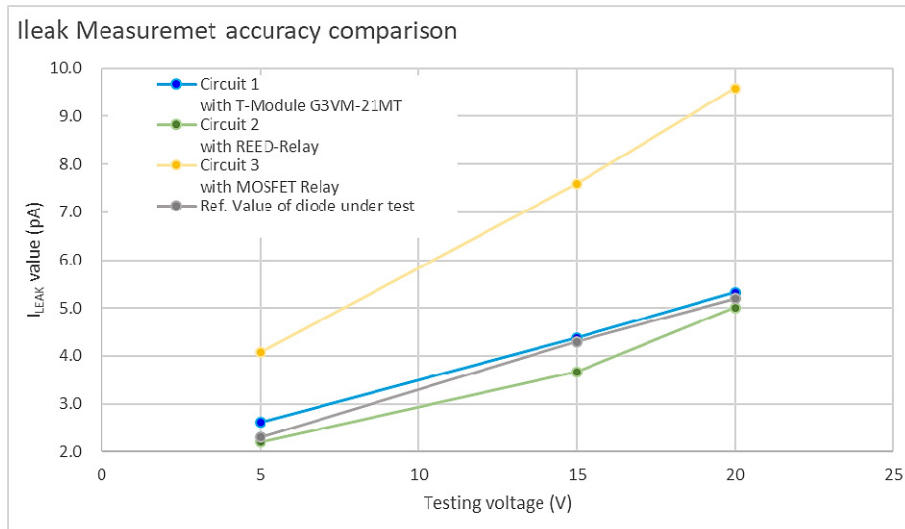
Fig.9 Recommended short circuit prevention resistor for output side

4 Test results

4.1 I_{LEAK} Test

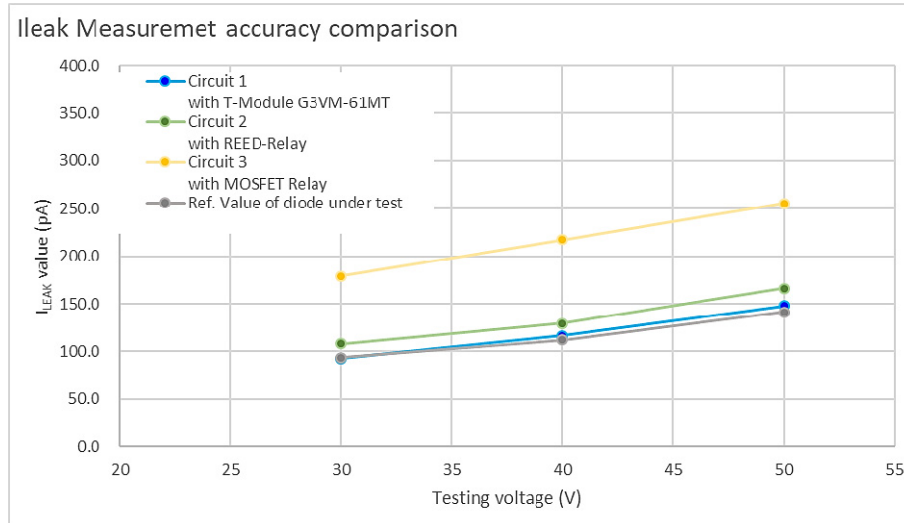
A leakage current test result with this reference design is shown below. The result shows the same level accuracy between circuits with T-module, Reed relay, and almost same value against reference value on DUT diode specification. Besides, these testing circuits with the MOSFET relays show higher leakage current than the reference value. It is caused by leakage current of the MOSFET relay itself.

1) G3VM-21MT reference design board testing result (DUT: FJH1100)



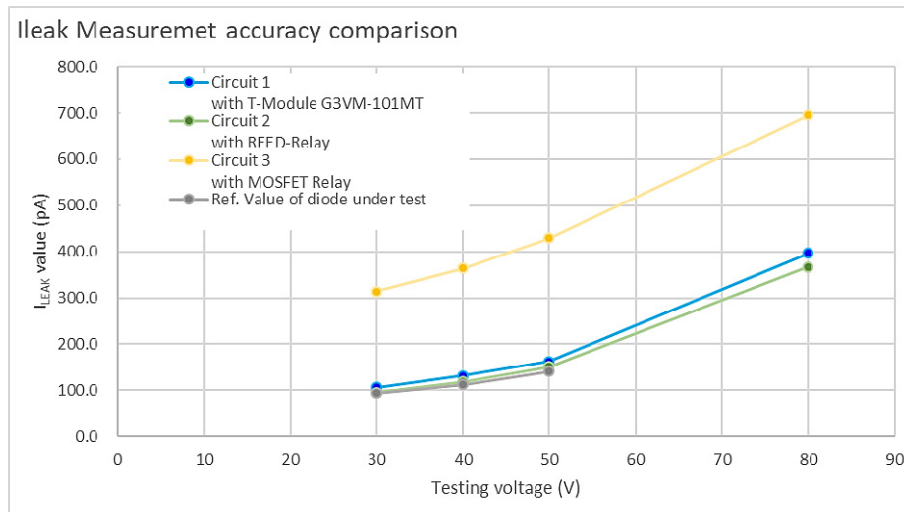
Test No	Item	Measurement line	Testing voltage	Ref. Value of diode under test	Circuit 1 with T-Module G3VM-21MT	Circuit 2 with REED-Relay	Circuit 3 with MOSFET Relay
			[V]	[pA]	[pA]	[pA]	[pA]
301	ILEAK1_1	DUT1	5	2	2.6	2.2	4.1
302	ILEAK2_1	DUT1	15	4	4.4	3.7	7.6
303	ILEAK3_1	DUT1	20	5	5.3	5.0	9.6
401	ILEAK1_2	DUT2	5	2	2.3	2.2	4.3
402	ILEAK2_2	DUT2	15	4	3.9	4.1	7.6
403	ILEAK3_2	DUT2	20	4	4.8	5.0	9.5

2) G3VM-61MT reference design board testing result (DUT: 1N3595)



Test No	Item	Measurement line	Testing voltage	Ref. Value of diode under test	Circuit 1 with T-Module G3VM-61MT	Circuit 2 with REED-Relay	Circuit 3 with MOSFET Relay
			[V]	[pA]	[pA]	[pA]	[pA]
301	ILEAK1_1	DUT1	30	94	92.6	108.2	178.9
302	ILEAK2_1	DUT1	40	112	116.4	129.3	217.0
303	ILEAK3_1	DUT1	50	141	148.0	166.3	255.4
401	ILEAK1_2	DUT2	30	90	89.5	106.2	169.6
402	ILEAK2_2	DUT2	40	111	109.8	129.8	208.1
403	ILEAK3_2	DUT2	50	141	140.1	164.3	246.7

3) G3VM-101MT reference design board testing result (DUT: 1N3595)

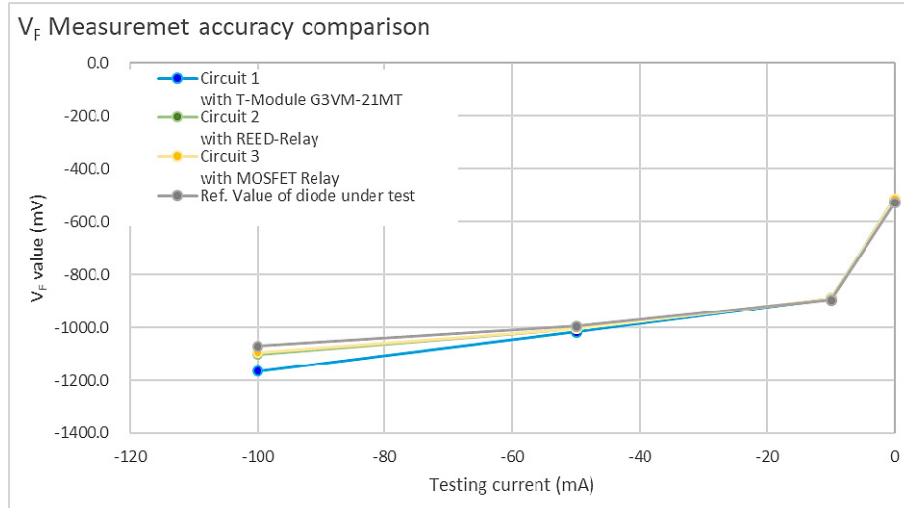


Test No	Item	Measurement line	Testing voltage	Ref. Value of diode under test	Circuit 1 with T-Module G3VM-101MT	Circuit 2 with REED-Relay	Circuit 3 with MOSFET Relay
			[V]	[pA]	[pA]	[pA]	[pA]
301	ILEAK1_1	DUT1	30	94	106.6	95.6	313.7
302	ILEAK2_1	DUT1	40	112	131.6	118.4	363.7
303	ILEAK3_1	DUT1	50	141	162.2	151.0	429.6
303	ILEAK3_1	DUT1	80	-	397.2	366.9	695.8
401	ILEAK1_2	DUT2	30	90	108.0	103.2	280.9
402	ILEAK2_2	DUT2	40	111	133.4	132.8	308.4
403	ILEAK3_2	DUT2	50	141	168.8	174.3	396.8
404	ILEAK3_3	DUT2	80	-	377.5	395.5	628.9

4.2 VF characteristics test

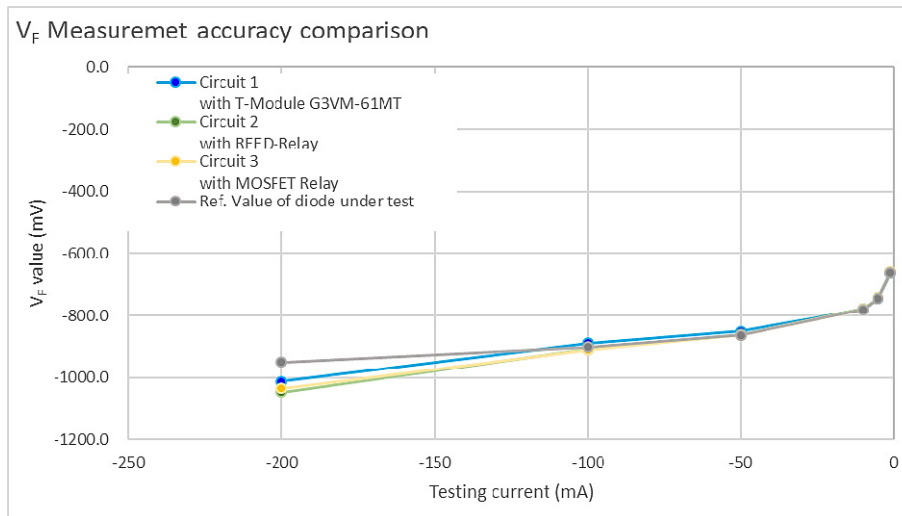
VF characteristics test result with this reference design is shown below. The result shows the same levels accuracy among circuits with T-module, Reed relay and MOSFET relay, and almost the same value against reference value on DUT diode specification.

1) G3VM-21MT reference design board testing result (DUT: FJH1100)



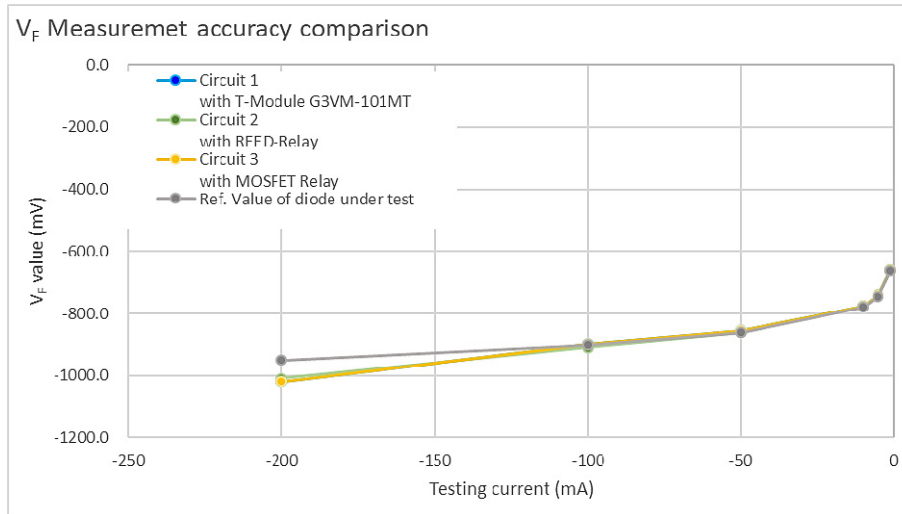
Test No	Item	Measurement line	Testing current	Ref. Value of diode under test	Circuit 1 with T-Module G3VM-21MT	Circuit 2 with REED-Relay	Circuit 3 with MOSFET Relay
			[mA]				
601	VF1_1	DUT1	-0.001	-530	-517.3	-520.9	-515.8
602	VF2_1	DUT1	-10	-895	-890.3	-892.7	-891.1
603	VF3_1	DUT1	-50	-995	-1017.1	-1004.4	-1004.2
604	VF4_1	DUT1	-100	-1070	-1164.7	-1101.6	-1093.9
701	VF1_2	DUT2	-0.001	-530	-518.3	-513.3	-514.4
702	VF2_2	DUT2	-10	-895	-888.1	-886.3	-887.4
703	VF3_2	DUT2	-50	-995	-998.2	-998.5	-994.9
704	VF4_2	DUT2	-100	-1070	-1116.5	-1089.0	-1078.0

2) G3VM-61MT reference design board testing result (DUT: 1N3595)



Test No	Item	Measurement line	Testing current	Ref. Value of diode under test	Circuit 1 with T-Module G3VM-61MT	Circuit 2 with REED-Relay	Circuit 3 with MOSFET Relay
			[mA]	[mV]	[mV]	[mV]	[mV]
601	VF1_1	DUT1	-1	-663	-663.1	-660.4	-661.1
602	VF2_1	DUT1	-5	-745	-744.1	-742.3	-743.3
603	VF3_1	DUT1	-10	-780	-779.5	-778.3	-779.1
604	VF4_1	DUT1	-50	-862	-850.7	-861.1	-862.4
605	VF4_1	DUT1	-100	-901	-889.3	-908.3	-909.4
606	VF4_1	DUT1	-200	-950	-1011.5	-1046.9	-1034.9
701	VF1_2	DUT2	-1	-664	-662.9	-662.3	-662.6
702	VF2_2	DUT2	-5	-745	-743.8	-744.8	-744.6
703	VF3_2	DUT2	-10	-781	-778.6	-780.3	-779.9
704	VF4_2	DUT2	-50	-866	-857.9	-862.4	-863.0
705	VF4_2	DUT2	-100	-909	-901.1	-907.7	-909.2
706	VF4_2	DUT2	-200	-965	-1028.9	-1012.0	-1015.6

3) G3VM-101MT reference design board testing result (DUT: 1N3595)



Test No	Item	Measurement line	Testing current	Ref. Value of diode under test	Circuit 1 with T-Module G3VM-101MT	Circuit 2 with REED-Relay	Circuit 3 with MOSFET Relay
			[mA]	[mV]	[mV]	[mV]	[mV]
601	VF1_1	DUT1	-1	-663	-660.3	-658.6	-660.4
602	VF2_1	DUT1	-5	-745	-741.3	-740.7	-742.5
603	VF3_1	DUT1	-10	-780	-776.3	-777.0	-778.1
604	VF4_1	DUT1	-50	-862	-855.3	-862.1	-861.8
605	VF4_1	DUT1	-100	-901	-898.1	-908.6	-907.9
606	VF4_1	DUT1	-200	-950	-1020.7	-1009.6	-1007.2
701	VF1_2	DUT2	-1	-664	-659.6	-660.1	-662.0
702	VF2_2	DUT2	-5	-745	-740.8	-742.5	-743.7
703	VF3_2	DUT2	-10	-781	-776.6	-780.6	-779.7
704	VF4_2	DUT2	-50	-866	-855.2	-873.6	-864.2
705	VF4_2	DUT2	-100	-909	-894.0	-929.8	-910.0
706	VF4_2	DUT2	-200	-965	-996.6	-1053.0	-1002.5

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