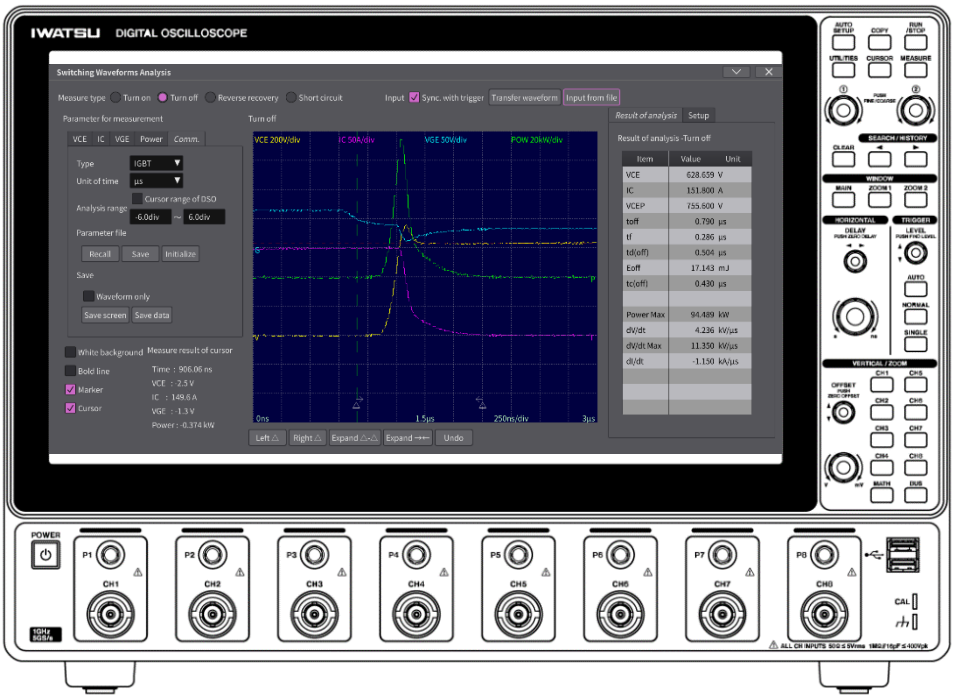
IWATSU ELECTRIC

DS-8000 Switching Waveforms Analysis Software

Instruction Manual



IWATSU

Introduction

◇ Thank you for purchasing our DS-8000 Switching Waveforms Analysis Software We hope you will continue to use our measurement instruments for many years to come.

◇ This instruction manual describes the basic operation of the DS-8000 Switching Waveforms Analysis Software, a plug-in software for the DS-8000 series Digital Oscilloscope. Please read the instruction manual carefully and understand the contents before use.

General Safety Summary

This section describes the items that you should follow in order to use this product safely and prevent injury to the human body and damage to property. Please be sure to read this section for safe use.

The Symbol and Term on this manual

⚠ **CAUTION**	Caution statement identifies the conditions or practices, or if the items described herein are ignored that could result in injury or damage to this product.

Note:

◇ Part of the contents of this manual may be changed without notice due to improvements in performance and functions.

◇ It is prohibited to reprint or copy the contents of this manual without permission.

◇ The contents of this manual correspond to DS-8000 instrument firmware Ver 4.05, and DS-8000 Switching Waveform Analysis Software Ver 1.06.

◇ When disposing of this product, follow the regulations of the local government.

◇ All product names and brand names included in this manual are listed for identification purposes. Each is a registered trademark held by the relevant individual or corporate body. The TM and ® marks are not displayed on the trademarks or registered trademarks of each company in this manual.

◇ If you have any questions regarding this product, please contact our sales department or sales office (see the attached "Sales Network and Inquiries").

Revision history

◇May 2022, 1st edition issued.

Please be sure to read for your safety.

⚠ CAUTION

●Cautions for USB memory stick use

- To remove the USB memory from the DS-8000 main unit, execute Menu>Remove USB Memory.
- Do not remove the USB memory stick from the DS-8000 main unit while the plug-in software is being installed.
- Handle the USB memory stick and the USB terminal of the DS-8000 main unit so as not to get scratches, dust, dirt, oil, etc. on them.
- Do not place the USB memory in direct sunlight, high temperature, or high humidity.

Check the contents of the package

When you receive this instrument, please check the contents. In the unlikely event that the product is out of stock or damaged during transportation, please contact the store where you purchased the product or our contact point (service center) immediately (see the attached "Sales Network and Contact Point").

Contents

- USB Memory Stick 1
- Instruction Manual..... 1
- Software License Agreement..... 1

Note: You should back up the data in USB memory just in case.

Software Version Upgrade

Please check with our sales staff or our website as the software version upgrade is applicable to each instrument.
URL: https://www.iti.iwatsu.co.jp/index_e.html.

Memo

Chapter 1 Table of Contents

Chapter 2 DS-8000 Switching Waveforms Analysis Software Overview

This chapter provides an overview of the switching analysis software for the DS-8000, how to install this plug-in software on the DS-8000 series, and how to update this plug-in software.

2.1 Key Features

Switching Analysis Software for DS-8000 is a plug-in software to be installed in DS-8000 series digital oscilloscopes. It analyzes the dynamic characteristics of power devices and displays the analysis results and waveforms on the screen.

- Target devices to be analyzed are IGBTs, IPMs, and MOSFETs.
- Analyzes turn-on, turn-off, reverse recovery, and short circuit, and displays analysis results based on measurement parameters.
- Waveforms during analysis can be displayed.
- Measurement parameter files can be saved and loaded.
- Waveform data can be saved and loaded.
- Waveform data specified by the cursors can be analyzed.

2.2 Obtaining a License Key

A license key is required to install this plug-in software. License keys consist of 12-digit alphanumeric characters and must be purchased. To purchase a license key, you will need the Product ID of the DS-8000 series main unit, so please contact the sales representative. The following shows how to check the product ID on the DS-8000 series main unit.

Select Menu > About on the DS-8000 series main unit to display the following.

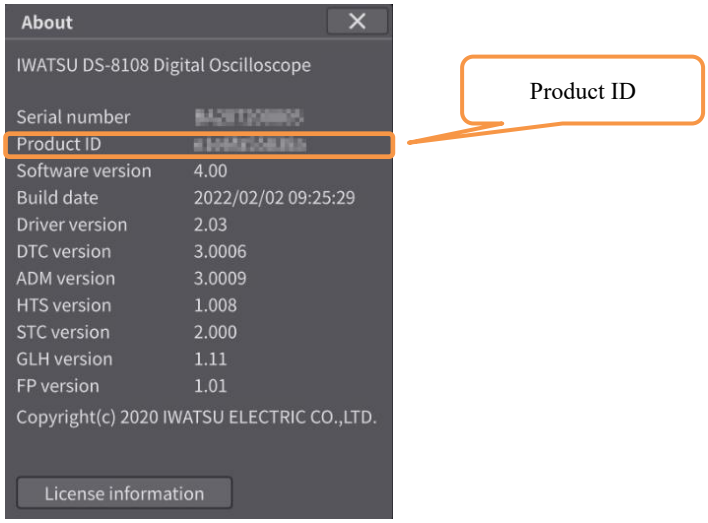


Fig 2.1 Product ID

2.3 Installation

The installation procedure for this plug-in software is described below.

1). Insert a USB Memory Stick containing the switching analysis software object into the USB terminal of the DS-8000 series main unit, then select Menu > Utilities > Plugin tab, and click “Import”.

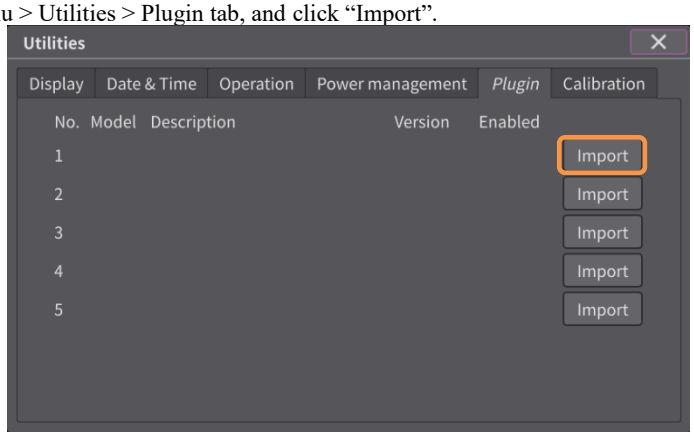


Fig 2.2 Plugin Tab

2). The “Select File” screen will appear, browse to the USB Memory Stick you purchased and select the switching analysis software object (zip file) and click “OK”.

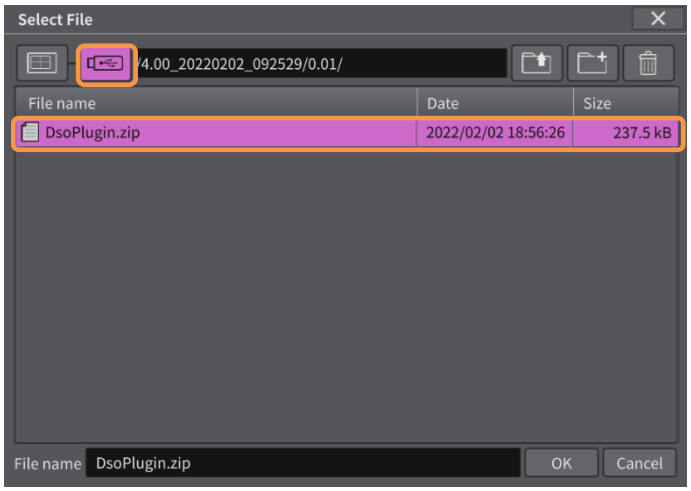


Fig 2.3 Select File Screen

3). The switching analysis software is incorporated into the software of the DS-8000 main unit as shown below.

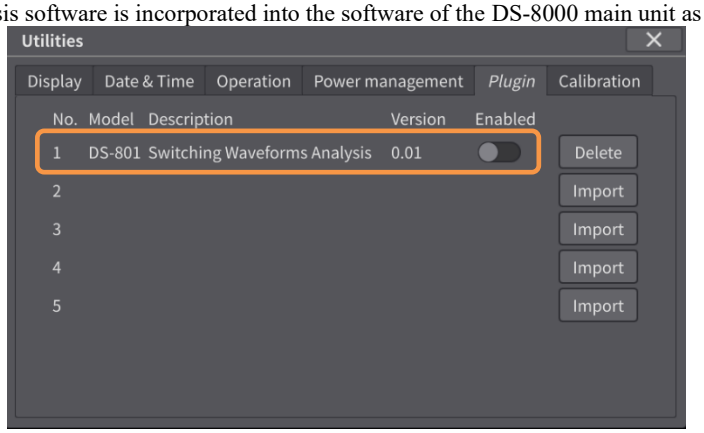


Fig 2.4 Plugin Tab

4). Enable the plug-in software. If you set "Enabled" to "On", the license key entry screen will appear. Click on the entry field, a software keyboard will appear, enter the license key, and click OK.

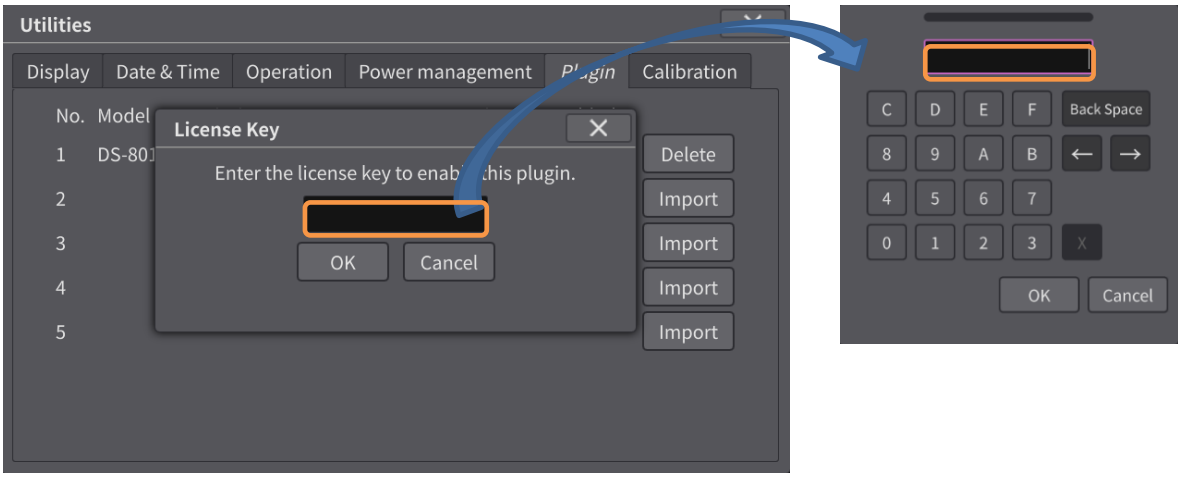


Fig 2.5 License Key Entry Screen

5). The following message will be displayed. Click “OK”, turn off the DS-8000 series main unit, and then turn it on again.

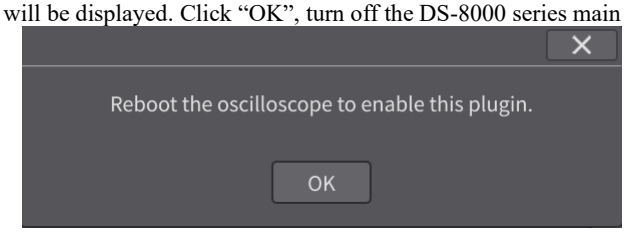


Fig 2.6 Reboot Message

6). Press the Menu button on the DS-8000 series main unit to confirm that the plug-in software is installed.

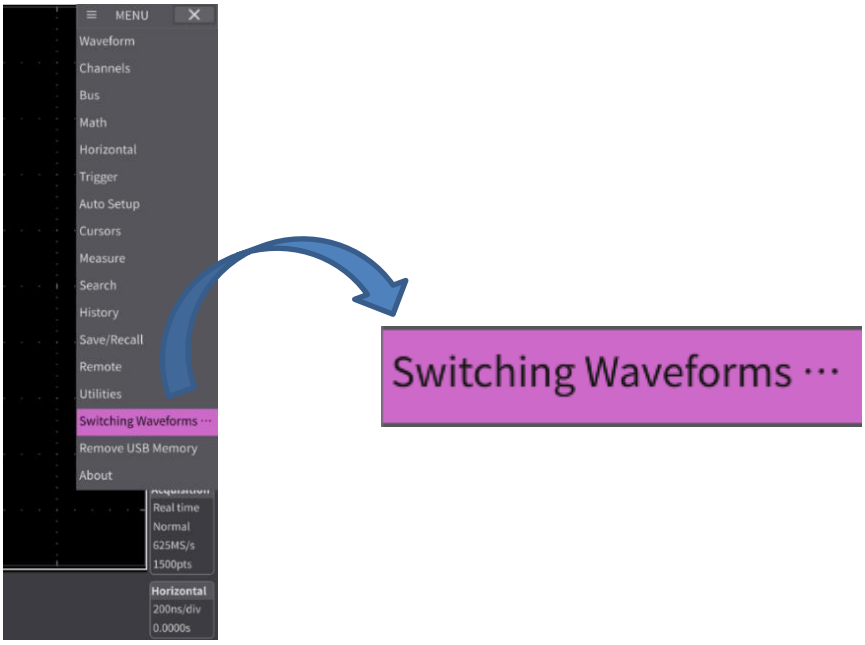


Fig 2.7 Plug-in Software

2.4 Software Update

The following is a description of how to update the plug-in software.

1). Disable the plug-in software: in the DS-8000 series, select Menu > Utilities and select Plugin tab, then turn Enable Off in the plug-in software.

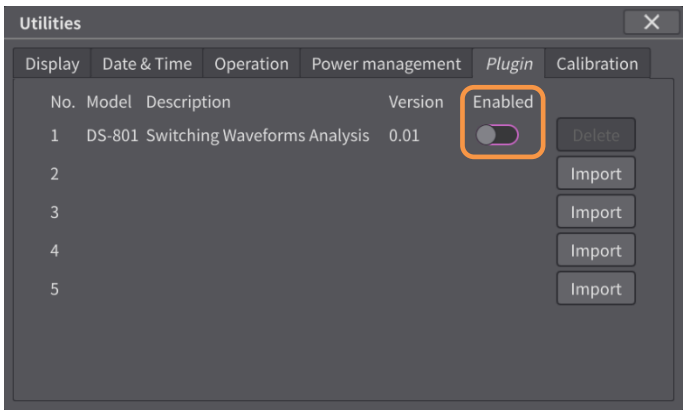


Fig 2.8 Plugin Tab

2). Turn off the power of the DS-8000 series and then reboot it. Then, select Menu > Utilities again, and select the "Plugin" tab. The Delete button is displayed as shown below, click Delete button to delete the plug-in software.

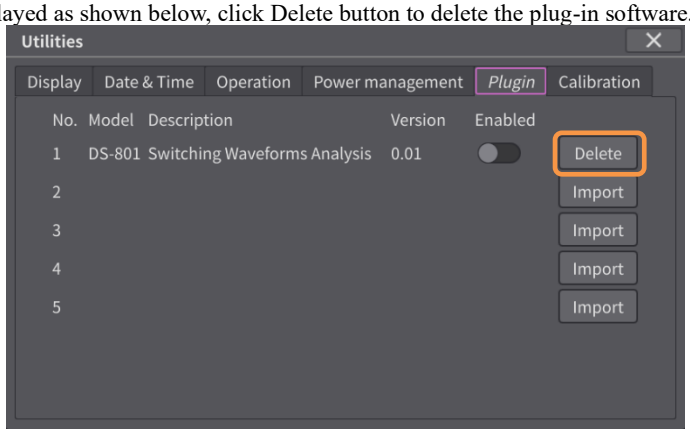


Fig 2.9 Plugin Tab

3). After deleting the plug-in software, you will see the following screen. Then, reinstall the updated plug-in software following to the procedure described in 2.3 Installation.

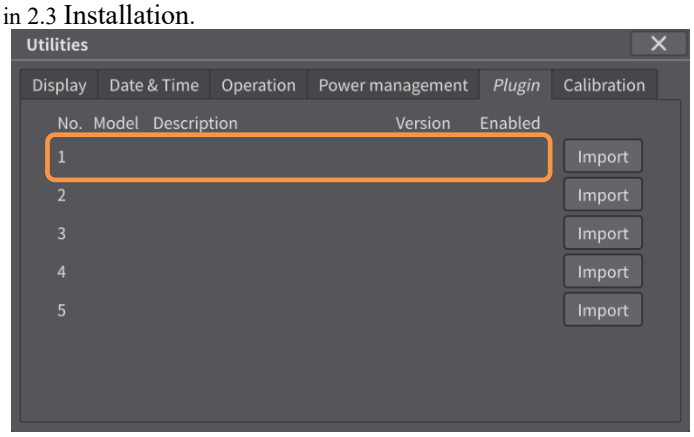


Fig 2.10 Plugin Tab

Chapter 3 Execution and Screen Configuration

This chapter describes how to execute the switching analysis software for DS-8000 and its screen configuration.

3.1 Execution

To start the switching analysis software for DS-8000, click "Switching Waveforms …" in the DS-8000 menu.

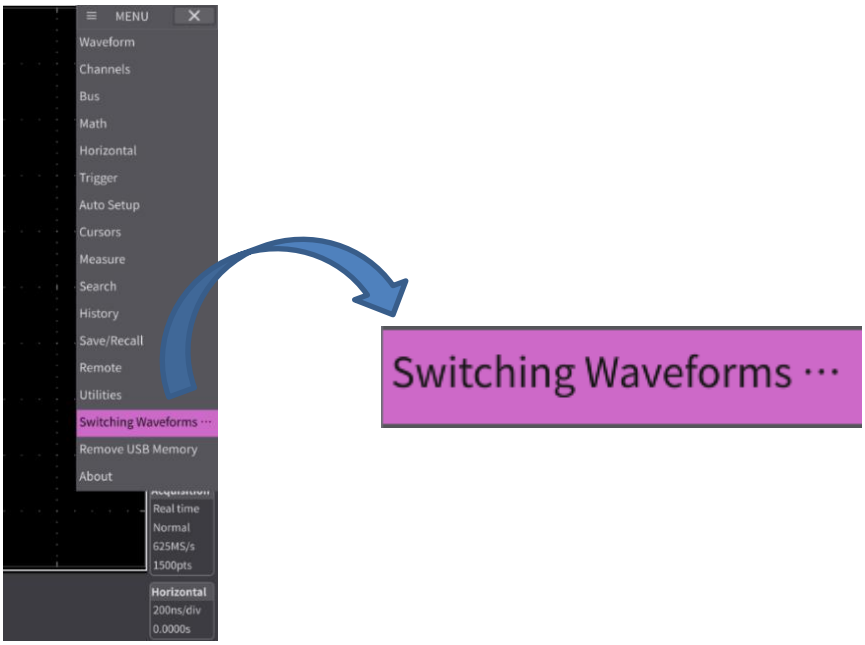


Fig 3.1 Execution

3.2 Screen Configuration

When "Switching Waveform Analysis" is executed, each display area is divided as shown below.

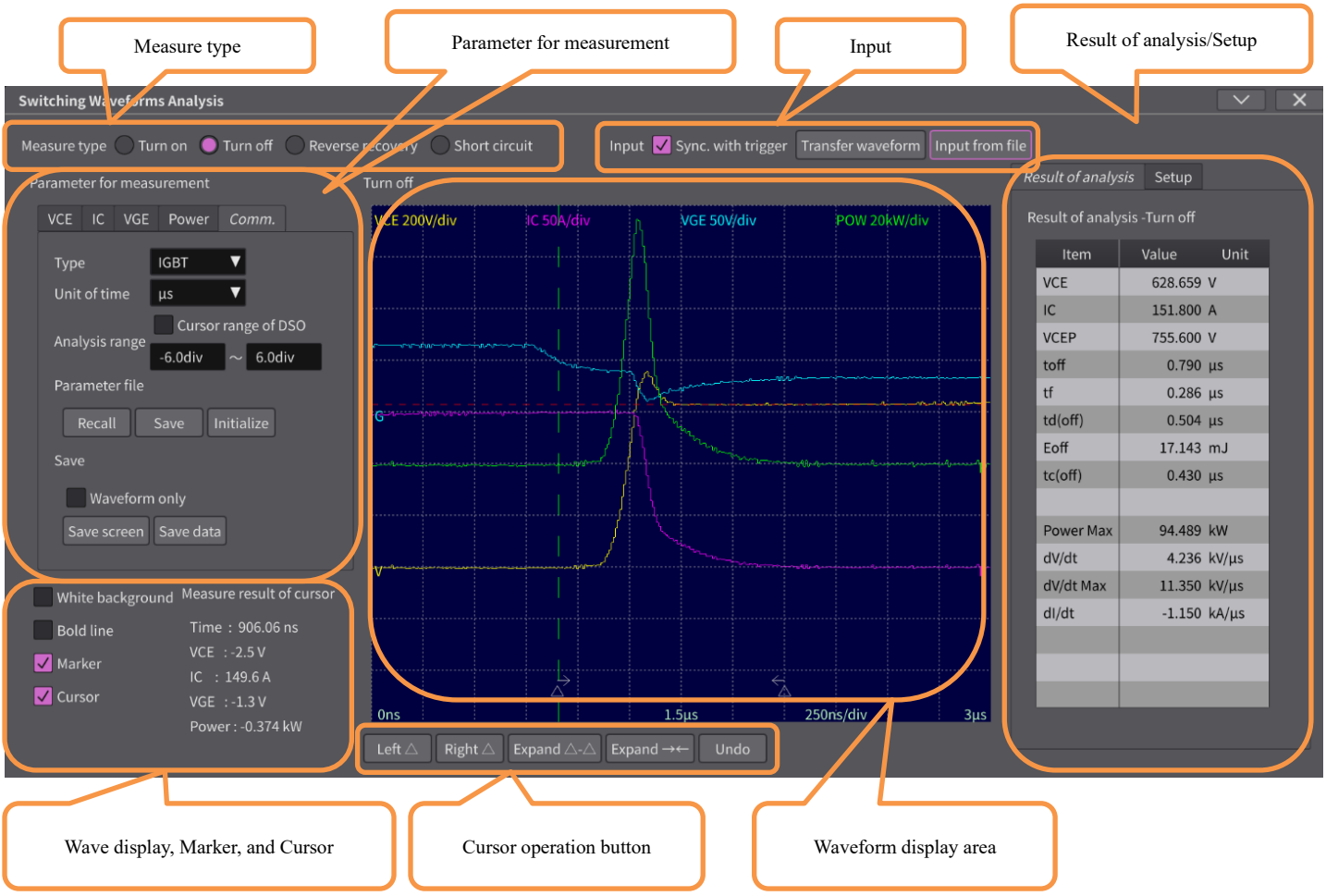


Fig 3.2 Whole Screen

3.2.1 **Measure type**

In “Measure type”, basic measurement items are selected. For the parameter settings of each “Measure type”, please refer to “Chapter 4: Measurement Parameters and Analysis Details" and thereafter.

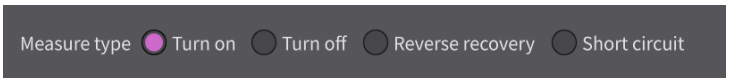


Fig 3.3 Measure type

Table 3.1 Measure type Tab Items

Measure Type	Description
Turn on	Analyze the turn-on dynamic characteristics of switching devices such as IGBTs, IPMs, and MOSFETs.
Turn off	Analyze the turn-off dynamic characteristics of switching devices such as IGBTs, IPMs, and MOSFETs.
Reverse recovery	Analyze the reverse recovery characteristics of freewheel diodes (FWDs) in switching devices such as IGBTs, IPMs, and MOSFETs.
Short circuit	Performs short-circuit analysis during arm short-circuit.

3.2.2 **Parameter for measurement**

"Parameter for measurement" area is used to set the conditions for analysis and measurement, and consists of five tabs, the names of which change depending on the selected "Measure type". See "Chapter 4: Measurement Parameters and Analysis Details" for more detail.

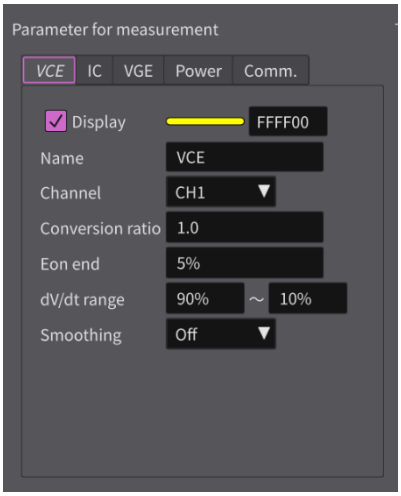


Fig 3.4 Parameter for measurement

3.2.3 **Input**

The Input area selects the method of importing the waveform to be analyzed into this application.

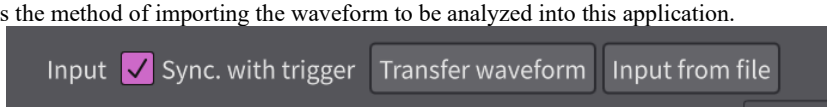


Fig 3.5 Input

Table 3.2 Input selection items

Input method	Description
“Sync. with trigger” Checkbox	Waveforms are captured and analyzed in synchronization with the waveform capture of the main unit software. The number of waveform data that can be imported is between 100 and 1500000.
“Transfer waveform” Button	When this button is pressed, the waveforms captured by the main unit software are transferred to this software for analysis. The number of waveform data that can be imported is between 100 and 1500000.
“Input from file” Button	Reads the CSV file output by Save (see 4.1.5 Save) and imports the waveform data into this software. See "5.1 CSV file format in "Input from file"" for the format of the CSV file.

3.2.4 **Result of analysis/Setup**

The "Result of analysis" tab displays the analysis results of the dynamic characteristics; and the "Setup" tab displays the current settings.

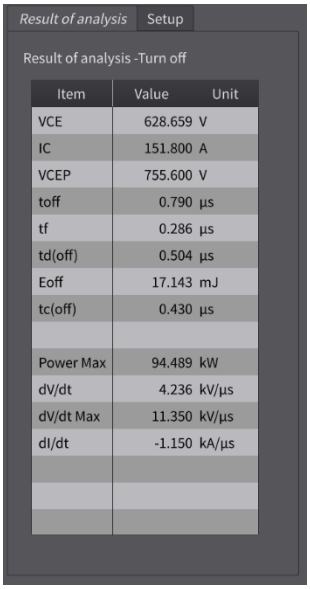


Fig 3.6 Result of analysis/Setup

3.2.5 **Wave display, Marker, and Cursor**

In the "Wave display, Marker, and Cursor" area, settings related to waveform display, marker display for specifying the analysis range, and cursor display are configured. When the cursor display is on, the measurement results by the cursor is displayed in the Measure result of cursor area.

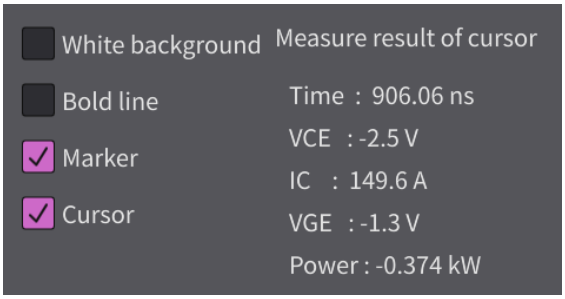


Fig 3.7 Wave display, Marker, and Cursor

Table 3.3 Checkboxes

Checkbox	Description
White background	When checked, the background of the waveform display area will display in white.
Bold line	When checked, the waveform is displayed with a bold line.
Marker	When checked, measurement markers are displayed at the bottom of the waveform display area. The range of the measurement markers will be the range to be analyzed. Refer to "4.1.3 Analysis range" for setting the marker range. (See Fig 3.8 Example of Measurement Markers Display.)
Cursor	When checked, cursor and magnification markers appear at the bottom of the waveform display area. (See Fig 3.9 Example of Cursor and Magnification Markers.)

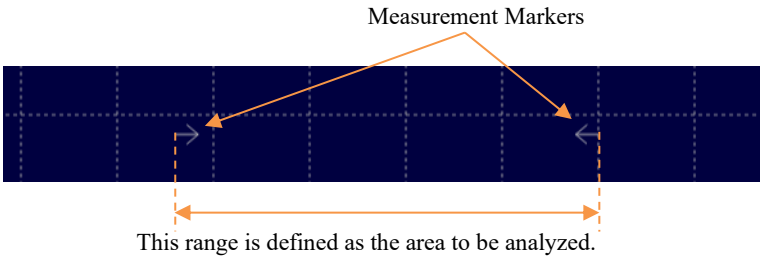


Fig 3.8 Example of Measurement Markers Display

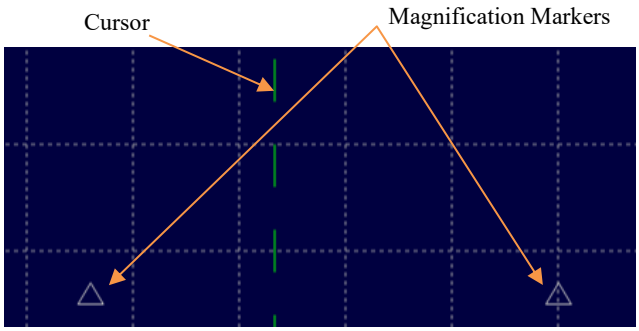


Fig 3.9 Example of Cursor and Magnification Markers

Table 3.4 Measure result of cursor

Measure result of cursor	Description
Time	Displays the time at the cursor with the left end of the waveform display area as the reference (0sec).
V_{CE}	Displays the voltage value of the V_{CE} waveform at the cursor position.
I_C	Displays the current value of the I_C waveform at the cursor position.
V_{GE}	Displays the voltage value of the V_{GE} waveform at the cursor position.
Power	Displays the power value of the power (POW) waveform at the cursor position.

3.2.6 **Operation button for Expand marker**

Operation buttons in the "Operation button for Expand marker" area are used to operate the expansion marker and to zoom in on the waveform in the time (horizontal) axis.

Fig 3.10 Operation buttons for Expand marker

Table 3.5 Operation buttons for Expand marker

Operation buttons for Expand marker	Description
Left△	Sets a left magnification marker at the cursor position.
Right△	Sets a right magnification marker at the cursor position.
Expand△-△	Magnifies the waveform in the direction of the time axis within the range of the left and right magnification markers.
Expand→←	Scales down the waveform in the direction of the time axis.
Undo	Reset to the initial display at the time of waveform acquisition.

3.2.7 **Waveform display area**

The waveforms captured according to the Input settings are displayed in the Waveform display area. Each readout is shown in the figure below.

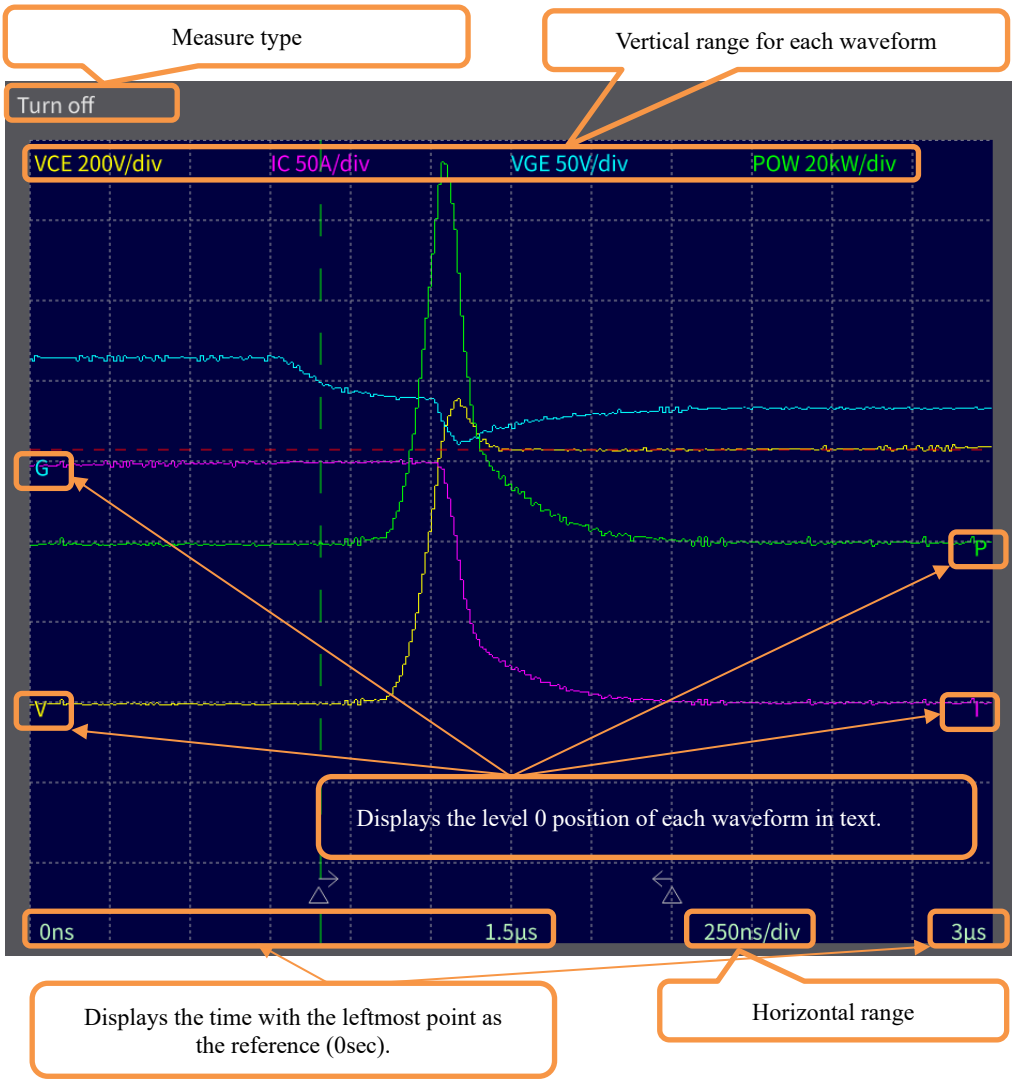
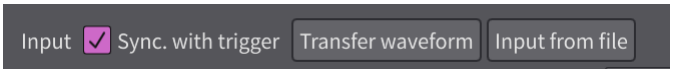


Fig 3.11 Waveform display area

3.3 Analysis execution timing

The analysis of this software is performed at the timing of the execution of Transfer waveform or Input from file. Therefore, to obtain correct analysis results, it is necessary to execute “Transfer waveform” and “Input from file” after setting various measurement parameters. The analysis execution flow is shown below.



3.3.1 Sync. with trigger

When "Sync. with trigger" is checked, the analysis timing is synchronized with the main unit software waveform acquisition operation as shown below.

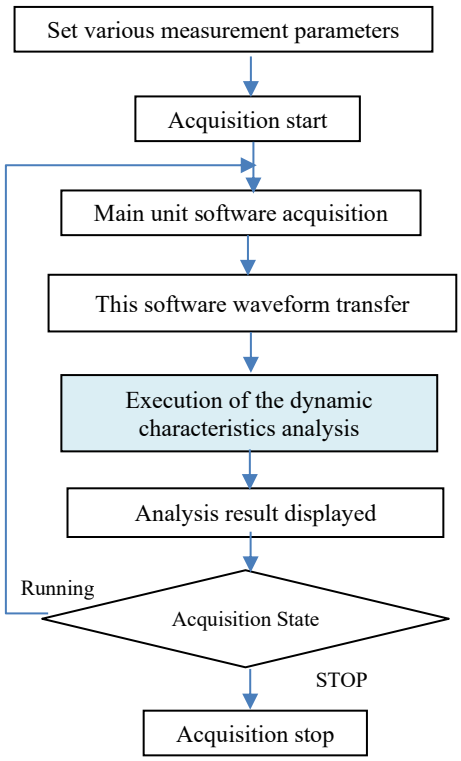


Fig 3.12 “Sync. with trigger” timing

3.3.2 Transfer waveform or Input from file analysis timing

When “Transfer waveform” or “Input from file” is executed, the analysis timing is as followed.

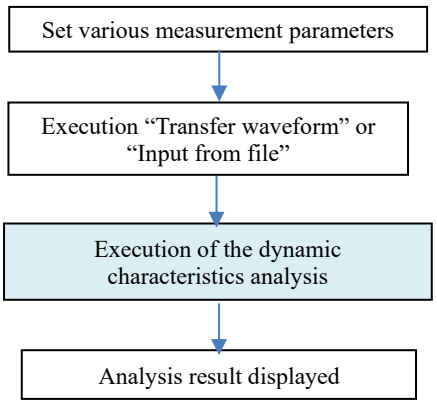


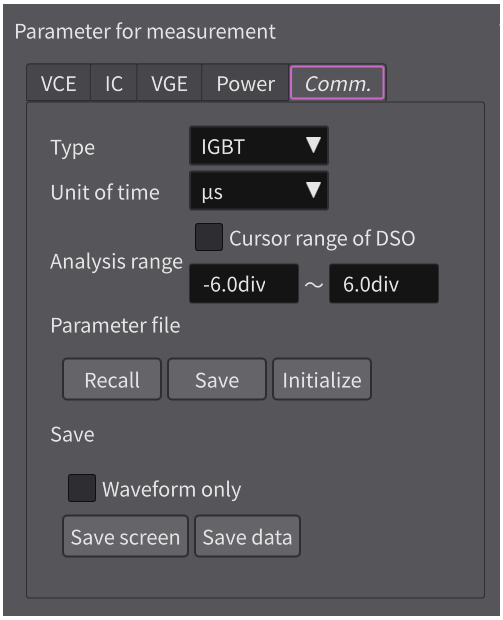
Fig 3.13 Analysis timing of “Transfer waveform” or “Input from file”

Chapter 4 Measurement Parameters and Analysis Details

This chapter describes the measurement parameters for each Measure type of the switching analysis software for DS-8000 and its analysis contents.

4.1 Comm. Tab

The “Comm.” tab sets measurement parameters common to all Measure types.



4.1.1 **Type**

In Type, select the type of device to be analyzed from IGBT, IPM, and MOSFET.

4.1.2 **Unit of time**

In Unit of time, select the unit of time to be displayed in the analysis results from ms, µs, or ns.

4.1.3 **Analysis range**

In Analysis range, select the range for dynamic characteristic analysis as shown in the table below.

Table 4.1 Analysis range

Cursor range of DSO Check Box	Range for Dynamic Characteristic Analysis
On	In the DS-8000 main unit software, the range specified by the two-time axis cursors is the target range for dynamic characteristic analysis. If the time axis cursors are not displayed, the range +1div from the left end and -1div from the right end is analyzed.
Off	The center of the screen in the switching analysis software is 0div, and the range specified by the number of divisions is the target range for dynamic characteristic analysis. If Marker is checked, measurement markers are displayed in the waveform display area. (See Fig 3.8 Example of Measurement Markers Display.)

4.1.4 **Parameter file**

The measurement parameters set by the switching analysis software can be saved/recalled to/from parameter files. All measurement parameters can be initialized. When shutting down, the measurement parameters are automatically saved, and the saved measurement parameters are recalled at the next startup.

Table 4.2 Save/Recall/Initialize parameter files

Parameter file Button	Target Range for Dynamic Characteristic Analysis
Recall	Recall parameters from a parameter file in the DS-8000's internal memory or USB memory. The extension is xxx.dcp.
Save	Save parameters to a parameter file in the DS-8000's internal memory or USB memory. The extension is xxx.dcp.
Initialize	Initializes measurement parameters.

4.1.5 **Save**

"Save" allows you to save the measurement parameters, analysis results, and waveform data in CSV file format. The button operates as shown in the table below, depending on the status of the "Waveform only" checkbox. For data format, see 5.2 Data Format at Save.

Table 4.3 Save data Operation

Button	"Waveform only" Check Box	Operation
Save data	Unchecked	Measurement parameters and analysis results are output as CSV files.
	Checked	Measurement parameters, analysis results, and waveform data are output as CSV files.

4.2 Waveform Display Parameter Setting

This section describes settings related to common waveform displays on each measurement parameter setting tab.

4.2.1 **Display**

If “Display” is checked, the corresponding waveform is displayed; if not checked, the waveform is not displayed. Also, clicking on RGB Selection displays the Select Color screen shown below, allowing you to change the waveform color.

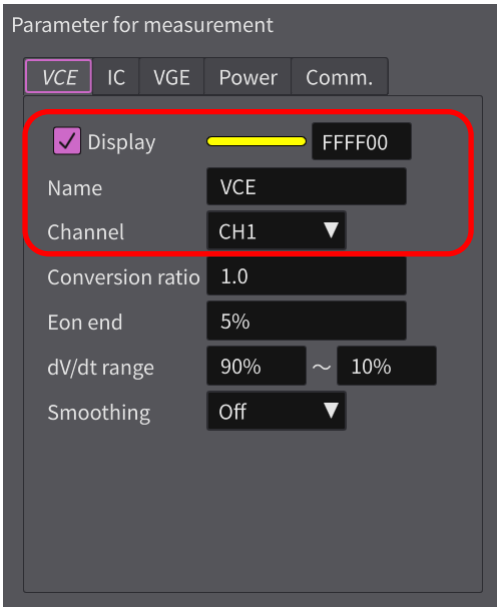


Fig 4.1 Waveform display settings

Fig 4.2 Select Color Display

4.2.2 **Name**

Name allows you to change the name of the waveform with up to 31 characters.

4.2.3 **Channel**

Channel sets the waveform data acquisition channel for each measurement parameter setting tab. Select channels in the DS-8000 main unit software from CH1 to CH8.

4.3 Turn on Measurement

This section describes the measurement parameter settings when the Measure type is set to “Turn on”, and the contents of the analysis results.

4.3.1 **Turn on Parameters and Analysis Results**

The following figure shows the relationship between measurement parameters and analysis results for the turn-on waveform.

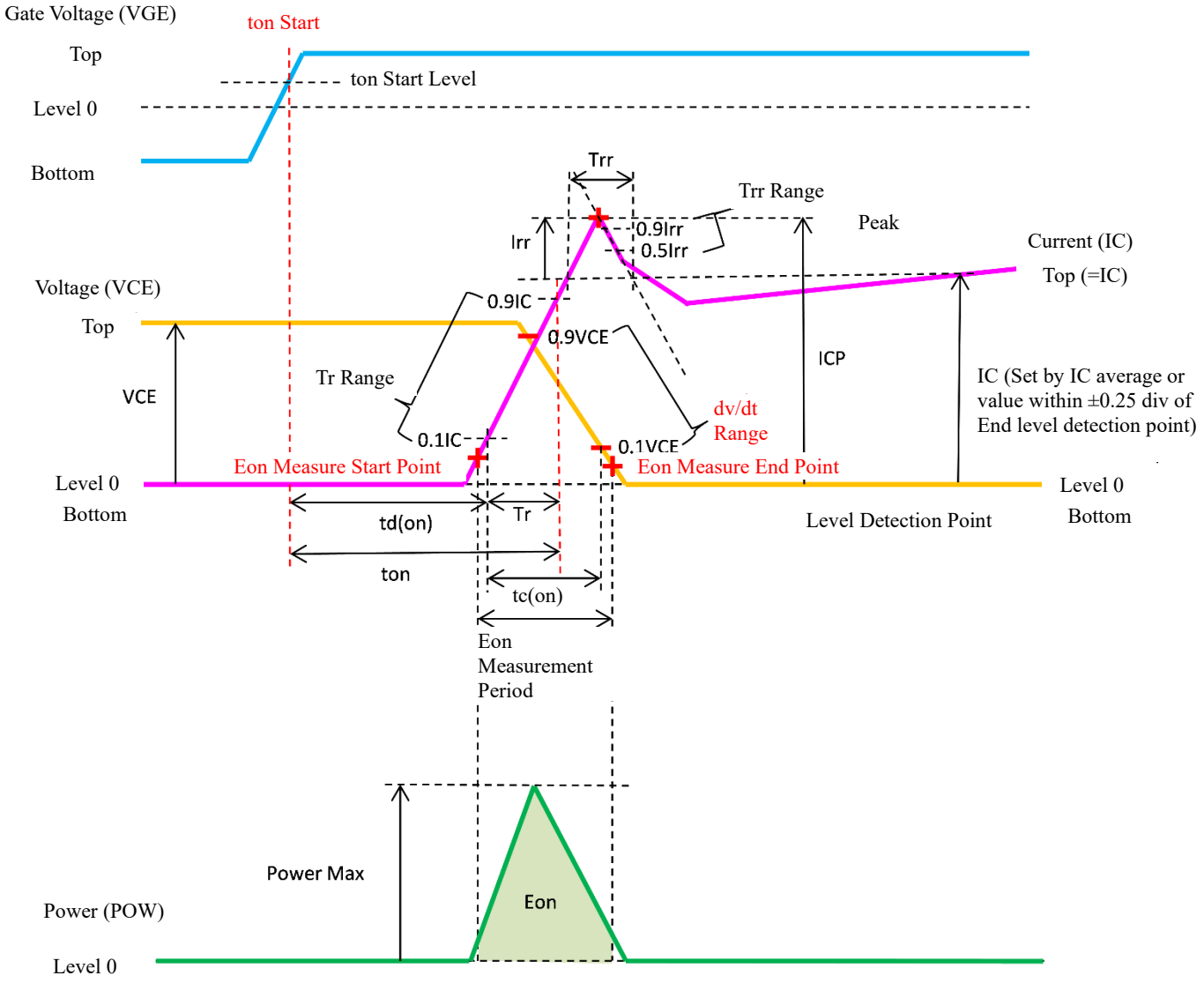


Fig 4.3 Measurement parameters and analysis results during Turn-on measurement

4.3.2 V_{CE} / V_{DS} Tab

If the Measure type is IGBT or IPM, set the parameters related to collector to emitter voltage (V_{CE}); if the Measure type is MOSFET, set the parameters related to drain to source voltage (V_{DS}).

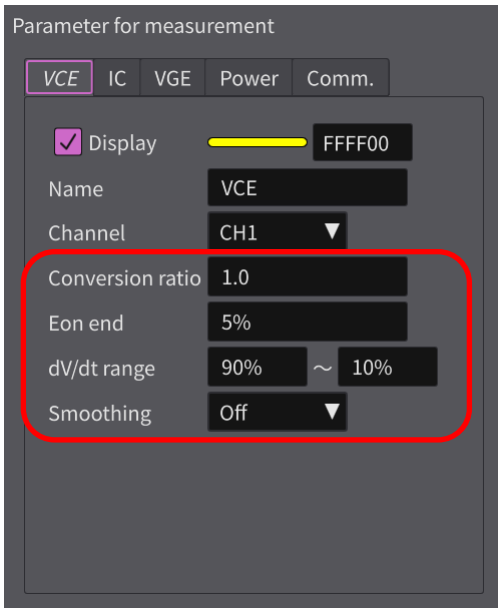


Fig 4.4 V_{CE} / V_{DS} Tab

Table 4.4 V_{CE} / V_{DS} Tab Setting

Parameter	Description	Default	Range	Resolution
Conversion ratio	The analysis is performed by multiplying the value of the imported waveform by a conversion factor.	1.0	0.1 to 1000	0.1
Eon end	Sets the endpoint of the turn-on loss Eon measurement in %. The bottom level is set to 0% and the top level to 100%.	5%	0% to 99%	1%
dV/dt range	Sets the range over which dV/dt is to be determined. Set the starting point (left setting box) and the ending point (right setting box) in %. The bottom level is 0% and the top level is 100%.	90% to 10%	1% to 99%	1%
Smoothing	Voltage waveform smoothing process setting	Off	Off, 3 points, 5 points	----

4.3.3 I_C / I_D Tab

If the Measure type is IGBT or IPM, set the parameters related to collector current (I_C); if the Measure type is MOSFET, set the parameters related to drain current (I_D).

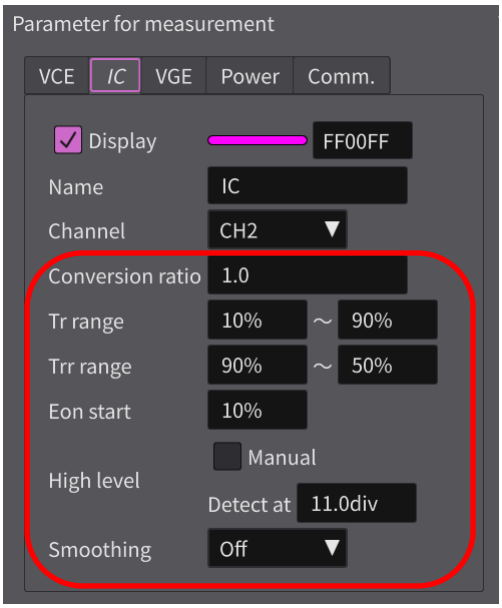


Fig 4.5 I_C / I_D Tab

Table 4.5 I_C / I_D Tab Setting

Parameter	Description	Default	Range	Resolution
Conversion ratio	Analysis is performed by multiplying the waveform value imported by the DS-8000 main unit software by a conversion factor.	1.0	0.1 to 1000	0.1
Tr range	Set the start point (left setting box) and end point (right setting box) of the rise time measurement in %. The bottom level is 0% and the top level is 100%.	10% to 90%	1% to 199%	1%
Trr range	Range of the left diagonal (-dI/dt) of the protrusion. The top level is set to 0% and the peak level to 100%.	90% to 50%	1% to 99%	1%
Eon start	Sets the starting point of turn-on loss Eon measurement in %. The bottom level is set to 0% and the top level to 100%.	10%	0% to 99%	1%
High level	If checked in Manual, the top level is set by the current value.	1 A	0 A to 100 A	0.1 A
High level Detect at	If not checked in Manual, the IC average value within ±0.25 div of the position specified in the time axis is used as the High level.	11 div	1 div to 11.5 div	0.1 div
Smoothing	Current waveform smoothing process setting	Off	Off, 3 points, 5 points	

4.3.4 V_{GE} / V_{CIN} / V_{GS} Tab

If the Measure type is IGBT or MOSFET, set the parameters related to gate voltage (V_{GE} / V_{GS}); if the Measure type is IPM, set the parameters related to control voltage (V_{CIN}).

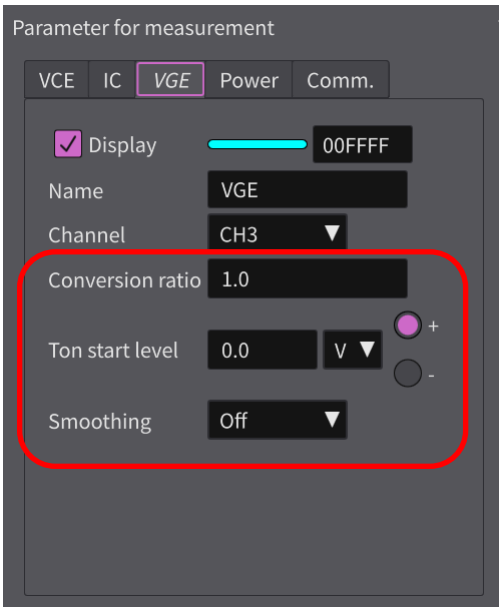
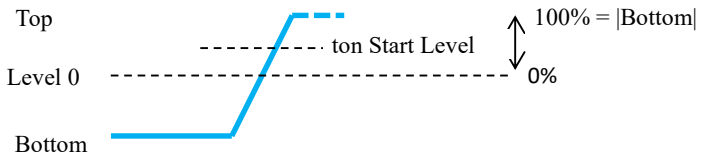
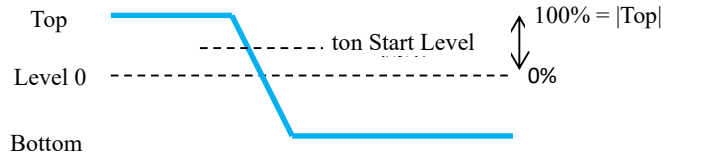
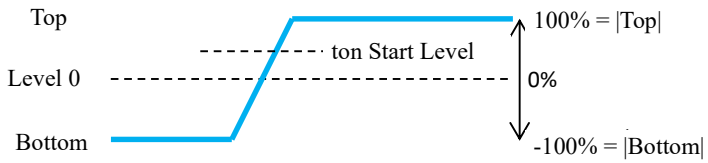
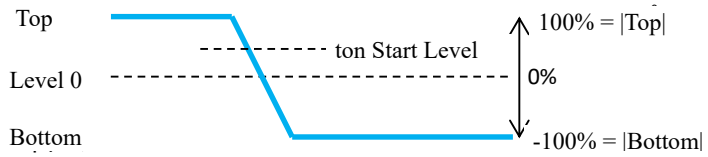


Fig 4.6 V_{GE} / V_{CIN} / V_{GS} Tab

Table 4.6 V_{GE} / V_{CIN} / V_{GS} Tab Setting

Parameter	Description	Default	Range	Resolution
Conversion ratio	Analysis is performed by multiplying the waveform value imported by the DS-8000 main unit software by a conversion factor.	1.0	0.1 to 1000	0.1
ton Start Level (V)	Set the ton Start Level by voltage value.	0.0 V (IGBT, MOSFET) 1.5 V (IPM)	0 to 1000 V	0.1
ton Start Level (±%)	Set the ton Start Level in %. (See Table 4.7 ton Start Level and Gate Voltage)	50%	0 to 100% (IGBT, IPM) -100% to 100% (MOSFET)	1%
ton Start Level (Polarity)	Sets the polarity of the gate voltage that detects the start of ton. (See Table 4.7 ton Start Level and Gate Voltage)	＋(Rising)	＋(Rising), －(Falling)	
Smoothing	Gate voltage waveform smoothing process setting	Off	Off, 3 Points, 5 Points	

Table 4.7 ton Start Level and Gate Voltage

Type	ton Start Level (±%)	Range for which ton Start Level can be set (arrow range)
IGBT	Valid only for +(Rising) % of |bottom level|, above level 0	
IPM	Valid only for -(Falling) Level 0 = 0% Top Level = 100%	
MOSFET	Valid for both +(Rising) / -(Falling) Top Level = 100% Level 0=0% Bottom Level = -100%	Polarity: + (Rising)  Polarity: - (Falling) 

4.3.5 **Power Tab**

The Power Tab sets items related to power (POW). Power (POW) is calculated by the following formula.

$$POW = V_{GE} \times I_C$$

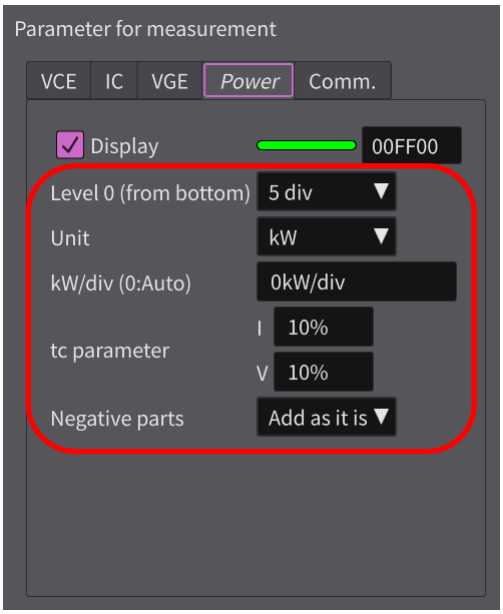


Fig 4.7 Power Tab

Table 4.8 Power Tab Setting

Parameter	Description	Default	Range	Resolution
Level 0 (from bottom)	Set the 0 level of the displayed waveform in terms of the number of graticules (div) from the bottom edge of the screen.	5 div	0 div to 9 div	1 div
Unit	Sets the SI prefix to be displayed in units of power.	kW	W, kW, MW	
kW/div (0:Auto)	Sets the power unit per div. If blank or 0, it is automatically calculated.	0	0 kW/div to 100 kW/div	1 kW/div
tc parameter I (%), V (%)	Set the respective levels I(%) and V(%) of the rising edge of I_C and the falling edge of V_{CE} in %.	I: 10% V: 10%	0% to 100%	1%
Negative parts	Sets the treatment for negative values when calculating switching losses.	Add as it is	Add as it is, Exclude, Add Absolute	

4.3.6 **Result of analysis**

The table below shows the meaning of the analysis results.

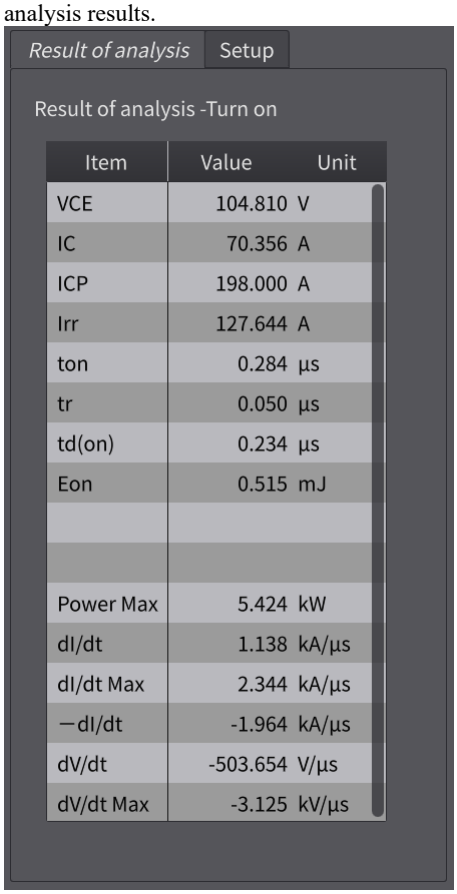


Fig 4.8 Result of analysis area

Table 4.9 Result of analysis

Result of Analysis			Description	Unit
IGBT	IPM	MOSFET		
V_{CE}		V_{DS}	(Top level – bottom level) of V_{CE} or V_{DS}	V
I_C		I_D	(Top level - bottom level) of I_C or I_D	A
I_{CP}		I_{DP}	(Peak level - bottom level) of I_C or I_D	A
Irr			Reverse recovery current. (Peak level - top level) of I_C or I_D	A
ton			Turn-on time. The period shown below. ・Start Point ➢ For IGBTs: The starting point is the point where the V_{GE} specified level is crossed with positive polarity. If it does not cross, it is the starting point of the analysis. ➢ For IPMs: The starting point is the point where the V_{GE} specified level is crossed with negative polarity. If it does not cross, it is the starting point of the analysis. ・End Point The end point is the tr end pint. If it does not cross, it is the end point of the analysis.	s
Tr			The rising time. Tr range time. The rising time of I.	s
td(on)		td(on)	Turn-on delay time. (ton – Tr)	s
Eon			Turn-on loss. The energy losses (mJ) between the time below. ・Start point: Starting point for I_C switching loss measurement ・End point: End point for V_{CE} switching loss measurement	J
	tc(on)		Switching turn-on time, the time between the rising edge of I and the falling edge of V (parameter).	W
	Trr		Reverse recovery current. The time of the Trr range. Falling time of the protrusion of I.	s
Power Max			Maximum value of Power	W
dI/dt			Slope of Tr range of Ic	A/s
dI/dt Max			Maximum value of the derivative of adjacent points in the dI/dt range (3-point moving average)	A/s

−dI/dt	Slope of falling edge of Trr section	A/s
dV/dt	The slope of the falling edge of V	V/s
dV/dt Max	Maximum value of |dV/dt|	V/s

4.4 Turn off Measurement

This section describes the measurement parameter settings and analysis results when "Measure type" is set to “Turn off”.

4.4.1 Turn off Measurement and Analysis Results

The following figure shows the relationship between measurement parameters and analysis results for the turn-off waveform.

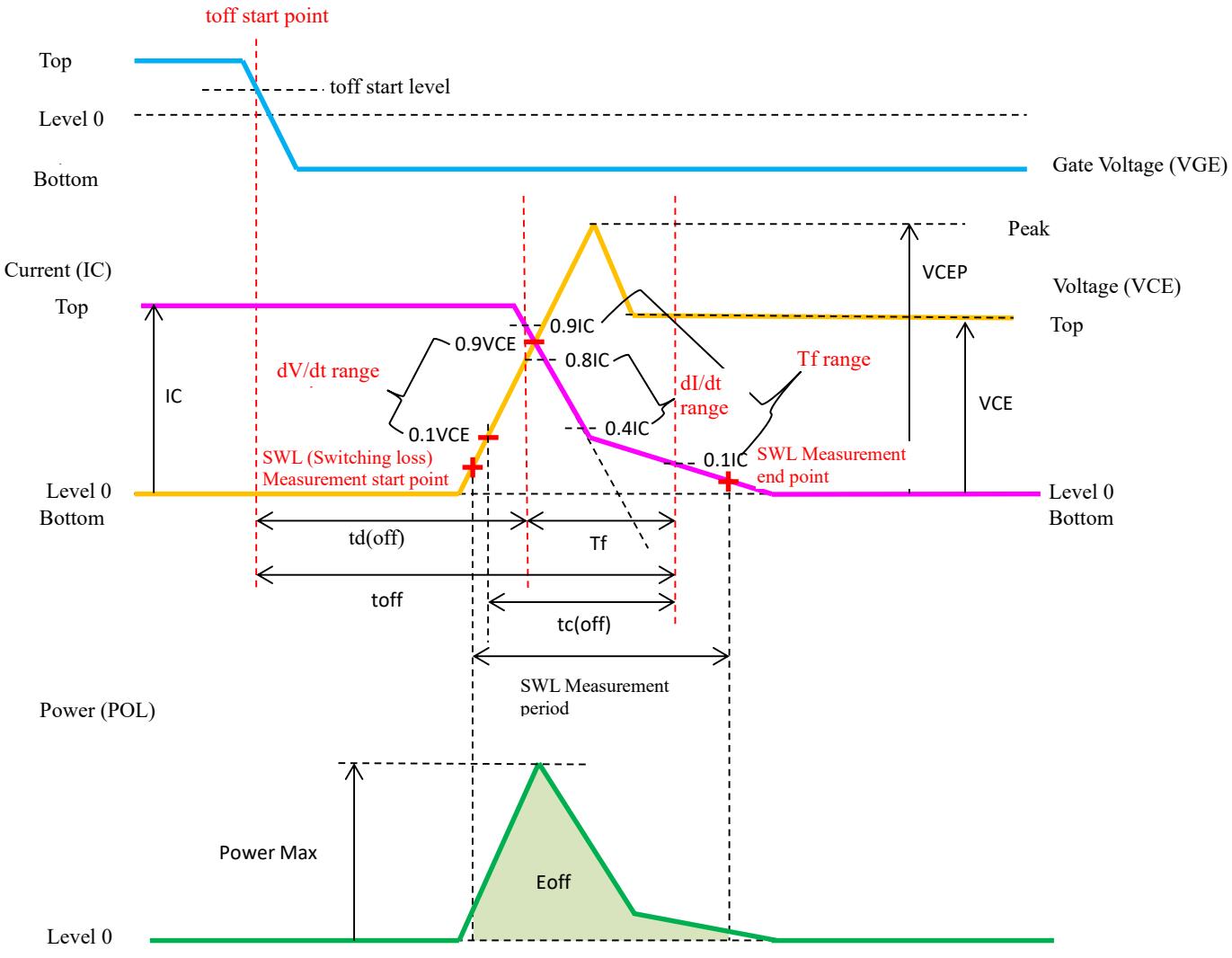


Fig 4.9 Measurement parameters and analysis results for Turn off measurement

4.4.2 V_{CE} / V_{DS} Tab

If the Measure type is IGBT or IPM, set the parameters related to collector to emitter voltage (V_{CE}); if the Measure type is MOSFET, set the parameters related to drain to source voltage (V_{DS}).

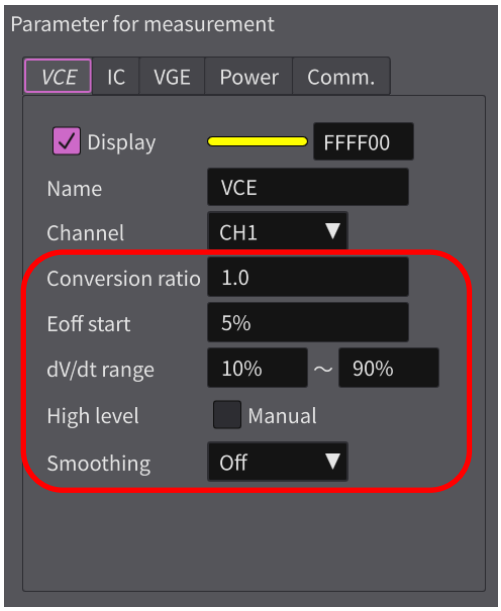


Fig 4.10 V_{CE} / V_{DS} Tab

Table 4.10 V_{CE} / V_{DS} Tab Setting

Parameter	Description	Default	Range	Resolution
Conversion ratio	Analysis is performed by multiplying the waveform value imported by the DS-8000 main unit software by a conversion factor.	1.0	0.1 to 1000	0.1
Eoff start	Sets the starting point for turn-off loss Eoff measurement in %. The bottom level is set to 0% and the top level to 100%.	5%	0% to 99%	1%
dV/dt range	Sets the range over which dV/dt is to be determined. Set the starting point (left setting box) and the ending point (right setting box) in %. The bottom level is 0% and the top level is 100%.	10% to 90%	1% to 99%	1%
High level	"Manual" Check Box Unchecked: Set the High level as desired within the range shown to the right. Checked: Automatically sets the top level to High level.	100 V	0V to 1,000 V	0.1 V
Smoothing	Voltage waveform smoothing process setting	Off	Off, 3 points, 5 points	

4.4.3 I_C / I_D Tab

If the Measure type is IGBT or IPM, set the parameters related to collector current (I_C); if the Measure type is MOSFET, set the parameters related to drain current (I_D).

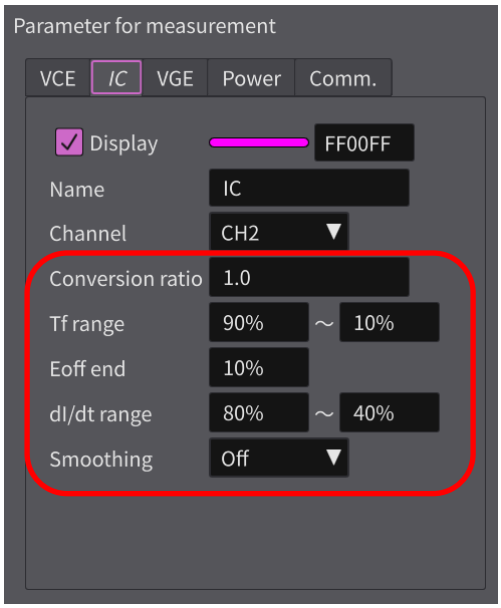


Fig 4.11 I_C / I_D Tab

Table 4.11 I_C / I_D Tab Setting

Parameter	Description	Default	Range	Resolution
Conversion ratio	Analysis is performed by multiplying the waveform value imported by the DS-8000 main unit software by a conversion factor.	1.0	0.1 to 1000	0.1
Tf range	Set the starting point (left setting box) and the ending point (right setting box) for the fall time measurement in %. The bottom level is 0% and the top level is 100%.	90% to 10%	1% to 90%	1%
Eoff end	Sets the endpoint of the turn-on loss Eoff measurement in %. The bottom level is set to 0% and the top level to 100%.	2%	0% to 99%	1%
dI/dt range	Sets the range over which dI/dt is to be determined. Set the starting point (left setting box) and the ending point (right setting box) in %. The bottom level is 0% and the top level is 100%.	80% to 40%	1% to 99%	1%
Smoothing	Current waveform smoothing process setting	Off	Off, 3 points, 5 points	

4.4.4 V_{GE} / V_{CIN} / V_{GS} Tab

If the Measure type is IGBT or MOSFET, set the parameters related to gate voltage (V_{GE} / V_{GS}); if the Measure type is IPM, set the parameters related to control voltage (V_{CIN}).

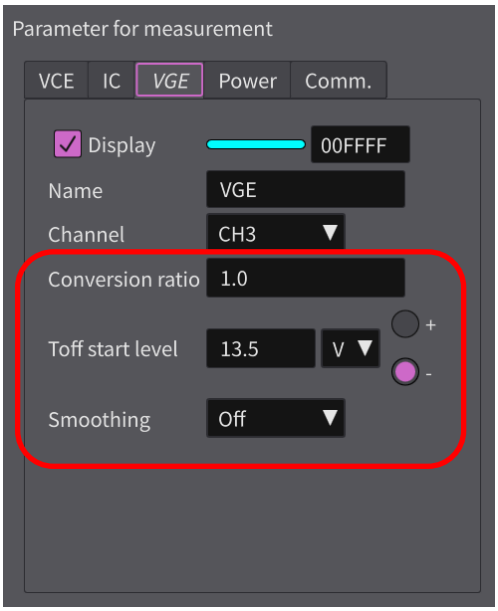
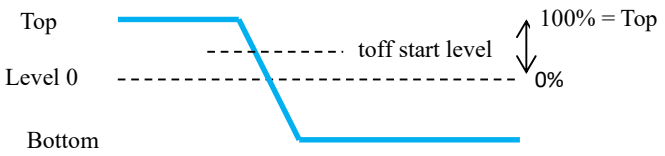
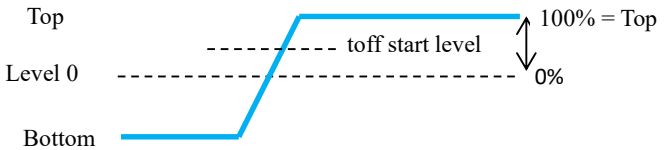
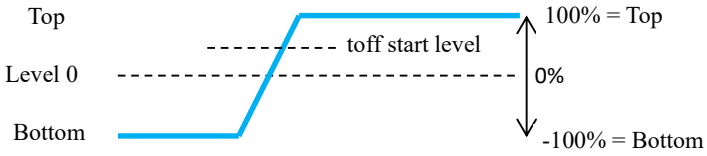
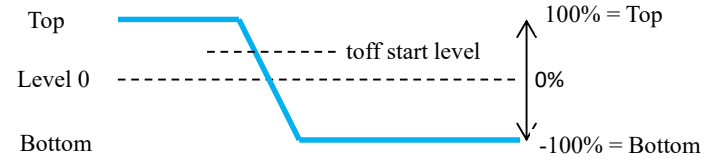


Fig 4.12 V_{GE} / V_{CIN} / V_{GS} Tab

Table 4.12 V_{GE} / V_{CIN} / V_{GS} Tab Setting

Parameter	Description	Default	Range	Resolution
Conversion ratio	Analysis is performed by multiplying the waveform value imported by the DS-8000 main unit software by a conversion factor.	1.0	0.1 to 1000	0.1
toff start level (V)	Set the toff start level in terms of voltage value.	13.5V(IGBT, MOSFET) 2.0V(IPM)	0 to 1000 V	0.1
toff start level (±%)	Set the toff start level in %. (See Table 4.13 toff start level and Gate voltage)	50%	0 to 100% (IGBT, IPM) -100 to 100% (MOSFET)	1%
toff start level (Polarity)	Sets the rising/falling polarity of the gate voltage that detects the start of toff. (See Table 4.13 toff start level and Gate voltage)	＋(Rising)	＋(Rising), －(Falling)	
Smoothing	Gate voltage waveform smoothing process setting	Off	Off, 3 points, 5 points	

Table 4.13 toff start level and Gate voltage

Type	toff start level (±%)	Range within which toff start level can be set (arrow range)
IGBT	Only valid for - (falling) Level 0: 0% Top level: 100%	
IPM	Only valid for + (rising) Level 0: 0% Top level: 100%	
MOSFET	Valid for both + (rising) / -(falling) Top level: 100% Level 0: 0% Bottom level: -100%	Polarity: + (Rising)  Polarity: - (Falling) 

4.4.5 **Power Tab**

The Power Tab sets items related to power (POW). Power (POW) is calculated by the following formula.

$$POW = V_{GE} \times I_C$$

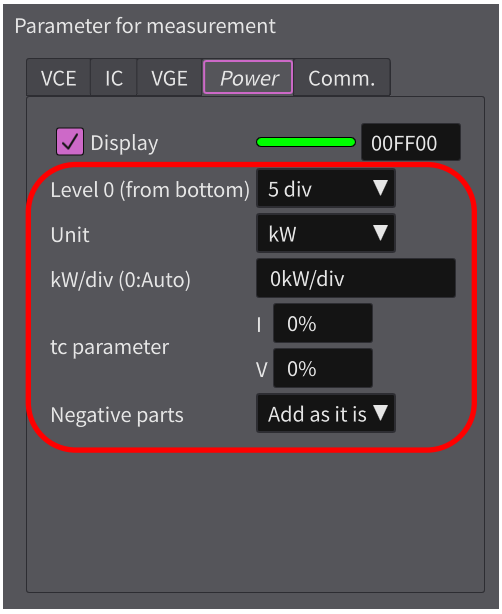


Table 4.14 Power Tab Setting

Parameter	Description	Default	Range	Resolution
Level 0 (from bottom)	Set the 0 level of the displayed waveform in terms of the number of graticules (div) from the bottom of the screen.	5 div	0 div to 9 div	1 div
Unit	Sets the SI prefix to be displayed in units of power.	kW	W, kW, MW	
kW/div (0:Auto)	Sets the power unit per div. If blank or 0, it is automatically calculated.	0	0 kW/div to 100 kW/div	1 kW/div
tc parameter I(%), V(%)	Set the respective levels V(%) and I(%) of the rising edge of V_{CE} and the falling edge of I_C in %.	I: 10% V: 10%	0% to 100%	1%
Negative parts	Sets the treatment for negative values when calculating switching losses.	Add as it is	Add as it is, Exclude, Add Absolute	

4.4.6 **Result of analysis**

The table below shows the meaning of the analysis results.

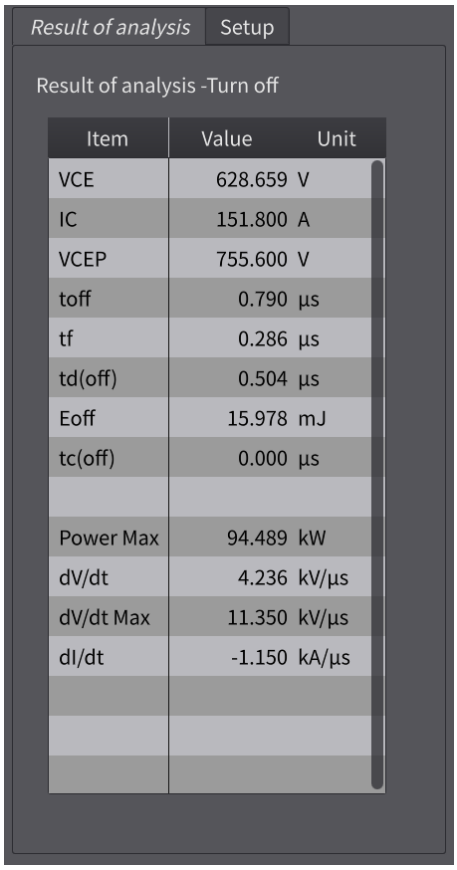


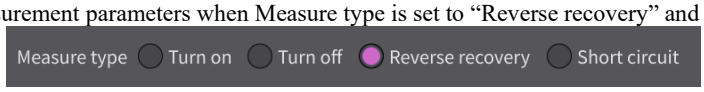
Fig 4.13 Result of analysis display

Table 4.15 Result of analysis

Result of Analysis			Description	Unit
IGBT	IPM	MOSFET		
V_{CE}		V_{DS}	(Top level - Bottom level) of V_{CE} or V_{DS}	V
I_C		I_D	(Top level - Bottom level) of I_C or I_D	A
I_{CEP}		I_{DSP}	(Peak level - Bottom level) of I_{CE} or I_{DS}	A
toff			Turn-off time. Time from toff start point to I_C bottom level.	s
tf			Falling time. The time from the falling edge of the I_C to the bottom level of the I_C.	s
td(off)		td(off)	Turn-off delay time. Time from toff start point to I_C bottom level.	s
Eoff			Turn-off loss. Energy loss (mJ) in the following ranges ・Start point: Switching loss measurement start point of V_{CE} ・End point: Switching loss measurement end point of I_C	J
	tc(off)		Switching turn-off time, the time from the rise of V_{CE} to the I_C bottom level.	s
Power Max			Maximum Power	W
dV/dt			Slope of dV/dt range of V_{CE} or V_{DS}	V/s
dV/dt Max			Maximum value of dV/dt in dV/dt range	V/s
dI/dt			Slope of dI/dt range of I_C or I_D	A/s

4.5 Reverse recovery measurement

This section describes the measurement parameters when Measure type is set to “Reverse recovery” and the contents of the analysis results.



4.5.1 Reverse recovery parameters and analysis results

The reverse recovery measurement automatically determines the direction of the peak current I_{EP} of IE. The relationship between measurement parameters and analysis results for the I_{EP} falling type (Fig 4.14 Measurement parameters and analysis results during reverse recovery measurement (I_{EP} falling type)) and IEP rising type (Fig 4.15 Measurement parameters and analysis results during reverse recovery measurement (I_{EP} rising type)) is shown below.

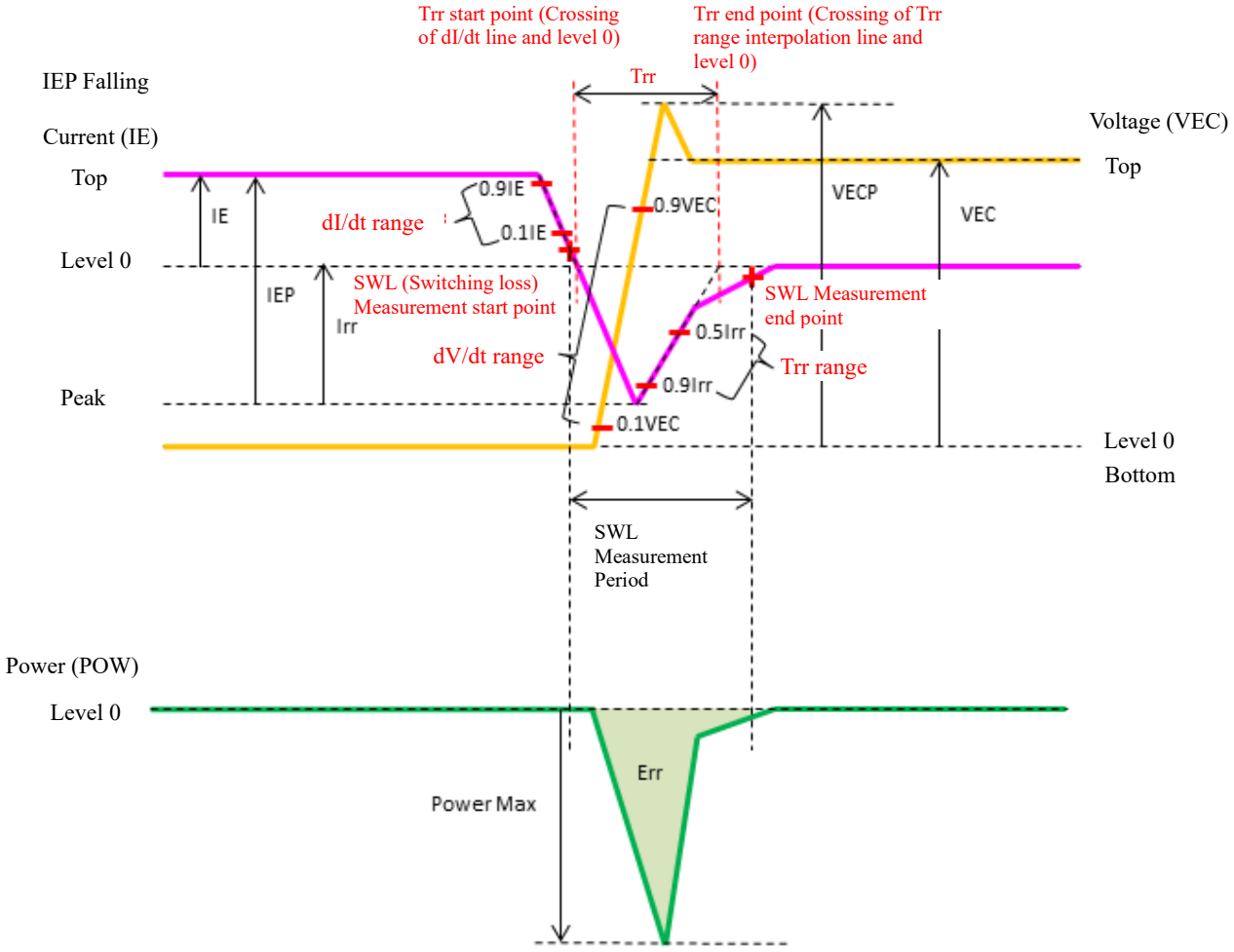


Fig 4.14 Measurement parameters and analysis results during reverse recovery measurement (I_{EP} falling type)

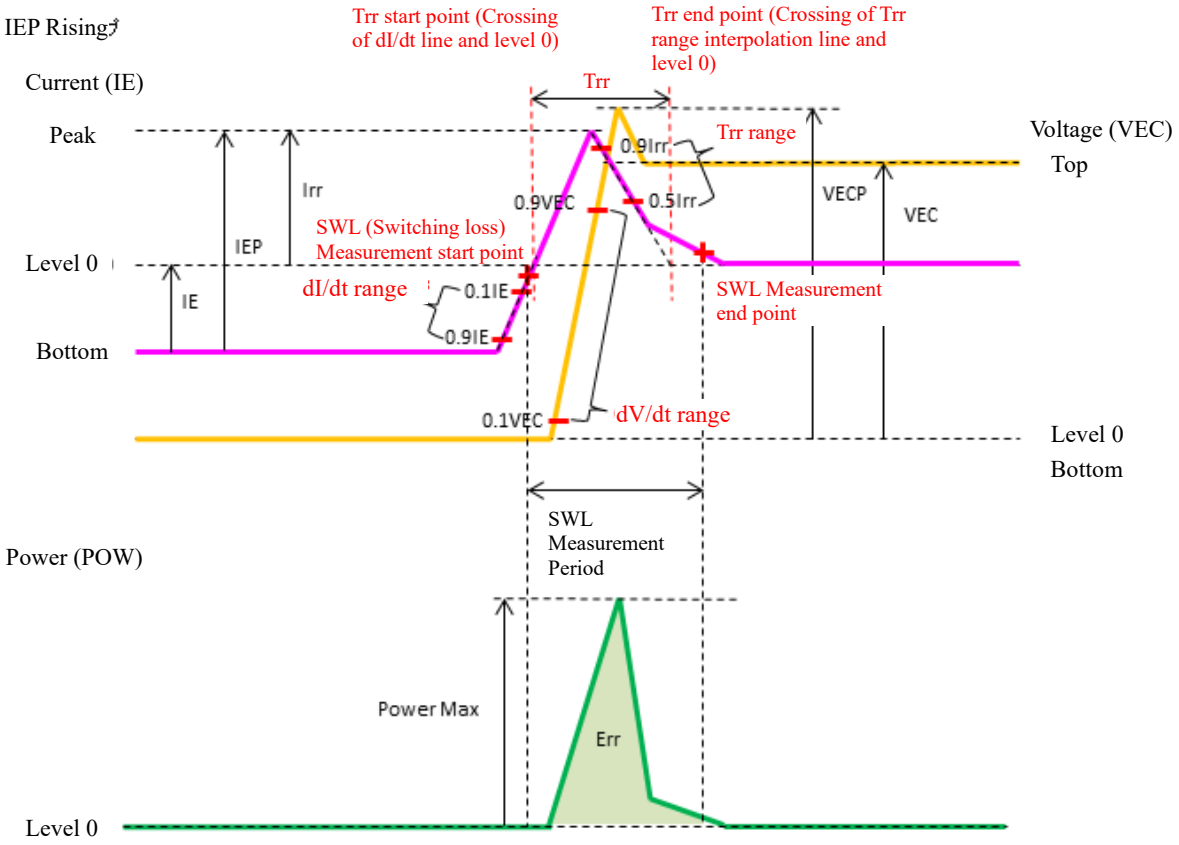


Fig 4.15 Measurement parameters and analysis results during reverse recovery measurement (I_{EP} rising type)

4.5.2 V_{EC} / V_{AK} Tab

Sets parameters related to the voltage across the freewheeling diode (FWD) terminals. If the Measure type is IGBT or IPM, set the parameters related to emitter-collector voltage (V_{EC}); if the Measure type is MOSFET, set the parameters related to anode-cathode voltage (V_{AK}).

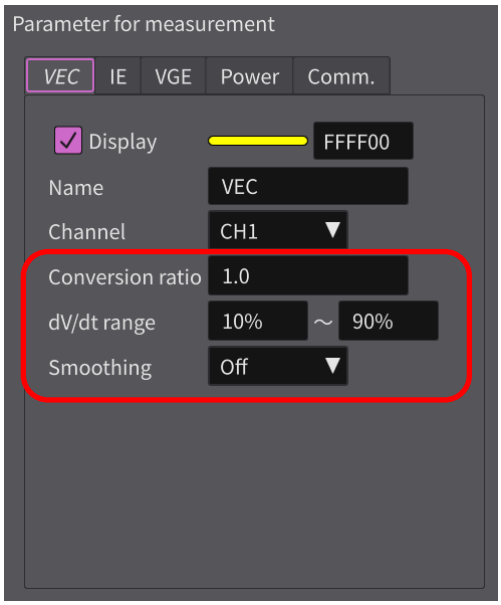


Fig 4.16 V_{EC} / V_{AK} Tab

Table 4.16 V_{EC} / V_{AK} Tab Setting

Parameter	Description	Default	Range	Resolution
Conversion ratio	Analysis is performed by multiplying the waveform value imported by the DS-8000 main unit software by a conversion factor.	1.0	0.1 to 1000	0.1
dV/dt range	Sets the range over which dV/dt is to be determined. Set the starting point (left setting box) and the ending point (right setting box) in %. The bottom level is 0% and the top level is 100%.	10% to 90%	1% to 99%	1%
Smoothing	Voltage waveform smoothing process setting	Off	Off, 3 points, 5 points	

4.5.3 I_E / I_F Tab

Sets parameters related to the current across the freewheeling diode (FWD) terminals. If the Measure type is IGBT or IPM, set the parameters related to emitter current (I_E); if the Measure type is MOSFET, set the parameters related to the forward current (I_D) of FWD.

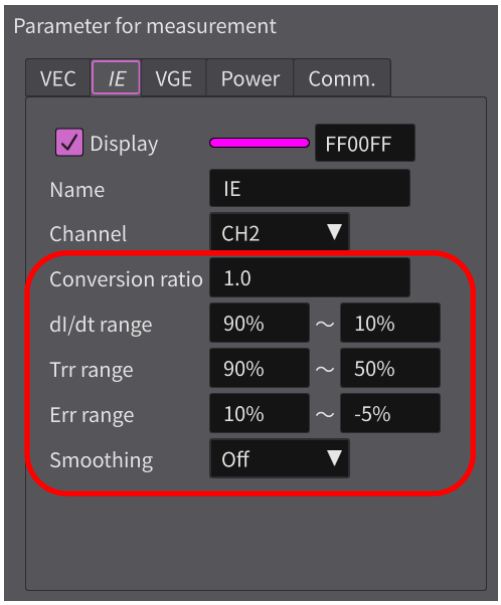


Fig 4.17 I_E / I_F Tab

Table 4.17 I_E / I_F Tab Setting

Parameter	Description	Default	Range	Resolution
Conversion ratio	Analysis is performed by multiplying the waveform value imported by the DS-8000 main unit software by a conversion factor.	1.0	0.1 to 1000	0.1
dI/dt range	Sets the range over which dI/dt is to be determined. Set the starting point (left setting box) and the ending point (right setting box) in %. Level 0 (0A) is set as 0%, and the +100% reference changes as follows depending on the I_E pulse direction. I_{EP} falling type: Top level is +100% I_{EP} rising type: Bottom level is +100%	90% to 10%	0% to 99%	1%
Trr range	Sets the Trr range to be used when determining the Trr end point. Set the starting point (left setting box) and the ending point (right setting box) in %. Set I_E level 0 (0A) as 0% and the I_E peak value as 100%.	90% to 50%	1% to 99%	1%
Err range	Sets the I_E current level at the beginning and end of the reverse recovery loss (Err). Set the starting point (left setting box) and the ending point (right setting box) in %. Level 0 (0A) is set as 0%, and the +100% reference changes as follows depending on the I_E pulse direction. I_{EP} falling type: Top level is +100% I_{EP} rising type: Bottom level is +100%	10% to -5%	1% to 99%	1%
Smoothing	Current waveform smoothing process setting	Off	Off, 3 points, 5 points	

4.5.4 V_{GE} / V_{CIN} / V_{GS} Tab

If Measure type is "Reverse recovery," the V_{GE} / V_{CIN} / V_{GS} tabs are blank because there are no setting items in the V_{GE} / V_{CIN} / V_{GS} tabs.

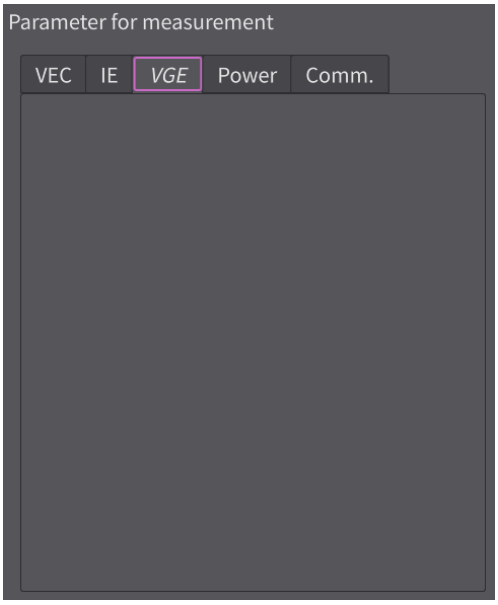


Fig 4.18 V_{GE} / V_{CIN} / V_{GS} Tab

4.5.5 **Power Tab**

The Power Tab sets items related to power (POW). Power (POW) is calculated by the following formula.

$$POW = V_{EC} \times I_E$$

Fig 4.19 Power Tab

Table 4.18 Power Tab Setting

Parameter	Description	Default	Range	Resolution
Level 0 (from bottom)	Set the 0 level of the displayed waveform in terms of the number of graticules (div) from the bottom of the screen.	4 div	0 div to 9 div	1 div
Unit	Sets the SI prefix to be displayed in units of power.	kW	W, kW, MW	
kW/div (0:Auto)	Sets the power unit per div. If blank or 0, it is automatically calculated.	0	0 kW/div to 100 kW/div	1 kW/div
Negative parts	Sets the treatment for negative values when calculating switching losses.	Add as it is	Add as it is, Exclude, Add Absolute	

4.5.6 **Result of analysis**

The table below shows the meaning of the analysis results.

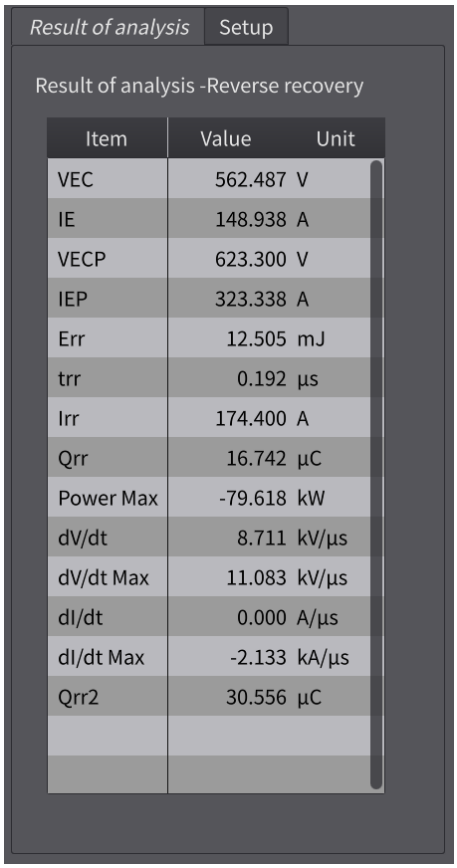


Fig 4.20 Result of analysis display

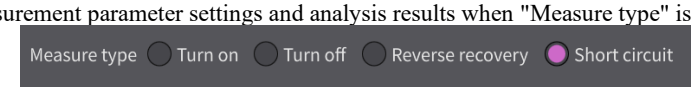
Table 4.19 Result of analysis

Result of Analysis			Description	Unit
IGBT	IPM	MOSFET		
V_{EC}		V_{AK}	(Top level - Bottom level) of V_{EC} or V_{AK}	V
I_E		I_F	(Top level – Level 0 (0 A)) of I_E or I_F	A
V_{ECP}		V_{AKP}	(Peak level - Bottom level) of V_{EC} or V_{AK}	V
I_{EP}		I_{FP}	It depends on the direction of the I_E pulse direction. ・I_{EP} falling type: I_E top level - I_E minus peak level ・I_{EP} rising type: I_E plus peak level - I_E bottom level	A
Err			Reverse Recovery Loss (mJ) and is determined between the points below. ・Start point: Switching loss measurement start point of I_E ・End point: Switching loss measurement end point of I_E	J
Trr			Reverse Recovery Time Time between the crossing point of the dI/dt line and I_E level 0 and the crossing point of the Trr range interpolation line and I_E level 0	s
Irr			Reverse Recovery Current Absolute value of (I_E peak level - I_E level 0)	A
Qrr			Reverse Recovery Charge Amount (Irr * Trr) / 2 (µC)	C
Power Max			It depends on the direction of the I_E pulse direction. ・I_{EP} falling type: - peak value of POW waveform ・I_{EP} rising type: +peak value of POW waveform	W
dV/dt			Start-to-end slope in the dV/dt range of V_{EC} or V_{AK}	V/s
dV/dt Max			Maximum value in dV/dt of each data within the dV/dt range of V_{EC} or V_{AK}	V/s
dI/dt			Start-to-end slope in I_E's dI/dt range It depends on the direction of the I_E pulse direction. ・I_{EP} falling type: dI/dt has negative value ・I_{EP} rising type: dI/dt has positive value	A/s

dI/dt Max	The following values within the dI/dt range. ・I_{EP} falling type: Minimum value in dI/dt for each data ・I_{EP} rising type: Maximum value in dI/dt for each data	A/s
Qrr2	Integral value (area) of I_E or I_F between Err ranges。(μC)	C

4.6 Short circuit Measurement

This section describes the measurement parameter settings and analysis results when "Measure type" is set to “Short circuit”.



4.6.1 Short circuit Parameters and Analysis Results

The relationship between measurement parameters and analysis results for short-circuit waveforms is shown in the figure below.

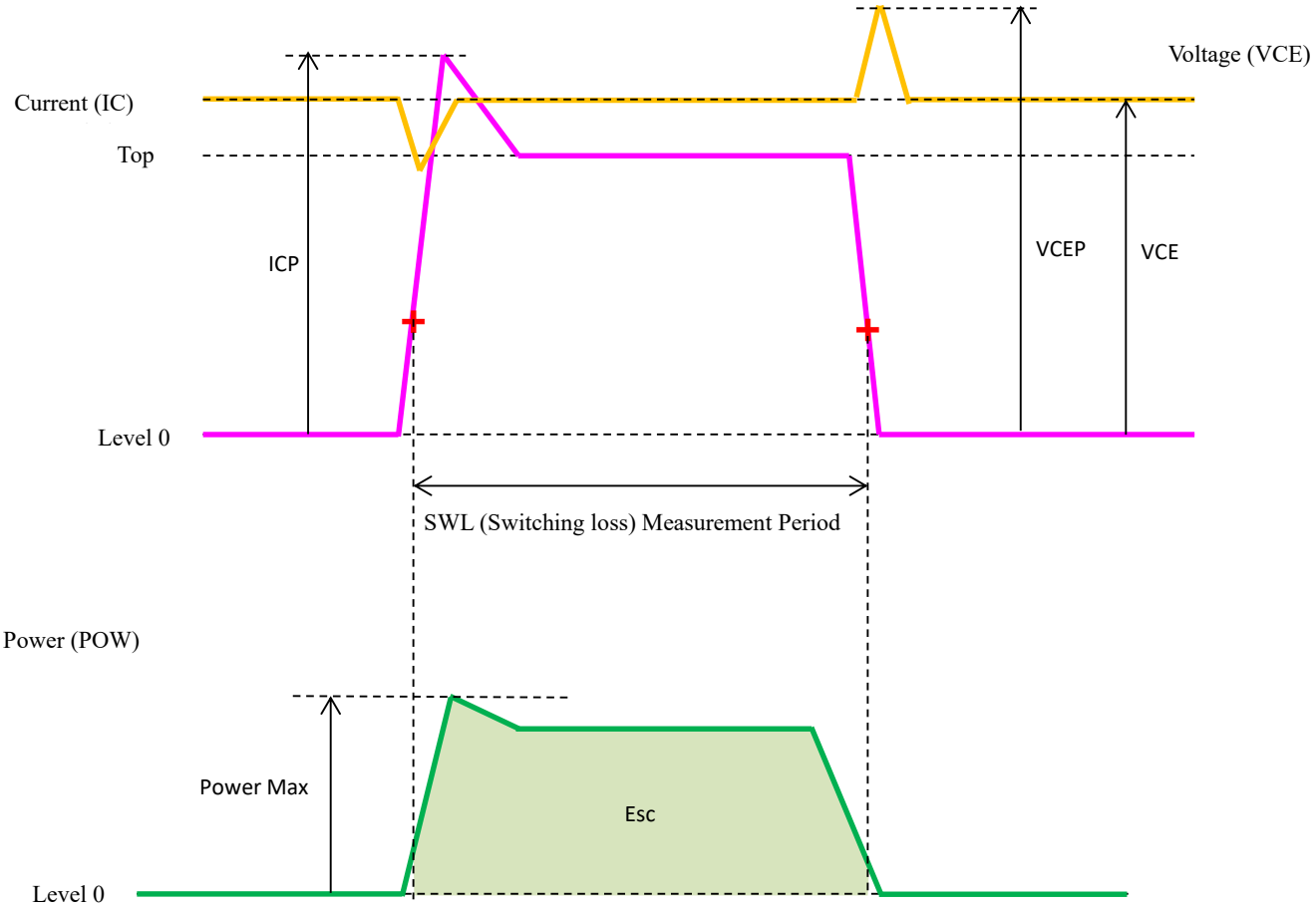


Fig 4.21 Measurement parameters and analysis results for short circuit measurement

4.6.2 V_{CE} / V_{DS} Tab

If the Measure type is IGBT or IPM, set the parameters related to collector to emitter voltage (V_{CE}); if the Measure type is MOSFET, set the parameters related to drain to source voltage (V_{DS}).

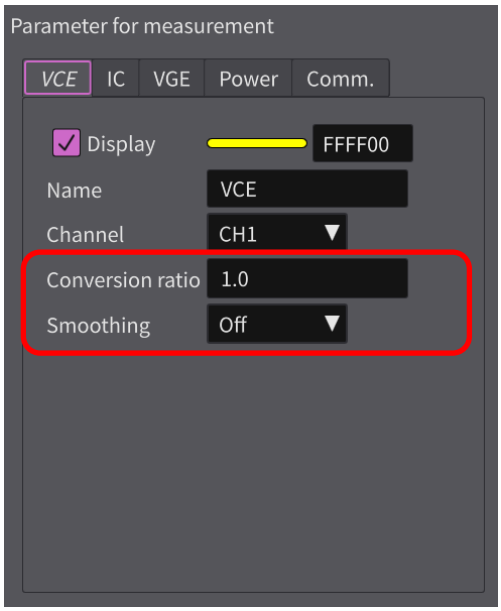


Fig 4.22 V_{CE} / V_{DS} Tab

Table 4.20 V_{CE} / V_{DS} Tab Setting

Parameter	Description	Default	Range	Resolution
Conversion ratio	Analysis is performed by multiplying the waveform value imported by the DS-8000 main unit software by a conversion factor.	1.0	0.1 to 1000	0.1
Smoothing	Voltage waveform smoothing process setting	Off	Off, 3 points, 5 points	

4.6.3 I_C / I_D Tab

If the Measure type is IGBT or IPM, set the parameters related to collector current (I_C); if the Measure type is MOSFET, set the parameters related to drain current (I_D).

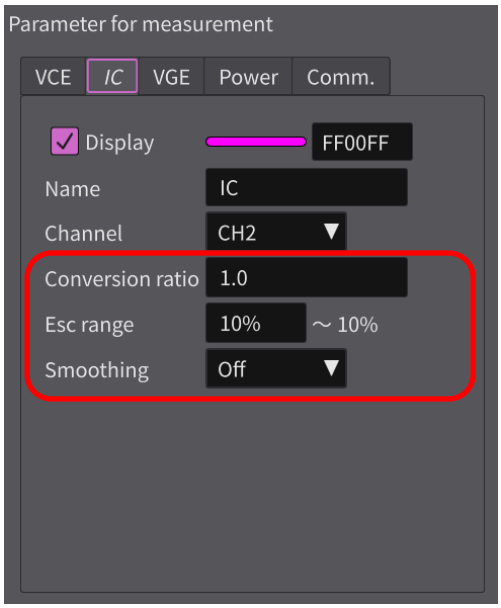


Fig 4.23 I_C / I_D Tab

Table 4.21 I_C / I_D Tab Setting

Parameter	Description	Default	Range	Resolution
Conversion ratio	Analysis is performed by multiplying the waveform value imported by the DS-8000 main unit software by a conversion factor.	1.0	0.1 to 1000	0.1
Esc range	Sets the range over which the switching loss Esc is to be determined. Set the starting point (left setting box) and the ending point (right setting box) in %. Determine Esc with I_C level 0 (0A) as 0% and I_C top level as 100%.	10%	1% to 99%	1%
Smoothing	Current waveform smoothing process setting	Off	Off, 3 points, 5 points	

4.6.4 V_{GE} / V_{CIN} / V_{GS} Tab

When Measure type is set to “Reverse recovery”, the V_{GE} / V_{CIN} / V_{GS} tabs are blank because there are no setting items in these tabs.

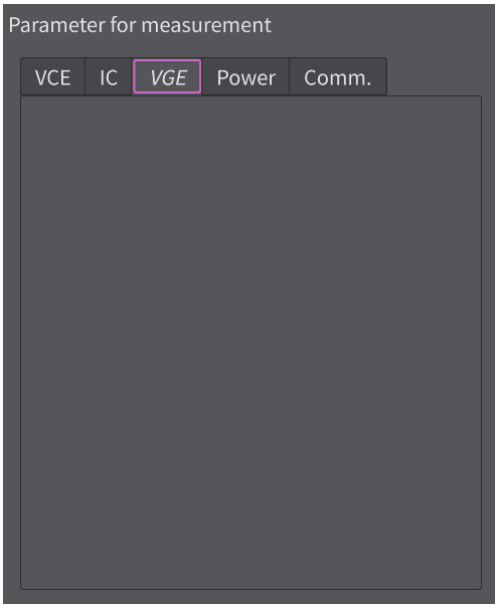


Fig 4.24 V_{GE} / V_{CIN} / V_{GS} Tab

4.6.5 **Power Tab**

The Power Tab sets items related to power (POW). Power (POW) is calculated by the following formula.

$$POW = V_{CE} \times I_C$$

Fig 4.25 Power Tab

Table 4.22 Power Tab Setting

Parameter	Description	Default	Range	Resolution
Level 0 (from bottom)	Set the 0 level of the displayed waveform in terms of the number of graticules (div) from the bottom of the screen.	4 div	0 div to 9 div	1 div
Unit	Sets the SI prefix to be displayed in units of power.	kW	W, kW, MW	
kW/div (0:Auto)	Sets the power unit per div. If blank or 0, it is automatically calculated.	0	0 kW/div to 100 kW/div	1 kW/div
Negative parts	Sets the treatment for negative values when calculating switching losses.	Add as it is	Add as it is, Exclude, Add Absolute	

4.6.6 **Result of analysis**

The table below shows the meaning of the analysis results.

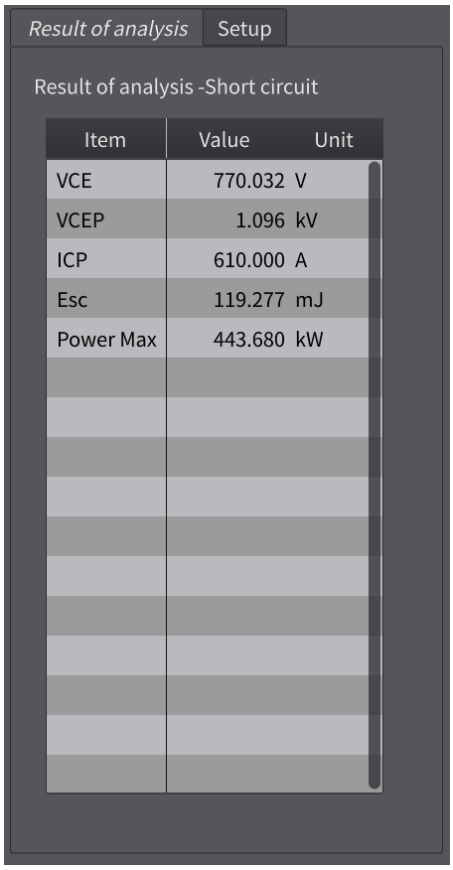


Fig 4.26 Result of analysis display

Table 4.23 Result of analysis

Result Analysis			Description	Unit
IGBT	IPM	MOSFET		
V_{CE}		V_{DS}	(Top level – Level 0 (0 V)) of V_{CE} or V_{DS}	V
V_{CEP}		V_{DSP}	(Peak – Level (0 V)) of V_{CE} or V_{DS}	V
I_{CP}		I_{DP}	(Pak – Level 0 (0 A) of I_C or I_{DP}	A
Esc			Turn-off loss. Energy loss (mJ) in the following ranges ・Start point: Switching loss measurement start point of I_C ・End point: Switching loss measurement end point of I_C	J
Power Max			+ Peak value of Power (POW) waveform	W

Chapter 5 Appendix

5.1 CSV file format in "Input from file"

The CSV file format for "Input from file" is as follows.

CSV Format Code	Description
Time/Point,1E-09	Specifies the sampling interval in NR3 format. If omitted, it is interpreted as 1E-09 sec.
Calc Range(Address),317,633	The analysis range is specified by address. If omitted, the range is from (data length/3) to (data length * 2/3).
//Wave Data	This is a comment line and may be omitted.
VCE(V),IC(A),VGE(V),POW(W)	This is the name of each waveform data. If it is omitted, subsequent CSV data will be treated as an array in this order.
105,-2,-15,-210	Thereafter, the waveform data is enumerated as CSV format. If at least VCE(V) and IC(A) data exist, it can be read. The maximum number of data is 1,000,000.
105,-2,-16.25,-210	
106.25,-0.4375,-14.375,-46.48438	
106.25,-2,-15.625,-212.5	
103.75,-3.5625,-15,-369.6094	
103.75,1.125,-15.625,116.7188	
103.75,1.125,-15.625,116.7188	
102.5,1.125,-15.625,115.3125	
102.5,-0.4375,-14.375,-44.84375	
…	
<EOF>	End-of-file code.

5.2 Data Format at Save

The data format for Save is shown below.

Data at Save	Description
//Data File Type,IGBT	Indicates what was selected in Type.
//Common Parameter Type,Turn On	Indicates what was selected in Measure type.
//Parameter VCE Input Ch,1 VCE Conv. Rate,1 VCE Smoothing(Points),No VCE Level0,0 VCE SWL Level(%),10 VCE dV/dt Range,90,10 IC Input Ch,2 IC Conv. Rate,1 IC Smoothing(Points),No IC Level0,0 IC SWL Level(%),10 IC Top Sel/Manual Value(V),0,1 Tr Range(Start:End)(%),10,90 Trr Range(Start:End)(%),90,50 VGE Input Ch,3 VGE Conv. Rate,1 VGE Smoothing(Points),No VGE Level0,0 VGE ton Start Level(%),0V Energy Process Type,0	Indicates the contents of “Parameter for measurement”.
//Result VCE(V),99.873962402344 IC(A),73.77640998506 ICP(V),201.629638671875 Irr(A),126.59761345244 ton(µs),0.284 Tr(µs),0.052 tdon(µs),0.232 Eon(mJ),3.538273546919 tcon(µs),0.72 Trr(µs),0.18 Power Max(kW),5424.095690250397 dIdt(A/µs),1135.021692077842 dIdt Max(A/µs),2343.75 (-)dIdt(A/µs),-1947.655591576002 dVdt(V/µs),-493.204752604167 dVdt Max(V/µs),-3125.000000000003	Indicates the contents of “Result of Analysis”.
//DSO Setup Wave Length(Points),6002 Time/Point,2e-09 Calc Range(Address),1,6000	Indicates the contents of the waveform data and the analysis range.
//Wave Data VCE Offset,0 IC Offset,0 VGE Offset,0 VCE(V),IC(A),VGE(V),POW(W),TIME(s) 105.341,-1.0376,-12.0941,-109.301,-6e-06 104.248,-0.610352,-14.7797,-63.628,-5.998e-06 105.817,-1.31836,-16.5176,-139.504,-5.996e-06 104.614,-2.31934,-14.4852,-242.636,-5.994e-06 107.239,-2.0874,-15.3687,-223.85,-5.992e-06 103.833,-3.63159,-13.765,-377.079,-5.99e-06 105.634,-2.47803,-15.3534,-261.763,-5.988e-06 105.133,-2.28882,-13.6627,-240.63,-5.986e-06 104.639,-2.76489,-15.4968,-289.315,-5.984e-06 104.95,-3.50952,-15.0986,-368.324,-5.982e-06 …	Waveform data offset values and waveform data represented in CSV format.
<EOF>	End-of-file code.

DS-821(DS8K SWA-SOFT)

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