Bi-Directional Control Thyristor

Product Information

ABB Semiconductors AG

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1. Introduction

The Bi-Directional Control Thyristor (BCT) is a new concept for high power phase control thyristors (PCTs) developed by ABB Semiconductors. Two anti-parallel high power thyristors are integrated onto one single silicon wafer and are assembled into one housing. This new feature will enable designers of static VAr compensators, static switches, soft starters and motor drives to meet higher demands concerning size, integration, reliability and cost for their end product.

ABB Semiconductors has developed this concept utilising 4“ and 5“ silicon technology aiming for a product matrix of 73, 84, 96 and 118 mm wafers and voltages from 1800 V to 6500 V. The range of 4“ devices (96 mm wafer) was released for production in 1998 and the 3“ (73 mm wafer), the 3.5“ (84 mm wafer) and the 5“ devices (118 mm wafer) are planned for release in 1999. The product range and the corresponding short form data are presented in section 2.

The basic product philosophy is the same as for the Phase Control Thyristors (PCTs). Standard devices are described in data sheets, and our flexibility in the irradiation and testing process gives opportunities for adapted standard devices.

The wafer design, the mechanical design, the manufacturing and the testing of the Bi-Directional Control Thyristors (BCTs) are based on the same technology and philosophy as for the well proven PCTs. In combination with the extensive qualification of newly developed devices this assures that the same high quality and reliability is achieved.

The Bi-Directional Control Thyristor (BCT) family is a strong complement to ABB Semiconductors' present PCT family, and our increased resources in application, customer technology, rating and evaluation assures that we continue to support our customers’ demands with an even more competitive product range.

2. BCT Product Matrix and Short Form Data

The matrix below gives an overview of the planned devices in the BCT family. All the data given below represents one "thyristor-half" of the device.

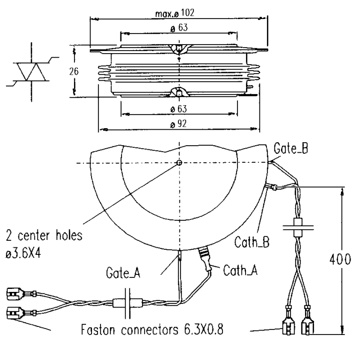
Type and ordering number	V_{SM} V	V_{RM} V	I_{TAVM} T_c=70°C A	I_{TSM} 10ms T_{vjm} kA	V_{TO} T_{vjm} V	r_t T_{vjm} mW	T_{vjm} °C	R_{thJC} K/kW	R_{thCH} K/kW	Housing type
5STB 16H2800	2800	2800	1580	18.0	0.82	0.37	125	16	10	H
5STB 18H1800	1800	1800	1845	21.0	0.83	0.23	125	16	10	H
5STB 09M6500	6500	5600	940	14.0	1.25	0.86	125	18	6	M
5STB 13N6500	6500	5600	1390	22.0	1.20	0.60	125	12	5	N
5STB 17N5200	5200	4400	1700	29.0	1.02	0.32	125	12	5	N
5STB 18N4200	4200	4200	1850	32.0	0.96	0.28	125	12	5	N
5STB 24N2800	2800	2800	2350	43.0	0.85	0.16	125	12	5	N
5STB 27N1800	1800	1800	3000	47.0	0.88	0.103	125	12	5	N
5STB 18U6500	6500	5600	1800	32.0	1.20	0.43	125	8	3	U
5STB 25U5200	5200	4400	2500	42.0	1.00	0.22	125	8	3	U

The devices in the N housing (96 mm wafer) except 5STB 27N1800 are available in production quantities in 1998.

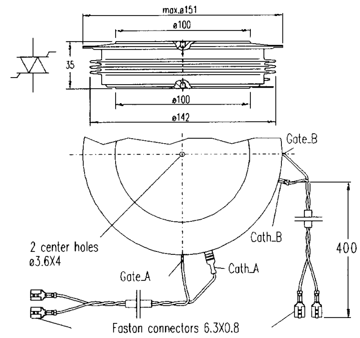
The devices in the U-type housing (118 mm wafer) are available in sample quantities in 1999 and in production quantities in 2000.

The device in the H housing (73 mm wafer), M housing (84 mm wafer) and the 5STB 27N1800 will be available upon request.

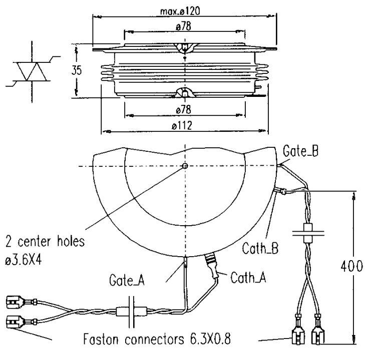
Final data sheets are released for the devices in N-housing and tentative data sheet are available for the other types. Final data sheets for those will be released as soon as the devices are approved and released for production.



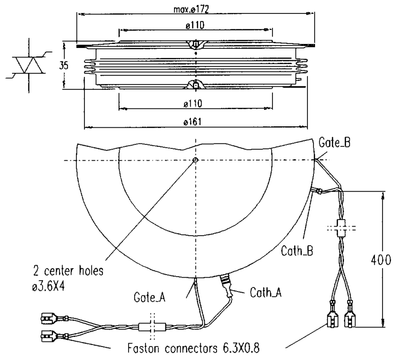
H-housing



N-housing



M-housing



U-housing

Fig. 2.1: Housing outline of the different BCT products.

3. BCT Design

The BCT is a unique device, bringing the customer the advantages of having two thyristors in one package: enabling more compact equipment design, simplifying the cooling system and increasing system reliability. The success of the BCT technology is based on its compatibility in process and design with ABB's well established PCT range. Reliability is guaranteed by our well proven negative bevel junction termination and free floating silicon technologies.

3.1 BCT Design Criteria

1. The electrical behaviour of a BCT corresponds to that of two anti-parallel thyristors (e.g. of approximately 27 cm^2 area each for the 96mm wafer diameter) integrated onto one silicon slice, (figure 3.1). Each thyristor-half performs like the corresponding full-wafer thyristor in respect to its static and dynamic properties.

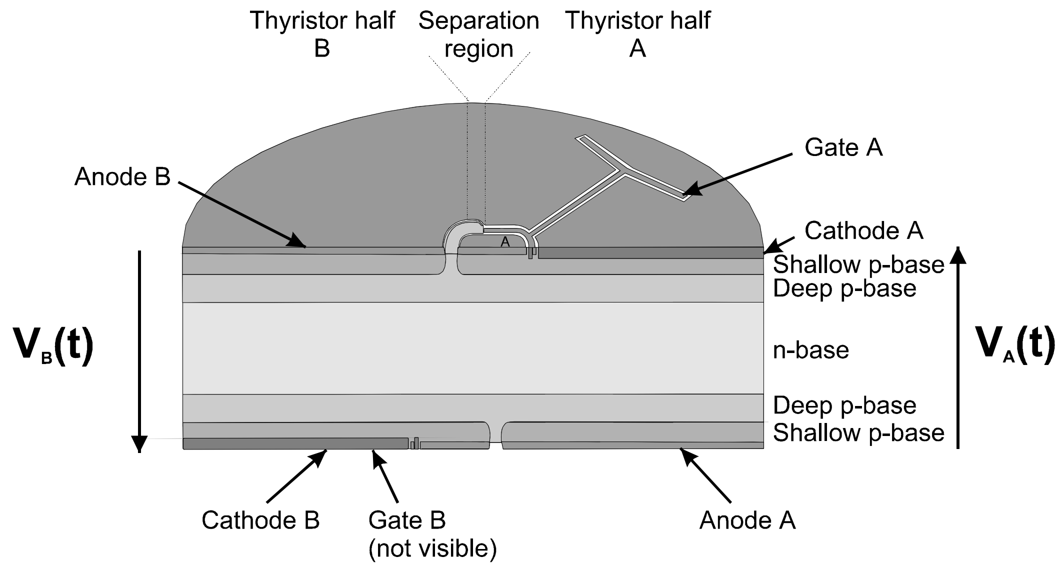


Fig. 3.1: Schematic cross-section of a BCT wafer showing A and B thyristor-halves and defining the two forward voltage directions $V_A(t)$ and $V_B(t)$. Later in the text these voltages will be labelled $V_{D(A)}(t)$ and $V_{D(B)}(t)$ for better clarity about forward and reverse directions.

2. A major challenge in the integration of the two thyristor-halves is crosstalk between the two halves. The photomask set has been designed with a high focus on avoiding harmful crosstalk effects under all relevant operating conditions.

3. Electrical performance shows very high uniformity between the two halves in device parameters such as reverse recovery charge and on-state voltage. This is demonstrated in figures 3.2 and 3.3. Figure 3.2 compares the spread in (Q) for the A thyristor-halves against the spread for the B thyristor-halves for 33 devices tuned by electron irradiation to have a fixed on-state voltage. Figure 3.3 shows leakage current distributions at 4400 V and 110°C.

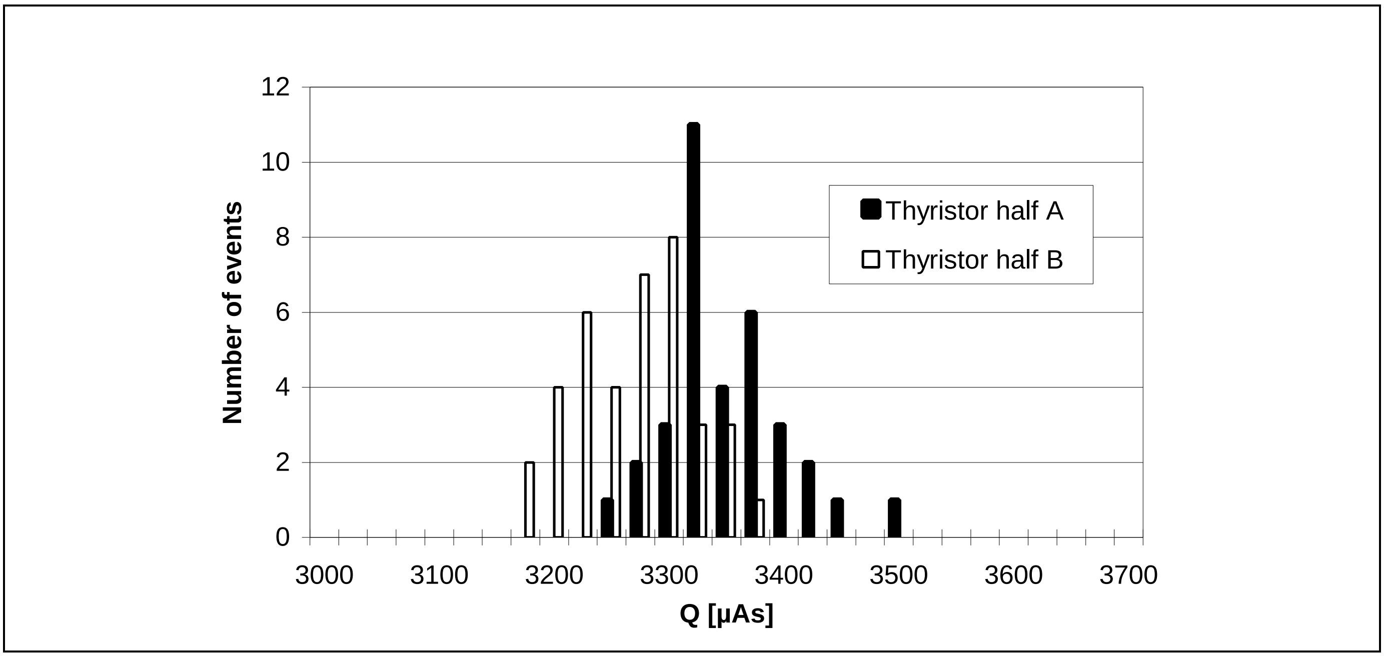


Fig. 3.2: Histogram of the reverse recovery charge distribution of the A and the B thyristor-halves in a sample of 33 BCT devices.

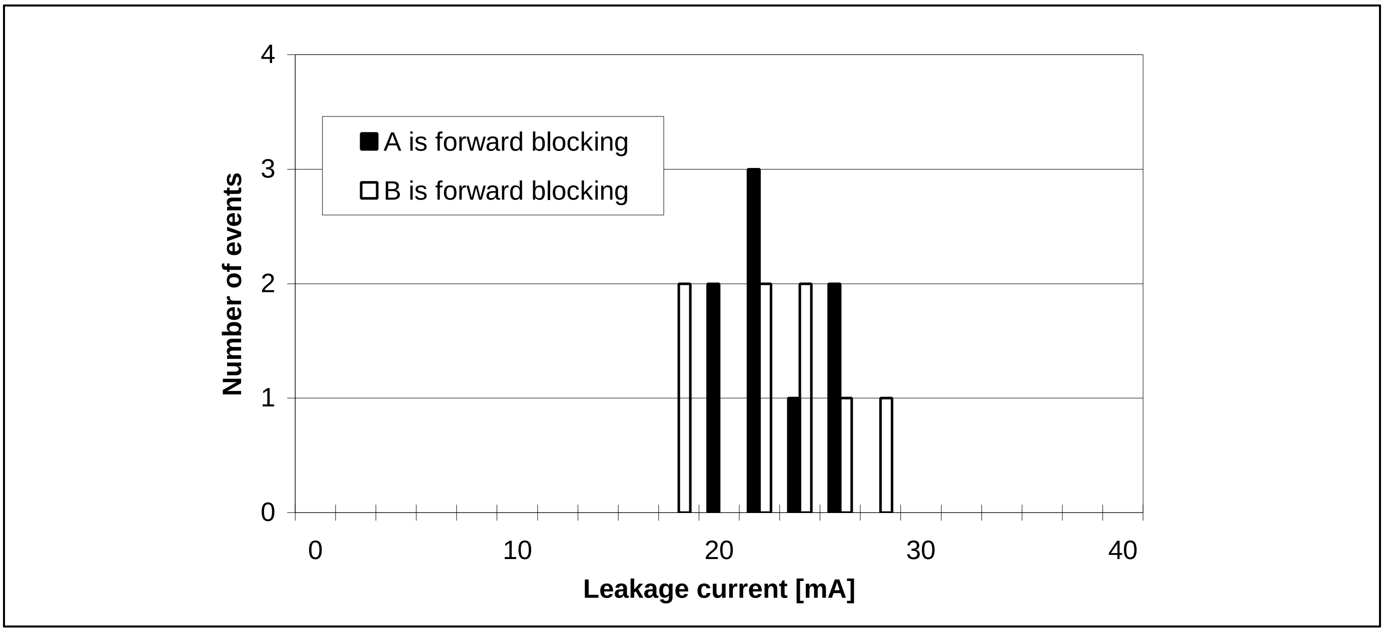


Fig. 3.3: Histogram of the leakage current at 4400 V and 110 °C for the A and the B thyristor-halves blocking in forward direction. Sample of 8 BCT devices.

3.2 Special BCT Features

1. Under off-state blocking conditions no unique reverse direction exists, both voltage polarities correspond to forward blocking states of the A thyristor-half or the B thyristor-half respectively. This has an effect on the specification and on the parameter terminology. There is therefore no extra reverse blocking requirement as in a standard Phase Controlled Thyristor (PCT).

2. The BCT wafer has anode and cathode regions on each face. The A and B thyristors are identified on the wafer by letters A, B on the central gate metallisation, (figure 3.1).

3. The BCT housings have been designed to correspond in size to our standard PCT range. The cathode of the A thyristor-half faces the large flange side of the housing (the cathode side of a standard PCT element). The cathode connections to the B thyristor-half are made through the wall of the ceramic nearest the unflanged side (the anode side of the standard PCT element).

Differently sized connectors to the A and B thyristor gate and cathode pairs prevent the false connection of the device during installation and maintenance. Fixed current collectors and specially machined molybdenum discs allow accurate and reliable centering of the wafer sandwich in the housing without the need for centering rings. Outlines of the housing dimensions are given in the BCT product matrix (figure 2.1).

3.3 Surge Current Behaviour of a BCT

In a classical thyristor the maximum allowable surge current depends on whether reverse or forward voltage is applied after the current transient. The most critical case is forward voltage.

Evidently in a BCT, a reverse voltage V_R for the A thyristor is simultaneously a forward voltage V_D for the B thyristor (fig. 3.4). Yet it makes a difference if the re-applied voltage after a surge current pulse is positive (in forward direction) with respect to the thyristor which was formerly conducting (thyristor A for example, case 1) or positive with respect to its counterpart B which was formerly not conducting (case 2). In the situation corresponding to re-applied forward voltage for a classical thyristor (case 1), the surge current limit of a BCT is similar to the one of a classical thyristor of equal area. In the case often relevant for SVC applications, however, where a classical thyristor is exposed to reverse re-applied voltage only, i.e. case 2, a situation unique to the BCT appears, where the edge regions 1 and 2 close to the separation region are the most sensitive. The mask layout has been designed such that the separation region is strong enough to prevent failure in these sensitive regions.

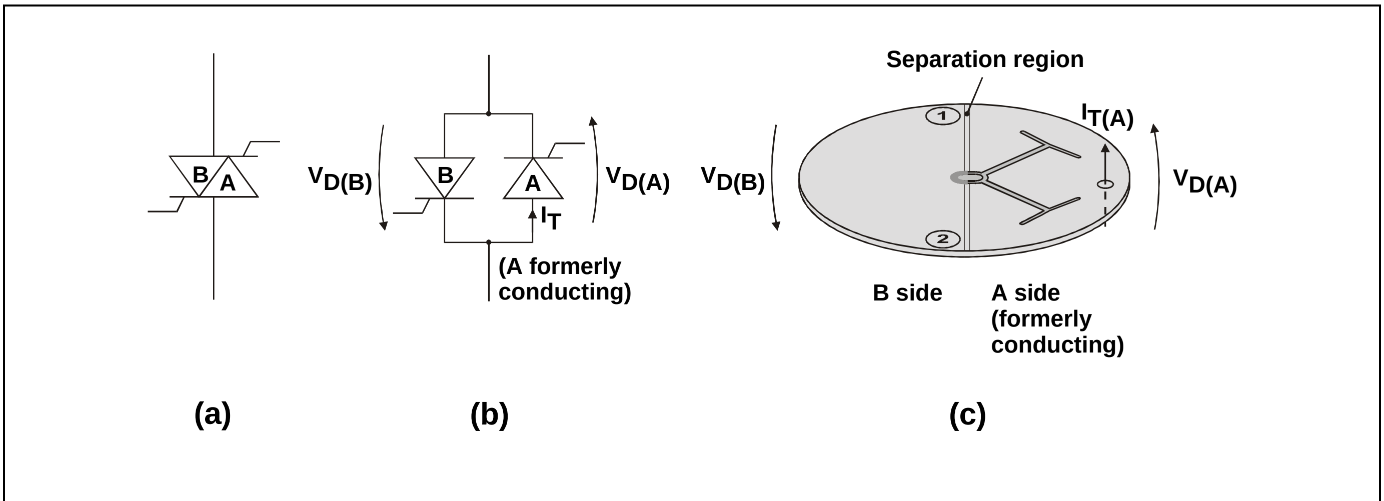


Fig. 3.4: Currents and voltages after turn-off of the A thyristor. (a): circuit diagram, (b): separated into two thyristors, (c): schematic view of the wafer. The regions 1 and 2 are the most sensitive in respect to surge current (with re-applied "reverse" voltage) and the t_q capability of a BCT.

3.4 Crosstalk and t_q

Again, the integration of the two thyristors on one wafer leads to a unique situation when the tq limit is approached in the application. The reason is again that the reverse voltage used to turn the conducting thyristor-half A off is a positive voltage for its counterpart (fig. 3.5). The regions 1 and 2 as well as their connecting area would be the most sensitive locations. The photomask set of the BCT has been conceived with particular attention to maintaining the tq capability of two separated thyristors.

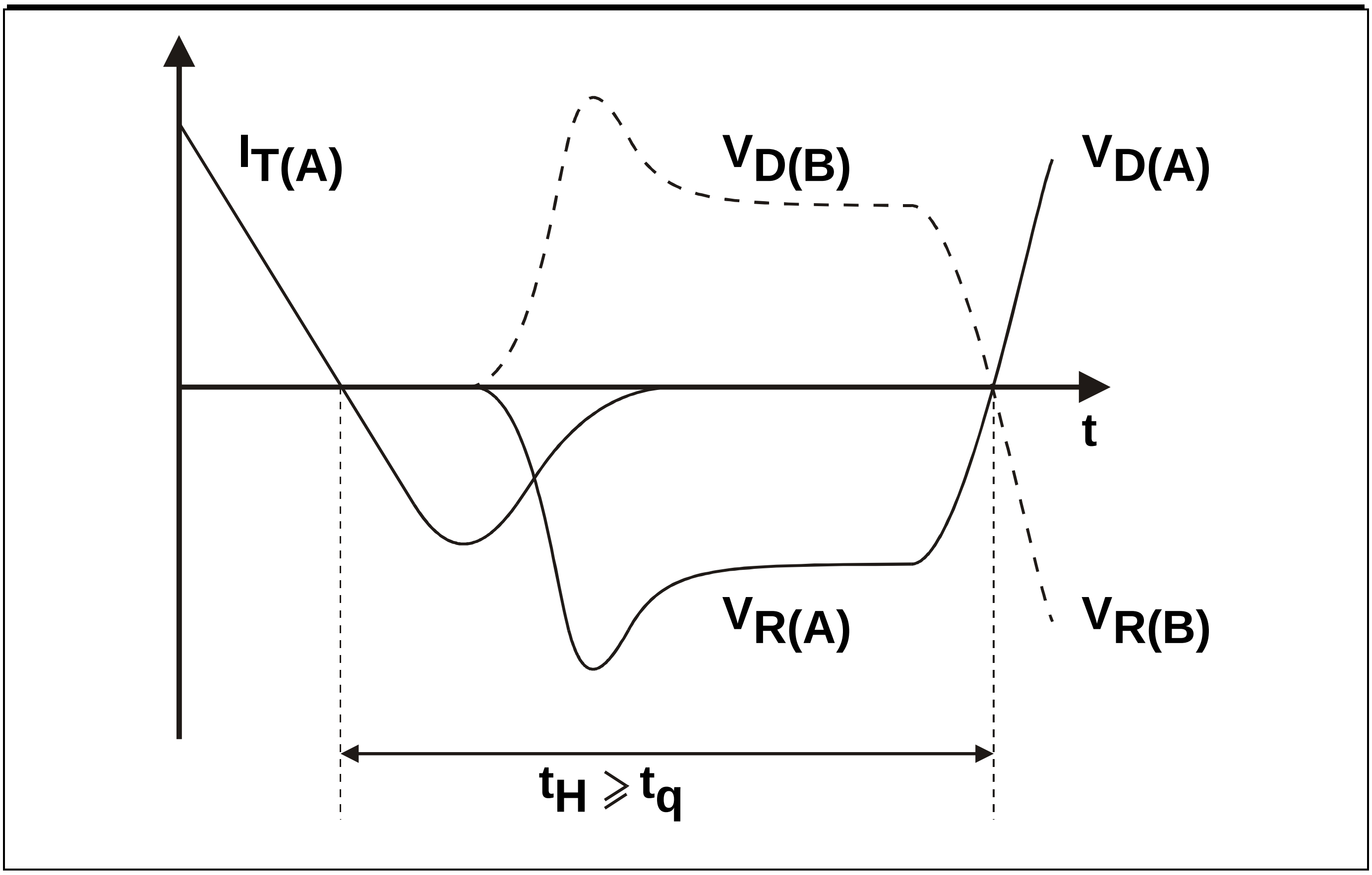


Fig. 3.5: Typical current and voltage waveforms after turn-off of the A thyristor. A reverse voltage for the A thyristor-half is simultaneously a forward voltage for the B thyristor-half. The holding time t_H has to be larger than or equal to the recovery time t_q of the BCT.

3.5 Quality and Reliability

3.5.1 Quality

Since a BCT is basically nothing more than two thyristors integrated on one wafer, most quality issues can be handled as for classical thyristors. The BCT-specific parameters are tested separately in addition to satisfy all quality requirements as described below in section 5. In particular, crosstalk tests are an essential part of the qualification procedure.

3.5.2 Reliability

From the design point of view, load cycling is expected to induce different stresses and movements in the device housing than in a classical thyristor. In our experiments, however, no perceivable difference in load cycle capability has been found.

In comparison with the classical thyristor, the BCT has no need for other high-voltage blocking junction termination measures. In particular, the separation region does not carry significant lateral voltage drops; it is even short-circuited by the metallisation on both wafer sides. Therefore, the voltage blocking reliability is by design as good as that of a classical thyristor.

The full characterisation and approval procedure is elucidated in section 5.

4. BCT User's Guide

As it was mentioned before, the BCT is a new way of monolithically integrating two high performance PCTs (Phase Control Thyristors) on the same silicon wafer in one housing. Consequently, the definitions and the characterising parameters of a BCT are practically almost the same as those of a PCT. Yet there are a few exceptions which will be explained in this section. The definitions and parameters not explained in this document are described in the ABB Semiconductors PCT data book. The data book also gives application information for PCTs which is applicable to BCTs as well.

4.1 BCT-Specific Features

4.1.1 Mechanical Design

To reduce logistical problems for both manufacturer and customer, most mechanical parts are the same for the BCT and the PCT. This brings the advantage of having the outer dimensions and the clamping forces for the BCT the same as for the standard PCT range of ABB Semiconductors. This enables the user to have the same mechanical clamping design for both PCT as BCT, which gives a good cost optimisation potential in applications where both PCTs and BCTs are used. One major difference exists though, and that is that the BCT has two gate and two auxiliary cathode contacts.

Connecting the gate wire intended for thyristor A to that of thyristor B and vice versa will in most applications lead to destruction of one or several components. To avoid this, the cathode contact on side A has a fast-on connector of size 6.3 x 0.8 mm, while the cathode contact on side B is a fast-on connector of size 4.8 x 0.8 mm. This feature makes the mounting procedure safe, since it is not possible to connect the wrong gate wire set on either side.

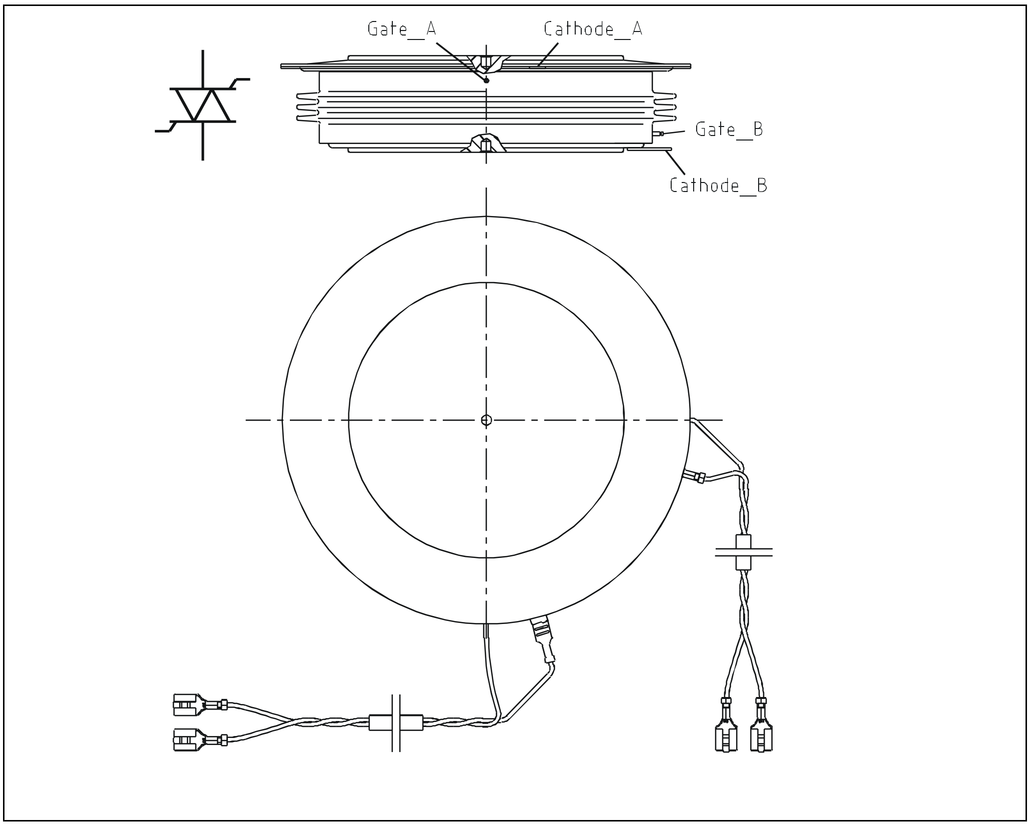


Fig. 4.1: BCT outline showing the gate and the cathode. At the housing wall, different connectors are used for the A and B thyristor-halves to avoid incorrect connection of the gate wires.

4.1.2 Electrical Parameters

As far as most electrical parameters are concerned, the BCT data is the same as for the standard PCT range. This enables the user, for example, to utilise the same gate driver units for both types of devices.

The BCT design makes it necessary to define certain parameters in a different way to a standard PCT. The absence of a unique reverse direction makes the PCT differentiation between forward and reverse voltages obsolete. The BCT device has forward blocking voltage characteristics in both directions. The blocking voltage and current parameters necessary to specify a BCT are the following:

V_{RM} is the maximum repetitive voltage level that the BCT is able to block in either direction. The voltage is defined for half-sine voltage pulses of a line frequency of 50 or 60 Hz. Exceeding the specified maximum V_{RM} will lead to uncontrolled triggering or thermal runaway which usually ends with device failure.

I_{RM} specifies the maximum leakage current when V_{RM} is applied. It is measured with 50 Hz half sine pulses at T_{vjmax}. A decrease in junction temperature will lead to a decreased leakage current.

V_{SM} is the maximum surge voltage level the BCT is able to block. V_{SM} represents the BCT's ability to withstand non-repetitive voltage transients with a pulse width of 10 ms or less, which may be caused by over-voltage transients due to switching. Exceeding V_{SM} can lead to uncontrolled triggering and to device destruction.

In our documentation, V_{SM} is not specified for devices with V_{RM} < 4400 V, since for those devices V_{RM} and V_{SM} are equal over the whole temperature range.

For devices with V_{SM} > 4400 V, V_{SM} and V_{RM} are equal for junction temperatures up to 110 °C. For temperatures below 110 °C, it is possible to utilise values of V_{RM} up to V_{SM}. As an example, it is possible to use the 5STB 13N6500 at $V_{RM} = V_{SM}$ = 6500 V at T_{vj}

< 110 °C, while V_{RM} = 5600 V must not be exceeded at T_{vj} = 125 °C.

I_{SM} specifies the maximum leakage current when V_{SM} is applied. It is measured at T_{vjmax} with t_p = 10 ms. Again, a decrease in junction temperature will lead to a decreased leakage current.

For the definition of the parameters I_{TSM}, Q, t_q, V_{GD}, I_{GD}, $(di/dt)_{crit}$, $(dv/dt)_{crit}$ and t_d in the data sheets, the abbreviations V_D and V_R are used. V_D is a voltage in the forward direction of the thyristor-half that will be or just has been triggered, in the case of t_d, or just has conducted current, in the case of Q and t_q. Analogously, V_R is a voltage in the reverse direction of the thyristor-half that is active for the parameter described.

The design and manufacturing technology of ABB Semiconductors makes it possible to produce BCTs with two thyristor functions with almost identical behaviour. For each electrical parameter, one value or one curve only is given in the data sheet. The value or curve given is valid for both thyristor functions in the BCT. One set of curves and data is sufficient for the application circuit design, and, from an electrical point of view, no particular care has to be taken in which direction the device is being mounted.

4.1.3 Thermal Parameters

The thermal resistance data and the thermal impedance curve are given for one thyristor half with the condition that both thyristors are in operation as in an SVC or a soft starter. Due to radial heat spreading the thermal values for operation with only one thyristor half at the time, as example in a DC-drive, will be slightly reduced. Studies of this effect are on-going and it is foreseen that new revisions of the data sheets include two thermal resistance figures. One for both thyristor halves operating and one for only one thyristor half operating.

4.2 Application Examples

The BCT has been developed as a complement to the standard PCT product range of ABB Semiconductors. The target was to reduce cost and thereby to increase the competitiveness of our customers in those areas where the common encapsulation of the two anti-parallel thyristors yields advantages. In this paragraph, three application examples are given which show the advantage of using the BCT in comparison with a standard PCT solution. One advantage common to all three examples is the increased reliability. The BCT is produced in the same manufacturing facility as our PCTs, and it uses the same basic parts, resulting in a product with the same high MTTF figure as each of our standard PCTs. Since one BCT replaces two PCTs, now, the MTTF for the whole assembly significantly improves. In addition, as can be seen in the application examples, the number of other (mechanical and electrical) parts is also reduced, so that a further increase in reliability for the whole equipment can be obtained.

4.2.1 Static VAr Compensation (SVC)

For efficient power transmission, the reactive power consumed by asynchronous motors or arc furnaces, for example, has to be compensated, to keep the power factor on the transmission line close to unity. One of several means to accomplish this is Static VAr Compensation. SVC has the advantage over rotating compensators that it lacks moving parts. The components included in an SVC installation are capacitors, inductors and thyristor stacks. The thyristor stacks consist of a number of series-connected thyristors, which normally have additional components in parallel to them. These components serve to reduce the voltage stresses caused by the turn-off process of the thyristor and to share static and transient voltages equally between the thyristors. For the sharing of transient voltages as well as for the reduction of the turn-off over-voltage peak, a resistor and a capacitor in series are often used. The sharing of the static voltage is kept equal by placing additional resistors parallel to each thyristor.

Since each stack of standard thyristors can only conduct current in one direction, two stacks have to be used in parallel for each phase of the equipment. This means that all mechanical parts needed, such as heat sinks, insulators and clamps as well as some of the electrical components have to be used for each current direction, as can be seen in figure 4.2. Using BCTs instead of PCTs, as in figure 4.2, only one stack per phase is needed, since the current can now be controlled in both directions. Depending on the choice of the system solution, the required number of electrical and mechanical components will be reduced by 10 - 30 %.

This reduction has a significant impact on cost and foot print and enables the SVC manufacturer to substantially raise the competitiveness of his product.

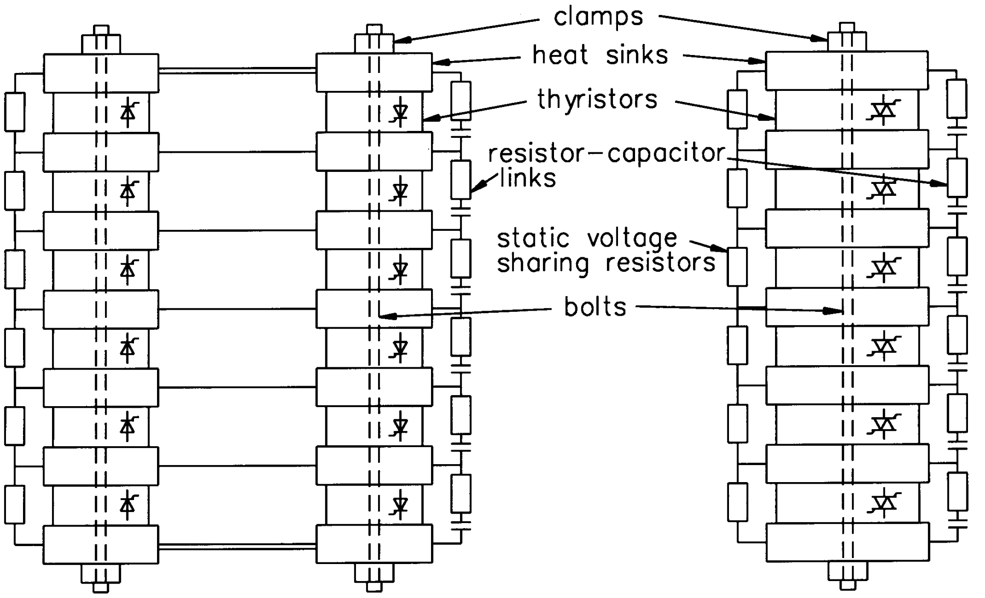


Fig. 4.2: Comparison between SVC thyristor stack assemblies with a conventional PCT solution on the left and a BCT solution on the right. For the stack itself, the BCT solution needs only 50 % of the mechanical and electrical parts that are used in the PCT solution.

4.2.2 Motor Drives

To control the speed of electrical motors, an AC or DC drive is commonly used, since other means of regulating the speed have become too costly and consume too much energy. The main application areas for the BCT in drives equipment are in DC drives and in feeding sections for AC drives with return (regeneration) of energy to the power grid during breaking. Another application area is that of cyclo-converters for large synchronous motors. The application example chosen below is a regenerative DC drive.

The standard solution for a regenerative DC drive is the so-called *(B6C)2* connection, which consists of two fully controlled rectifiers in anti-parallel connection. This is accomplished by using an assembly with 12 thyristors. An example of this is given in figure 4.3.

When BCTs are utilised, a *(B6C)2* bridge is built with only 6 semiconductor components. Depending on the solution used, the *(B6C)2* bridge then has either a reduced height or width. The use of the BCT in this application enables a more compact solution requiring less mechanical components like heat sinks and supports. The choice of a more compact solution again means a foot print reduction for a larger system, like a rolling mill line-up, by about 10 - 30 %. This is a major cost saving, since building electrical rooms is quite expensive. It can also enable high power drives equipment to be located in rooms with reduced height, as in a harbour crane, avoiding paralleling of low power bridges when more power is needed. This solution is drawn in figure 4.3. The user can not normally save on RC-circuit and fuse cost after substituting BCTs, since these components are already shared in the classical PCT solution.

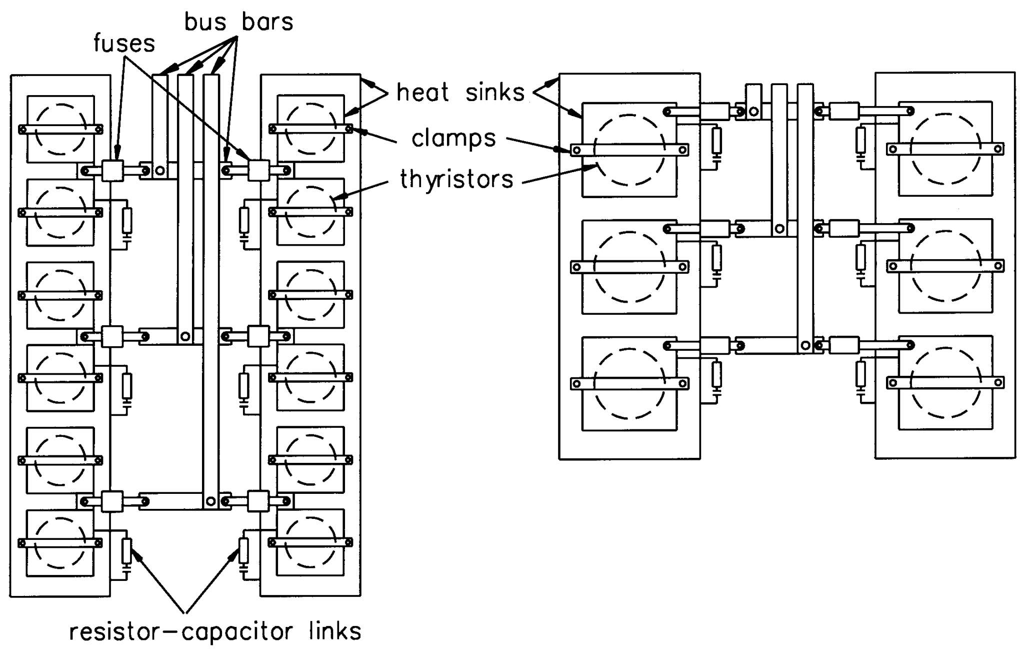


Fig. 4.3: Comparison between PCT and BCT assemblies for four-quadrant DC drives. The left assembly is using PCTs, and the right one is made of BCTs. The example shows the possibility of reducing height when using BCTs which enables high power DC drives to be installed in locations with height restrictions, like a harbour crane.

4.2.3 Soft Starters

When starting an asynchronous machine which is directly fed from a three-phase supply net, the machine and the feeding circuit will be heavily loaded by the high starting currents. To reduce this stress, a soft starter is often used. This soft starter consists of pairs of anti-parallel thyristors having one pair per phase. As can be seen in figure 4.4, these anti-parallel thyristors can be directly replaced by a BCT. As for the DC drive, this substitution leads to a reduced number of mechanical parts like mounting clamps, and it enables a more compact solution.

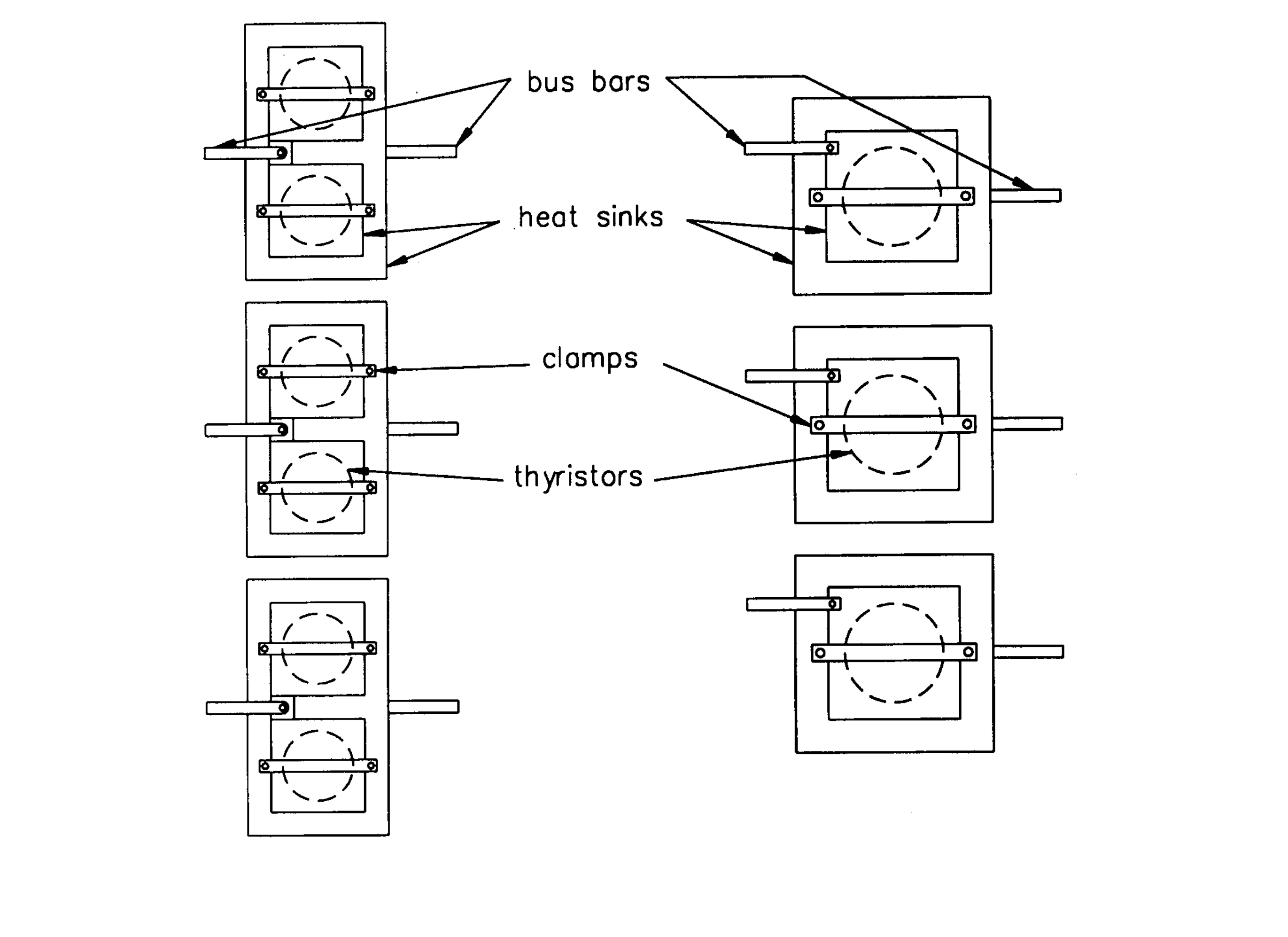


Fig. 4.4: Comparison of three-phase soft starter assemblies using PCTs and BCTs. The left assembly is made of PCTs, and the right one is using BCTs. The BCT solution enables a reduction in the number of required mechanical parts and therefore in size.

4.2.4 Improvement potential in using the BCT

BCT designs offer considerable volume and part counts reduction over conventional PCT ones. The table below summarises expected improvements by application and power level.

Application	Power level	Anticipated average volume improvement (*)	Anticipated average parts count reduction (*)
DC-drive	800 kW	30%	30%
DC-drive	2000 kW	30%	25%
Soft starter	250 kW	25%	20%
Soft starter	450 kW	30%	20&
SVC_B	50 MVAr	35%	35%

(*) Compared to conventional PCT solutions.

5. Production Testing and Product Qualification

The testing of a Bi-Directional Control Thyristor (BCT) is based on the same testing sequence and philosophy as the one for the well proven PCT. In combination with the extensive qualification of the newly developed devices this assures that the same high quality and reliability are achieved. The routine production testing as well as the qualification test procedures are described below.

Sections 4.6 and 4.7 of the 1996 edition of the PCT data book of ABB Semiconductors describe related documents and standards as well as product traceability and failure analysis. These sections are also applicable to the BCT.

5.1 General Production Testing

Group A Testing:
100% Routine Production Testing

The basic electrical parameter testing is performed at the wafer level (before and after electron irradiation) and after packaging (standard or customised final test procedure), exactly as for PCTs.

The main difference lies in the fact that the BCT has two thyristor-halves (A and B), so that the device has to be measured twice with respect to many parameters. Examples are:

Q_A: recovery charge of thyristor-half A,
Q_B: recovery charge of thyristor-half B,
V_{RMA}: maximum forward repetitive voltage for thyristor-half A,
V_{RMB}: maximum forward repetitive voltage for thyristor-half B.

The table below shows the parameters that are 100% routine tested in production.

Parameter	Temperature	Type of test	Protocols	Remark
V_{RMA}	25/125°C	100%	test report	
V_{RMB}	25/125°C	100%	test report	
V_{SMA}	125°C	100%	test report	for 5200 and 6500V devices
V_{SMB}	125°C	100%	test report	for 5200 and 6500V devices
dv/dt $crit_A$	125°C	100%	test report	tested on wafer level
dv/dt $crit_B$	125°C	100%	test report	tested on wafer level
Q_A	125°C	100%	test report	tested on wafer level
Q_B	125°C	100%	test report	tested on wafer level
V_{TA}	125°C	100%	test report	
V_{TB}	125°C	100%	test report	
I_{GTA}	25°C	100%	test report	
V_{GTA}	25°C	100%	test report	
I_{GTB}	25°C	100%	test report	
V_{GTB}	25°C	100%	test report	
t_{qA}	125°C	100%	test report	for adapted standards, tested on wafer level
t_{qB}	125°C	100%	test report	for adapted standards, tested on wafer level
I_{TSMA}	125°C	100%	test report	for adapted standards
I_{TSMB}	125°C	100%	test report	for adapted standards

I_{TSM} with re-applied voltage and t_q are the most common requirements for measurements of adapted standard products. Other parameters not listed in the table may equally be agreed upon.

The test reports are the computer print-outs of the final test. Since dv/dt, Q and t_q are measured at *wafer level,* these values are included in the test report where this is required by the customer.

The test sequence and the lay-out of the test report for adapted standard products are defined in the *spec review process* as described in the PCT data book.

Group B Testing: Lot Control Tests (Scheduled Product Audits)

In order to assure and to monitor the long-term voltage stability, Group B testing may be integrated for final screening. Eight devices per selected lot undergo a voltage stability test for 24 h at $V_{DC\ A,B}$ = 2/3 V_{RM} ($V_{DC\ A}$ = DC forward voltage at thyristor-half A, V_{RM} = maximum forward repetitive voltage). A typical pass criterion is that the drift of the leakage current be ≤ 0.2 mA.

Examination or Test		Reference Documents		Inspection Requirements		
Sub-group	**Test Category**	**IEC Ref.** ***MIL-STD-750C Ref.***	**Conditions**	**n**	**c**	**Notes**
B2	Endurance: DC blocking	1048	24 h at T_C = 80°C...T_{vjmax} V_A, V_B = 2/3 V_{RM}	8	0	

5.2 Qualification Approval Tests and Qualification Maintenance Tests

For the BCT qualification procedure it has been particularly necessary to introduce an additional characterisation test assuring that there is no disturbing interaction between the two separated anti-parallel thyristor-halves located on the wafer. This so-called "crosstalk test" is performed as follows.

For the BCT crosstalk test, a circuit as shown in fig. 5.1 is utilised. A capacitor (C = 1 mF) is charged up to 2500 V and is then discharged (i_{Tmax} = 2000 A) through an inductor (L = 1.3 mH) after the BCT is triggered. When, for example, thyristor-half A is turned off, a reverse voltage develops across it. This voltage is simultaneously a forward voltage for thyristor-half B (figure 3.5). The peak amplitude depends on the capacitance and the resistance of the snubber used. With our set-up, it is somewhat below V_{SM}.

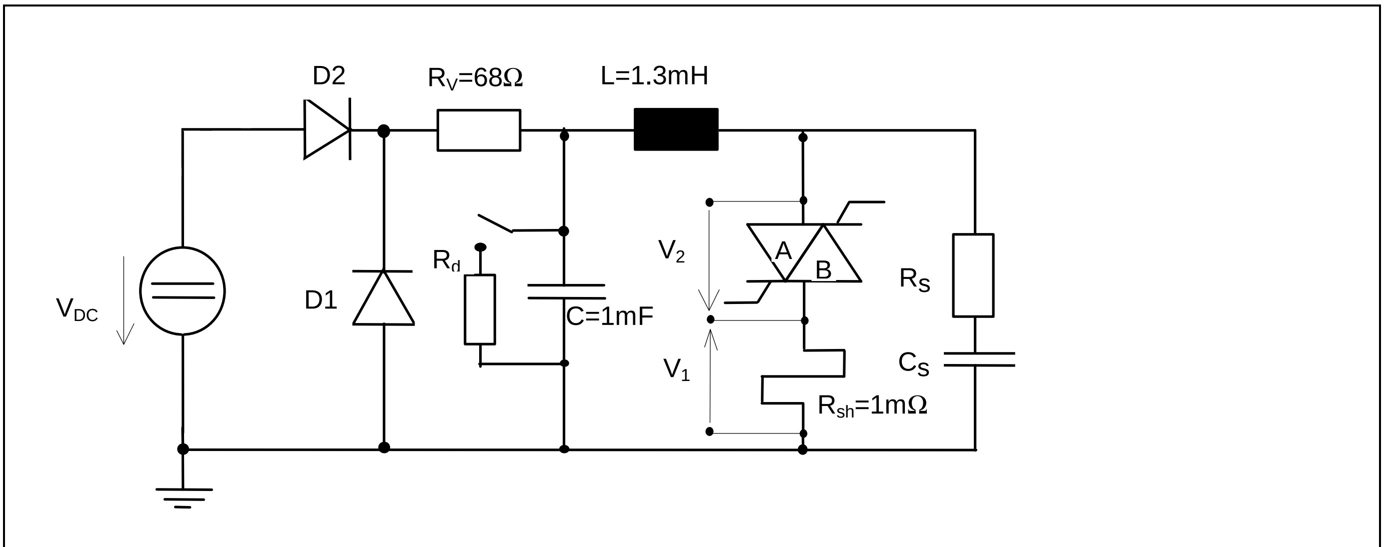


Fig. 5.1: Test circuit for the crosstalk measurement

The new designs undergo rigorous qualification testing (Group D testing), whereby the data sheet values are verified and the reliability ascertained: this is an essential part of our development model. The BCTs are qualified and released for production and sale when the defined tests have been passed. Most of these tests are also part of the bi-annual reliability monitoring tests (Group C testing). The table below summarises ABB Semiconductors' commitment to reliability.

Examination or Test		Reference Documents		Inspection Requirements		
Sub-group	**Test Category**	**IEC** MIL 750C JIS C 7021	**Conditions**	**n**	**c**	**Notes**
D1a	Characteristics inspection	Internal Ref.	Parameters and quantities see applicable test specification			
D1b	Complementary characteristics inspection	Internal Ref.	Parameters and quantities see applicable test specification			
D1c	Verification of maximum ratings	Internal Ref.	Parameters and quantities see applicable test specification			
D2	Endurance: Storage at high temperature	68-2-2 1031.4 7021 B-10	1000 h at T_{stg} max	10	0	Note 1
D3	Endurance: Storage at low temperature	68-2-1 Aa 7021 B-12	500 h at T_{stg} min	10	0	Note 1
D4	Endurance: AC blocking	747-6 V	1000 h at T_{vj} max Sine wave 50 Hz $V_{D(R)}$ = 0.7...0.8 $V_{D(R)RM}$	8	0	Note 1
D5	Endurance: DC blocking	1048 7021 B-20	1000 h at 90°C...T_{vj} max $V_{D(R)}$ = 0.7...0.8 $V_{D(R)RM}$	8	0	Note 1
D6	Endurance: DC blocking	Internal Ref.	1000 h at T_C = 25°C $V_{D(R)} = V_{D(R)RM}$ (or de-rated voltage)	30		Note 4
D7	Endurance: Thermal cycling load (Thermal fatigue)	747-6 IV, 4 1037.1 7021 B-18	ΔT_{vj} = 80°C ... 100°C $1 \cdot 10^5$ cycles (Traction) $0.2 \cdot 10^5$ cycles (Industry)	12	0	Note 1
D8	Endurance: Operating life	Internal Ref.	$1 \cdot 10^6$ on/off cycles with I_{TGQM} and V_D max, specific drive and snubber circuits	10	0	Note 4
D9	Rapid change of temperature	68-2-14 Nc 1056.2 7021 A-3	0°C to 100°C, 15 cycles, liquid to liquid	10	0	Note 1
D10a	Shock	68-2-27 Ea 2016.2 7021 A-7	Components in stack a = 50 gn, 11 ms, 3 shocks per direction	4	0	Note 2
D10b	Vibration	68-2-6 Fc 2056 7021 A-10	Components in stack 10 to 500 Hz, d ≤ 0.75 mm, a ≤ 10 gn, 10 cycles per axis, 113 min	4	0	Note 2
D11a	Shock	68-2-27 Ea 2016.2	Components in transport box a = 50 gn, 11 ms, 3 shocks per direction	4	0	Note 2
D11b	Impact Shock (Bump)	68-2-29 Eb	Components in transport box a = 40 gn, 6 ms, 1000 shocks per direction	4	0	Note 2
D11c	Vibration	68-2-6 Fc 2056	Components in transport box 10 to 500 Hz, d ≤ 0.35 mm, a ≤ 5 gn, 10 cycles per axis, 120 min	4	0	Note 2
D12	Salt mist	68-2-11 Ka 1046.2	35°C, 5% NaCl, 7 days	4	0	Note 3
D13	Robustness of terminations	68-2-21 2036.3 A 7021 A-11	Tension, 40 N, 10 s	4	0	

Notes:

1.) Failure criteria for Diodes:
I_{RRM} (T_{vj} max) < 1.1 USL, V_{FM} < 1.1 USL
Failure criteria for Thyristors:
I_{RRM}, I_{DRM} (T_{vj}max) < 1.1 USL,
V_{GT} (25°C) < 1.1 USL,
V_{TM} (T_{vj} max) < 1.1 USL
2.) Failure criteria for all Puck devices: Integrity of package materials, wafers, sealing, lead connections
The device must meet requirements listed under note 1.
3.) Failure criteria for all Puck devices: No significant corrosion.
4.) Not applicable for BCT-devices.

6. Customer Technology and Application Support

For most applications the explicit data sheets of ABB Semiconductors give sufficient information to design a powerful and competitive application circuit. In some cases, however, for customer projects with revised or new circuit concepts, it may be that a somewhat different set of thyristor parameters is desirable. This includes the trade-off between conduction and switching losses, but it often goes beyond that. As is also described above and in the ABB Semiconductors PCT data book, a so-called "adapted standard" product can be produced in a manner analogous to the standard PCT thyristors.

During development of new circuit technologies and concepts, it often happens that very specific device data and relationships are needed which cannot be extracted from the data sheets. Moreover, the customer may need support and advice about how to most efficiently utilise and control the semiconductor device in his new circuit. ABB Semiconductors has a wealth of experience to offer in this field as well. This includes areas such as power loss calculations, temperature calculations under transient conditions, or gate driving. Very powerful and versatile tools are available to perform application-oriented simulations of device behaviour as well as to perform special application-oriented tests on our semiconductor devices.

If you need information or support in one of the above areas, please contact our sales organisation or your nearest ABB Semiconductors agent.

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