Japan Comments for Battery Durability GTR EVE37

8.September.2020

1 .SOH metric as explained at EVE-34th by Japan (see P.3)

The physically or technically correct metric should be allowed.

1) For the verification of SOH, both range method and capacity method will be prepared.
(OEM responsibility for SOH calculation algorithm)

2) The above. will be verified by ISC _ Part _ A (Range or Capacity)

3) SOH criteria (MPR) have to be the same numerical values for Range and/or Capacity

The SOH indicator for each indicator (below) is the difference from the certified value in the WLTP Type I test.

F (UBE _ now / UBE _ measured @ ta)
F (EAC _ now / EAC _ measured @ ta)
F (Range _ now / Range @ ta = CoC)

There is a concern about UBE/EAC because the value measured at Type I test is the base value.
(See detailed explanation on page 4).

Definitions is important in SOH metric discussion (matrix summarized in the WLTP.)

Terminology	PEV	OVC-HEV	note
Electric Consumption	E_{AC}/PER	E_{AC}/EAER	
Metric :Capacity (UBE)	$\Sigma \Delta E_{REESS}$	NA	Battery supply energy during WLTP operation (Wh)
Metric :Capacity (E_{AC})	power supplied from the power supply(Wh)		
Metric :Range (PER or EAER)	UBE/EC_{DC} ($EC_{DC} = \Delta E_{REESS}/d$)	$\left(\frac{M_{CO2,CS,declared} - M_{CO2,CD,avg} \times \frac{M_{CO2,CD,declared}}{M_{CO2,CD,ave}}}{M_{CO2,CS,declared}}\right) \times R_{CDC}$	

Range: 1) Range based on WLTP . 2) Range under current driving conditions (for user information).
We should consider 1) as "Range" here comparing with the other SOH metrics.

[PROPOSAL] State of Health monitor (SOH)

Revised EVE34-15e

1）Definition of SOH :

The **capacity estimation value in the ECU** should be used in phase 1 of GTR

2）Methods of verification ISC_Part_A

These TWO methods should be prepared.

<EV range method >

SOH = Current EV Range/EV Range in CoC @ WLTP

<Capacity method* >

SOH = Current EAC / EAC in Certification Test report of WLTP

where, the denominator (EAC)is the value of the test report at the time of authentication.

i) For third-party evaluations or verification , make test report values available for them.

or ii) Add EAC to CoC, if necessary

***Need for Capacity Method**

It is desirable to prepare a verification method in consideration of the **development of HDV** with larger difference of Electric consumption depending on the vehicle type and **Re-use of the In-vehicle battery** to other purposes.

If the degradation of the electric consumption is considered to be negligible small, EV Range method and capacity method can be considered to produce the same results. [evidence in P.11]

[for information] Basic formula of SOH in ECU

SOH in ECU = Current Estimated Usable Capacity/Cert. Vehicle Usable Capacity(fixed value)

EV Range(in ECU)= Usable capacity in ECU / Electric consumption (fixed value).

The effect of Electric consumption degradation is negligible smal.

2.JARI reanalysis results

JC08モード	No blended mode	車両B N=1	車両B N=2	1回目と2回目の差の割合 Diff 1 &2	catalog 認証値反映	SOH
UBE [kWh]	エンジンONまで	5.35	5.37	-0.4	N/A	
距離 [km]	EAER/AER	68.8	67.4	2.1	68.2	99.9
Eac [kWh]		6.09	6.09	0.0	6.47	94.1
電費 [km/kWh]	UBE(エンジンON)	12.86	12.55	2.4		
電費 [Wh/km]		77.78	79.69	-2.4		
電費 [km/kWh]	Eac	11.30	11.07	2.1	10.54	
電費 [Wh/km]		88.52	90.36	-2.1		
実測容量 [Ah]		22.44		-	25	89.8

EV range is the certified declared value.

Eac :measured value @ cert test
EC :measured capacity/declared cert. range

<PROBLEM>
SOH by range and SOH by Eac are different.
<99.9> **<94.1>**
If the electric consumption is the same,
it should be well correlated.

The different reason is:
Measured range @ Cert. > declared cert. range

トヨタ プリウスPHV 主要諸元表 **Spec table of Prius PHV in Japan**

		A プレミアム	"レザーパッケージ"	A
車両型式・重量・性能	車両型式	DLA-ZVW52-AHXHB	DLA-ZVW52-AHXGB(L)	DLA-ZVW52-AHXGB
	車両重量 kg	1,530[1,550]		
	車両総重量 kg	1,750[1,770]		
	最小回転半径 m	5.1[5.4]		
	ハイブリッド JC08モード 燃料消費率 (国土交通省審査値) km/L	37.2[30.8]		
	主要燃費改善対策	可変バルブタイミング、アイドリングストップ装置、電動パワーステアリング、プラグインハ		
	充電電力使用時走行距離*1 (プラグインレンジ、国土交通省審査値) km	AER 68.2[55.2]		
	EV走行換算距離*1 (等価EVレンジ、国土交通省審査値) km	EAER 68.2[55.2]		
	電力消費率(国土交通省審査値) km/kWh	10.54[8.65]*2		
	一充電消費電力量 kWh/回	Eac 6.47[6.38]*2		

*2.AC200V/16A充電時の値。

<proposal>
Both UBE and EAC require definition of certification value* as well as EV range
***) declared or adjustment factor**

SOH based on certified vehicle range: 72.4 km (P.5)

	1回目 N=1	2回目 N=2	平均 average
SOH_Eac	94.1	94.1	**94.1**
SOH_Range_cert.	100.9	98.8	99.9
SOH_Range_meas.	95	93.1	**94.1**

If the definitions set together, there is a good correlation.
SOH_range varies more than SOH_Eac

Prius PHV certification report

PACT－2016－007

NATIONAL TRAFFIC SAFETY AND ENVIRONMENT LABORATORY
NTSEL
TYPE APPROVAL TEST
'16.07.19
JAPAN

F-2

電気式プラグインハイブリッド自動車の燃料消費率試験記録

[redacted]

◎試験自動車

車名・型式(類別)：トヨタ　DLA-ZVW52　型　(AHXHB)　用途：　乗　用

[redacted]

車台番号：[redacted]　原動機型式：　2ZR　型　サイクル：　4　気筒：　4

走行キロ数：[redacted] km　総排気量：　1.797　L　最高出力：[redacted]

車両重量：　1530　kg　変速機：　自動　前進　無　段　減速比：　3.218

等価慣性重量（設定値）：　1590　kg　使用燃料：　ﾚｷﾞｭﾗｰ･電気併用式　[redacted]

◎試験成績

○ＣＤレンジ（R_{CD}）

[redacted]

○等価ＥＶレンジ（R_{EEV}）

等価ＥＶレンジ
72.4 ∨ km

EAER

○ＣＳ燃料消費率（FC_{CS}）

[redacted]

○ＣＤ燃料消費率（FC_{CD}）

$FC_{CD(N-1)}$	ＣＤ燃料消費率
[redacted]	

○一充電消費電力量（E_1）

E_{CSS}	E_{CSC}	一充電消費電力量
[redacted] kW-h		6.47 kW-h

EAC

○電力量消費率（EC_{CD}）

電力量消費率
[redacted]

3. Electric Consumption :EAC/PER <kWh/km>

Deterioration in Electric Consumption

1) Decrease in range (PER)

(1) Reduction of Battery Capacity
(2) Increase in the internal resistance of the battery
(3) Deterioration of efficiency of electric power train components (Inverter loss, motor loss, etc.)
(4) Market conditions (Air conditioners, heaters, changes in running resistance, etc.)
← This is outside the scope of the IWG and will not be discussed**.**

2) Increase in the amount of charge from the outlet (Eac)

(1) Deterioration of charger efficiency
(2) Increase in the internal resistance of the battery

Electric consumption:
The relationship between denominator (range) and numerator (EAC) is considered.

1. Since both the battery capacity and the internal resistance are in the denominator and the numerator , the degradation effect should be offset.
2. Excluding the actual market conditions, only the efficiency change of the charger and the electric power train(*) will affect the Electric Consumption EC.

(*) Actual data of in use vehicles or durability test results, which will show the impact of electric consumption, will be prepared and presented in the coming EVE-XX.

PEV：EC Effects due to Battery Degradation

$$EC_{WLTC} = \frac{E_{AC}}{PER_{WLTC}} \longrightarrow PER_{WLTC} = \frac{UBE_{STP}}{EC_{DC,WLTC}} \longrightarrow EC_{DC,WLTC} = \sum_{j=1}^{2} EC_{DC,WLTC,j} \times K_{WLTC,j}$$

Electric Consumption

Range

UBEstp is the battery discharge energy before the vehicle speed cannot maintain its criteria.
ECdc,wltc is the electricity consumption during the cycle.
The concern ;How the battery degradation effect to ECdc,wltc ?

where ECdc is Σ (V * I)/actual mileage during cycle.
The actual cycle distance in DS does not change (Variation exists).
Does battery degradation affect voltage and current?
The energy required to run the cycle is equal before and after degradation.
If the motor efficiency is the same, the same VxI is supplied from battery. It means Battery does not affect Σ (V * I).
Accordingly,
ECdc,wltc are not affected by the battery degradation.

UBE_{STP} is the usable REESS energy determined from the beginning of the shortened Type 1 test procedure until the break-off criterion as defined in paragraph 3.4.4.2.3. of this annex is reached, Wh;

$EC_{DC,WLTC}$ is the weighted electric energy consumption for the applicable WLTP test cycle of the shortened Type 1 test procedure Type 1 test, Wh/km;

and

$$UBE_{STP} = \Delta E_{REESS,DS_1} + \Delta E_{REESS,DS_2} + \Delta E_{REESS,CSS_M} + \Delta E_{REESS,CCS_E}$$

where:

$\Delta E_{REESS,DS_1}$ is the electric energy change of all REESSs during DS_1 of the shortened Type 1 test procedure, Wh;

$\Delta E_{REESS,DS_2}$ is the electric energy change of all REESSs during DS_2 of the shortened Type 1 test procedure, Wh;

$\Delta E_{REESS,CSS_M}$ is the electric energy change of all REESSs during CSS_M of the shortened Type 1 test procedure, Wh;

$\Delta E_{REESS,CSS_E}$ is the electric energy change of all REESSs during CSS_E of the

With the decrease in capacity and the increase in internal resistance, the time required to maintain the output voltage becomes shorter, the UBEstp decreases. Measuring UBE shows the range effect of battery degradation.

4.Secondary use of batteries

With regard to secondary use of batteries in this GTR, we would like to confirm whether the secondary use of batteries will be described in Phase 1, and if YES, what items should be considered.

<Examples to be considered>

1) The battery used in vehicle A as a new vehicle might be regulated with SOH of the secondary use of batteries in different vehicle B as a new vehicle in the future.
   The degradation of the vehicle B from the time of certification must be evaluated.
   In this case, it is necessary to discuss measures of COP of vehicles using secondary use of batteries and where to place responsibility for those batteries.

2) How should it be handled when it is used as a spare or substitute battery?

<Proposal>

When you will discuss the handling of secondary batteries, in parallel with the preparation of the GTR draft (Phase 1), which is required to be developed in a short period of time,
Will the another task team be considered to start?

5. Information about SAE-OBD-PID

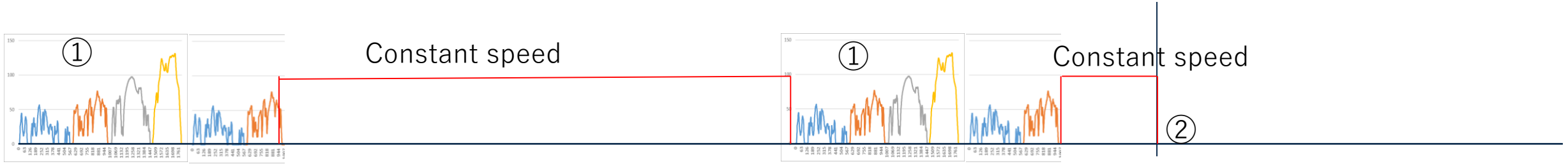
1)Progress of SAE-J 1979

0xB2	0xF4B2	**Traction Battery Pack Performance Retention Rate**						
		Traction Battery Pack Performance Retention Rate	A	0%	100%	100/255%	BAT_RET: xxx.x%	BAT_RET shall inform the percent retention rate of in vehicle battery energy performance representative of EV range for the electrified vehicle, expressed as a percentage from the initial performance. Commonly referred to as a variety of State Of Health (SOH). BAT_RET= 100 X [current vehicle battery energy performance representative of EV range for the electrified vehicle] / [the initial performance]

Japan has already applied “ SOH “ for the purpose of our guideline to SAE and PID has been given.
It will be published in October because it will be voted and published together with J 1979 -2 (Response to the CARB OBD revision) which is currently underway.

Appendix

: **Shortened Test Procedure**

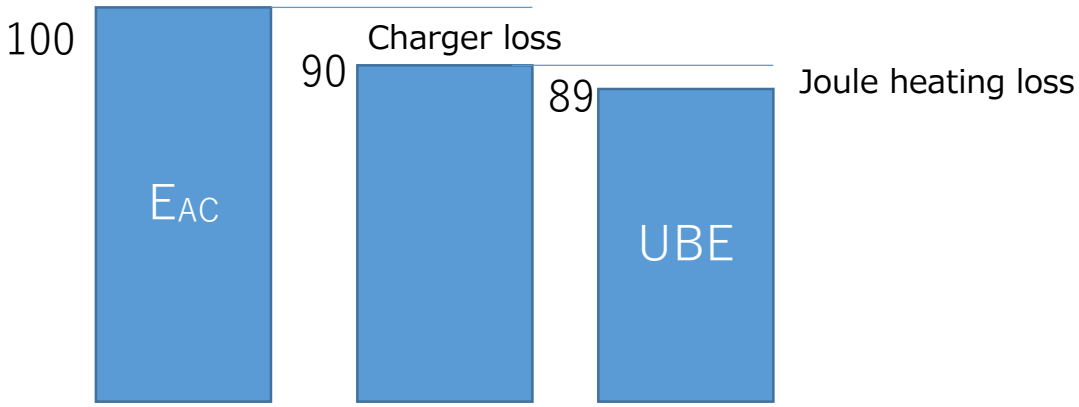


① : Measuring **cycle EC** (kWh/km) from Σ voltage x current and cycle travel distance

② : Measure Σ voltage x current to the point where the vehicle cannot maintain criteria. (= > **UBE**: kWh)

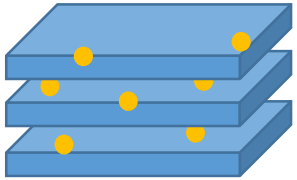
EV range (km) calculated from **UBE** (kWh)/**cycle EC** (kWh/km)

Relationship between EAC and UBE as seen from the electricity input



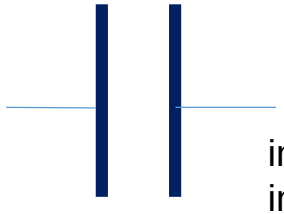
Main factor for the degradation of electric consumption

Battery (simplified model)



$Li(X)O_2+C \longleftrightarrow Li_{1-x}(X)O_2+Li_x$

Chemical reactions (characteristic change)

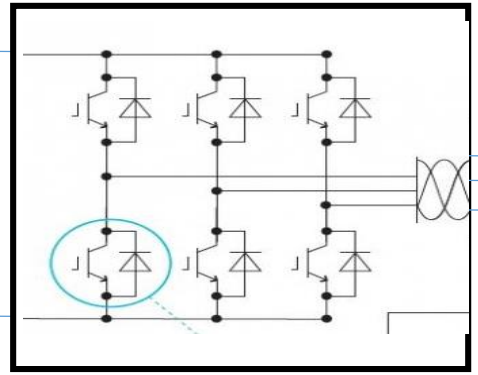


internal resistance increase

capacity decrease

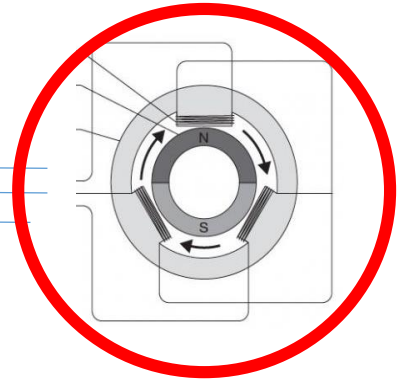
Measure : V,I

Inverter



switching loss increase

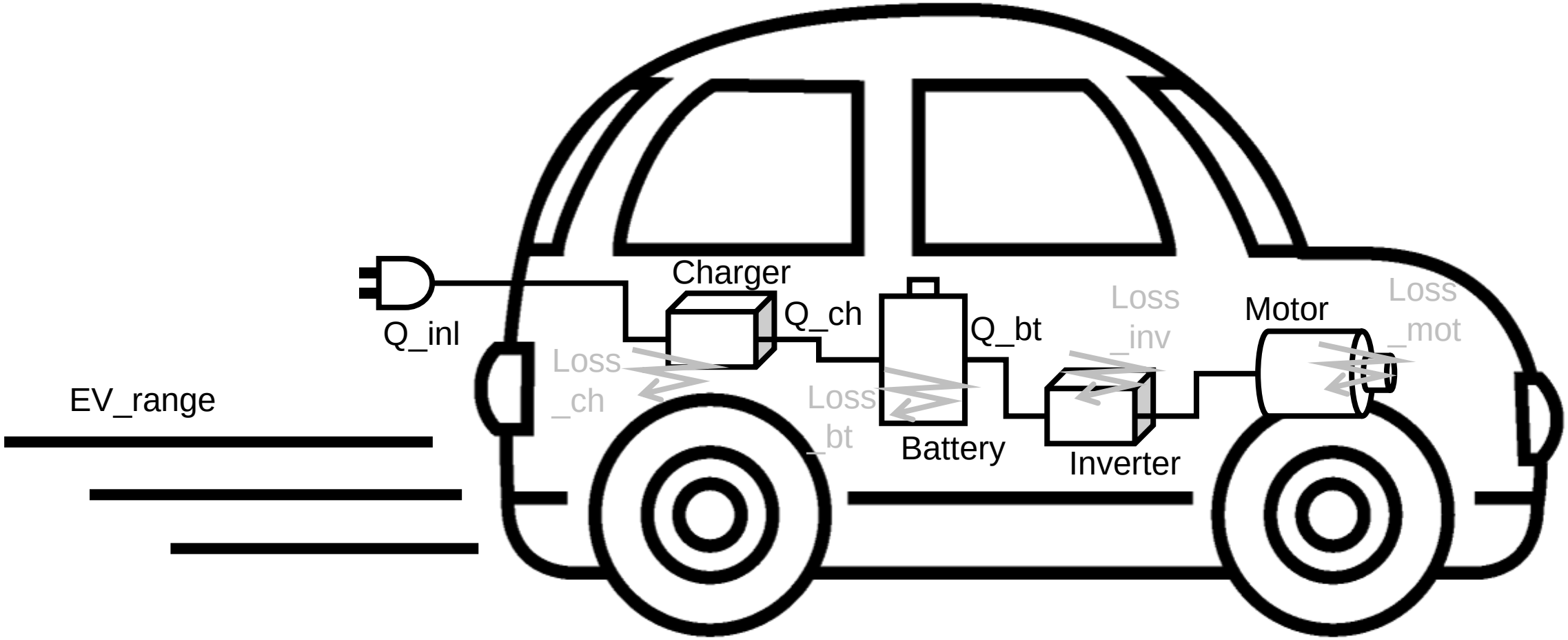
Motor



Motor efficiency deterioration and demagnetization
increase in friction loss

DATA required: Comparison between new and durable components

1.Inverter efficiency (It can be substituted by the single durability result.)
2.Motor performance (It can be substituted for the single unit durability result.)
3.Battery performance
 The effect of the increase in internal resistance should be minimal.



EV_range = f(Q_bt, Loss_bt, Loss_inv, Loss_mot,)
UBE = g(Q_bt, Loss_bt)