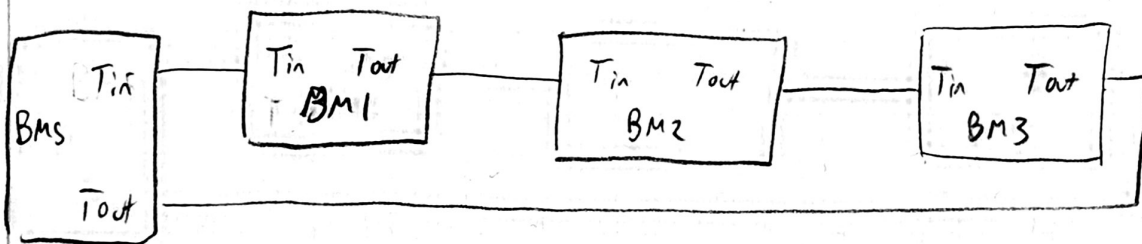# How does Startup Sequence Work?

How do we think Startup Sequence works?

Definitions
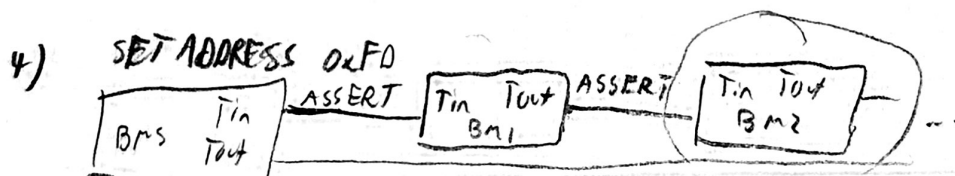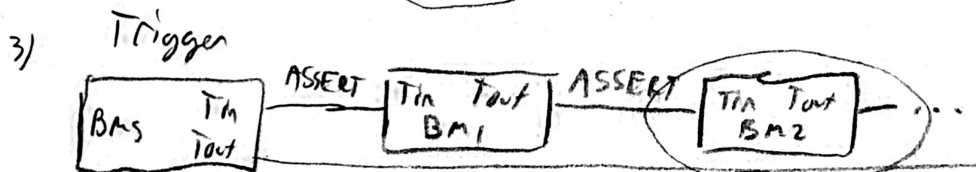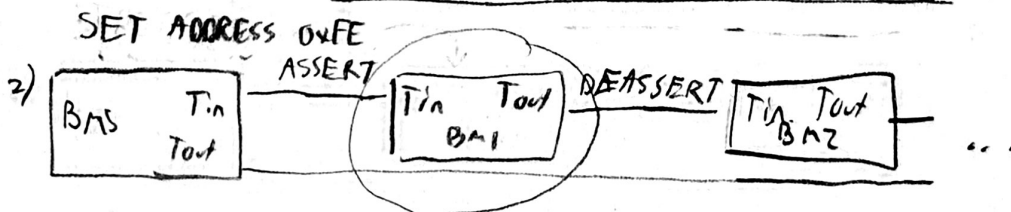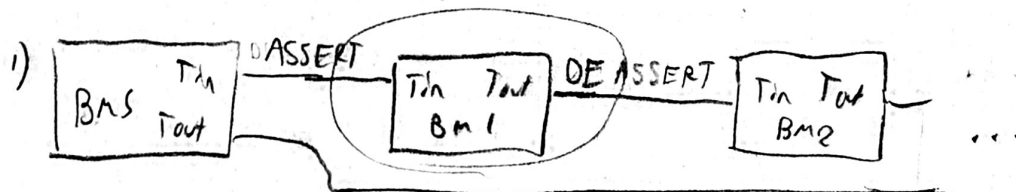- Active =
- Assert =

How are addresses captured?

→ "The global broadcast command causes the one BM with an active TRIGGER_IN input to capture the address for itself. An acknowledge packet is sent back to the BMS containing the captured address and fixed address. code 0x7F"

→

How does this work to sequentially give each BM an address?

Hypothesis 1
- sending "TRIGGER" causes each module, at the time it receives this command, to sample its Tin and some short time later, output that same signal on Tout. This in the beginning:
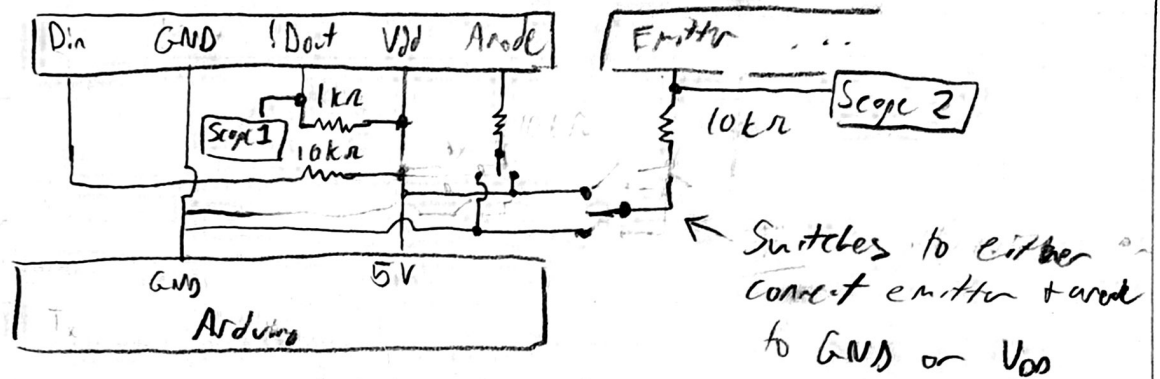
1)

DASSERT ... DEASSERT

SET ADDRESS 0xFE

2)

ASSERT ... DEASSERT

3) Trigger

ASSERT ... ASSERT

4) SET ADDRESS 0xFD

ASSERT ... ASSERT

5) AUTO ADDR DONE

How Does Startup Sequence Work?

Test 5 Trying to identify TRIGGER_IN vs OUT pins

• **Setup**: Using BMS connectors.png for reference,

← Switches to either connect emitter + anode to GND or V_{DD}

Test:

Emitter State	Anode State	Packet received on startup?
V_{DD}	V_{DD}	~~Yes~~ No
V_{DD}	GND	Yes
GND	V_{DD}	No
GND	GND	~~No~~ Yes

Emitter	Anode	Packet
FLOAT	GND	Yes
FLOAT	V_{DD}	No

Conclusion: ANODE = TRIGGER_IN , GND = ASSERTED, V_{DD} = DEASSERTED

extrapolation: emitter = Trigger_out ?

Test 6 Is the address which we think is adopted at startup actually being adopted?

Setup:
• Same as Test 5 with emitter floating (no switch)
• Send the SEND_SUMMARY command with addresses 0xFE and 0xAB (random)
• Try both when Anode (TRIGGER_IN) was connected to V_{DD} on boot vs GND

Result:

ANODE (TRIGGER_IN)	Address	Response?				
V_{DD}	0xFE	x58	xFE	...	x08	xE3
V_{DD}	0xAB			NONE		
GND	0xFE	x58	xFE	...	x08	xE3
GND	0xAB			None		

Test 7 Demonstrate trigger command, $V_{DD} \rightarrow GND$ on TRIGGER-OUT

.setup: · Same as test 5 but with
- emitter (TRIGGER-OUT) = Floating, ← scope this +
- anode (TRIGGER-IN) = GND   Doit
· Send trigger command

Result: · As soon as trigger command is sent, emitter dropped
from 5V to 0V, demonstrating successful trigger.
propagation
· No acknowledge was generated

Conclusion: Defining: emitter = TRIGGER-OUT
anode = TRIGGER-IN
asset = GND
notes specification for Trigger command which states,
"If TRIGGER_IN is active, the BM activates the
trigger to the next BM in the chain by asserting
the TRIGGER-OUT digital output pin. No acknowledge
is generated"

Test 8 Demonstrate trigger command, $GND \rightarrow V_{DD}$ on TRIGGER_IN

Setup: · Same as test 5 but with
- emitter (TRIGGER-OUT) = Floating
- anode (TRIGGER_IN) = GND on first trigger

V_{DD} on second trigger

· Run first trigger with anode = GND so that
the emitter will be pulled down to GND

Result: · Second trigger pulls emitter back from 0V
up to 5V, demonstrating it is a digital output
pin (no need for pull-up), and successful trigger prop.
· Acknowledgement is received and packet is same as boot

x58	xFE	x7F	x38	xCA	x04	x01	x77	x14	xEE	xYF	x01	x53	x5E

Note This ALSO works without first triggering with anode=GND.
If anode = V_{DD} (5V) at start, we get emitter=V_{DD} and response packet

How Does Startup Sequence Work?

[Test 9] Demonstrate renaming module

Setup: • Same as test 5, but with
- emitter (TRIGGER_OUT) = floating
- anode (TRIGGER_IN) = GND
- Command Sequence (spaced by 5000 μs)

1) SEND_SUMMARY, Addr = 0xFE
2) TRIGGER
3) GLOBAL_SET_ADDRESS, Addr = 0xAB   } Address of BM should be 0xFE
4) AUTO_ADDR_DONE
5) SEND_SUMMARY, Addr = 0xFE   } Address of BM is now 0xAB
6) SEND_SUMMARY, Addr = 0xAB

Result: As expected,
1) Responds with addr 0xFE
5) Does **NOT** respond
6) Responds with addr 0xAB

[Test 10] Verify need for CRC

Setup: • Same as test 9
• Send command SEND_SUMMARY with good, garbage CRC.

Result: Using CRC calculation from datasheet, we get a response, and none if its wrong

[Test 11] Demonstrate reading cell voltages   **[Note]** Start-up mode needs to be set to prior to read voltages

Setup: • Same as 9
• Tie pin 12 to VDD to setup address, then tie to GND to get response. This is needed because BM seems to wait some amount of time before it is finished booting and can begin sampling

Result: Received cell voltages of 3.8V when setup on 40V supply, which is what we expect