

EE2026: DIGITAL DESIGN

Academic Year 2020-2021, Semester 2

LAB 4: Sequential Circuits in Verilog - Part 2

OVERVIEW

This lab is a continuation of Lab 3. In this Lab 4, more applications of sequential circuits will be explored, and this will be the last lab practice before the EE2026 project.

The pre-requisites for this lab are:

- Knowing how to obtain slower clock frequencies from a faster one.
- Brief understanding of the purpose of a D-Flip-Flop (D-FF) in a sequential circuit.

This lab will cover the following:

- Schematic and design of a single pulse circuit, by using two D-FFs with a clock signal.
- Schematic and design of a debounced single pulse circuit, by using two D-FFs with a slow clock signal.
- Incrementing a counter value by 1 when a pushbutton is pressed.
- Multiplying a counter value by 2 when a pushbutton is pressed.

Tasks for this lab include:

- Simulating a single pulse circuit, whereby the D-FFs use a 100 MHz clock.
- Implementing a debounced single pulse circuit, by using a 3 Hz clock, on the Bays 3 development board.
- Observing patterns on the physical LED array, through counters that use the debounced single pulse signal.

GRADED ASSIGNMENT [LUMINUS SUBMISSION: MONDAY 15th MARCH 2021, NOON]:

This is the final lab assignment to test whether you have properly mastered the technical contents from your three previous lab assignments. In this lab 4 assignment, the focus will be more on logic.

You are encouraged to complete this assignment before the start of Week 8 (Monday 8th March 2021), as the focus will be on the EE2026 project from there on.

Further details are available at the end of this lab manual.

CREATING A SINGLE PULSE OUTPUT

In this section, a single pulse output circuit will be created. The circuit from [Figure 4.1](#), consisting of two D-FFs and an AND gate, can be used to generate a single pulse output signal. The latter will be a synchronised logic true signal that lasts for the duration of one clock cycle.

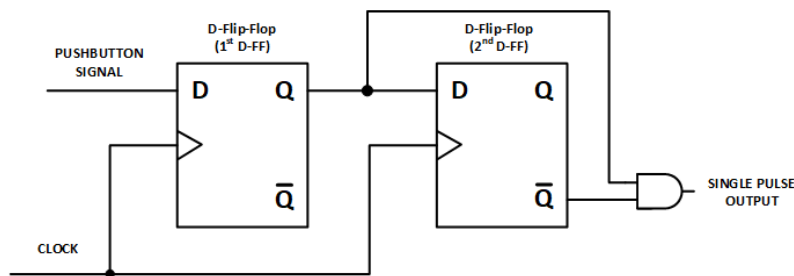


Figure 4.1: Single pulse circuit

The waveform for the single pulse circuit is as shown in *Figure 4.2*

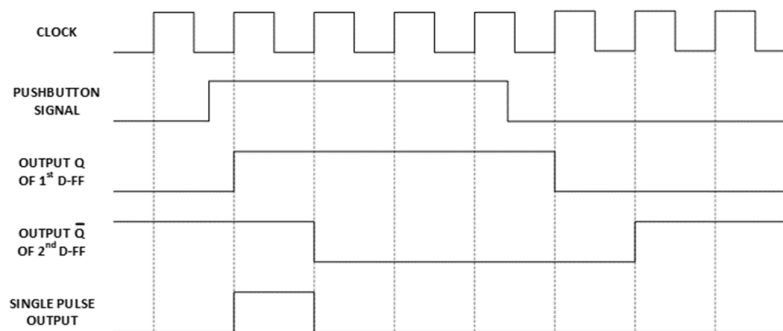


Figure 4.2: Waveform from a single pulse circuit

UNDERSTANDING | TASK 1

Through behavioural modelling in Verilog, the code for a positive-edge triggered D-flip-flop can be created:

Verilog code for a positive-edge triggered D-flip-flop

```

module my_dff(input DFF_CLOCK, D, output reg Q = 0);

    always @ (posedge DFF_CLOCK) begin
        Q <= D;
    end

endmodule

```

Using structural, dataflow and/or behavioural modelling, create the Verilog design for the circuit shown in [Figure 4.1](#). Create the simulation for the single pulse design module, **with a simulated 100 MHz clock** and appropriate stimuli, to confirm that a single pulse can be obtained. Take note of the time scale in the simulation window, and determine the duration of the single pulse output.

CREATING A DEBOUNCED SINGLE PULSE OUTPUT [THINK HOW TO DO THIS BEFORE THE LAB!]

On a physical device, the single pulse circuit can also be used to debounce mechanical switch signals. A slower clock, whose time period is longer than the bouncing of the switch signal, is required. Feeding this slower clock signal to the two D-FFs of a single pulse circuit will create a debounced single pulse output, as illustrated in *Figure 4.3*

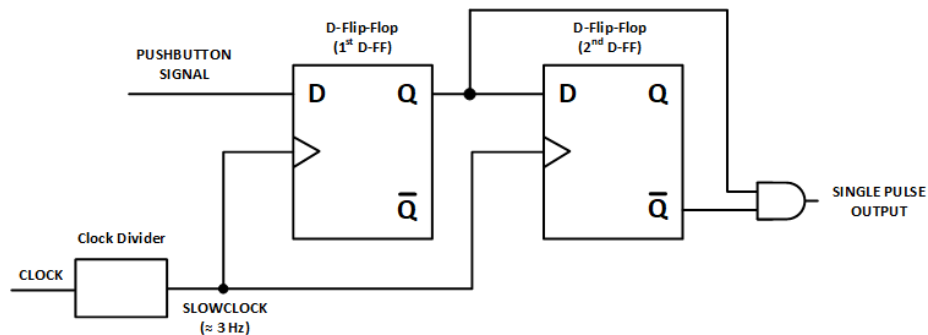


Figure 4.3: Debounced single pulse circuit

The waveform for the debounced single pulse circuit is as shown in *Figure 4.4*

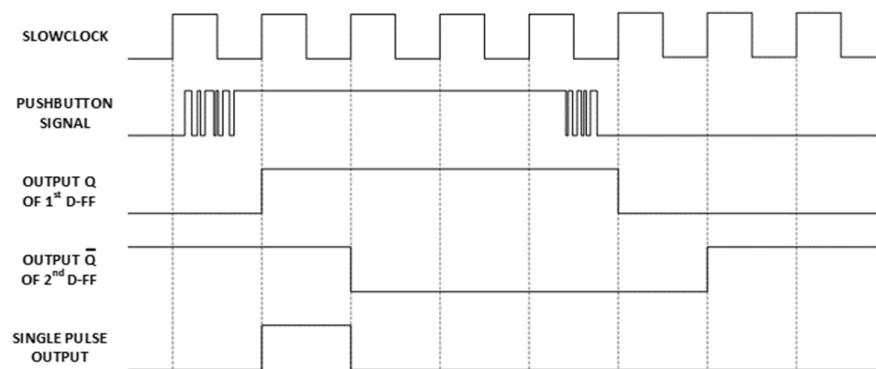


Figure 4.4: Waveform from a debounced single pulse circuit

UNDERSTANDING | TASK 2

Implement the circuit in [Figure 4.3](#) on the Basys 3 development board, by linking the debounced single pulse output to an LED. Press and hold the pushbutton to see if a single pulse of 1 clock cycle is obtained.

How much of simulated time would be required in order to see the single pulse output in the simulation waveform window?

Can you think of other ways of implementing a debounced single pulse output?

APPLYING THE DEBOUNCED SINGLE PULSE

From **UNDERSTANDING | TASK 2**, it is noted that no matter how long the pushbutton is pressed and held, a single synchronous pulse of only one clock cycle is created. This allows for the creation of a counter whose value can be made to increase by 1 each time a pushbutton is pressed, as such press would result in a positive edge of a single pulse.

UNDERSTANDING | TASK 3

Design an 8-bit counter that makes use of the debounced single pulse output, in order to increase its value by 1 each time the pushbutton is pressed, and for no matter how long the pushbutton is held. Implement the design on the Basys 3 development board, and observe how the physical LED array pattern changes whenever the pushbutton is pressed (and optionally held for a long time). Consider using the code below to detect the rising edge of the single pulse signal:

Partial Verilog code for a count that increments by one at the positive edge of the synchronised single pulse signal

```
// Initialise the initial 8-bit counter value to 8'b0000_0000
always @ (posedge SLOWCLOCK) begin
    if (SINGLE_PULSE_OUTPUT == 1) begin
        my_counter <= my_counter + 1;
    end
end
```

Important: The clock used in the sensitivity list must be exactly the same clock that was used to create the single pulse output

UNDERSTANDING | TASK 4

Shifting the values in a register to the left multiplies the register value by the base value. Create another design for a 16-bit counter, whereby pressing the pushbutton multiplies the value by 2 (Binary / Base-2 system). Implement the design on the Basys 3 development board. You may use the Verilog code template given below:

Partial Verilog code for a count that multiplies by 2 at the positive edge of the synchronised single pulse signal

```
// Initialise the initial 16-bit counter value to 16'h000C;
always @ (posedge SLOWCLOCK) begin
    if (SINGLE_PULSE_OUTPUT == 1) begin
        my_counter <= my_counter << 1;
    end
end
```

Record the values that you see from the LED array in the table below:

	Value from the Physical LED Array	Unsigned Decimal
Original Value	0000 0000 0000 1100	12
1 st Pushbutton Press		
2 nd Pushbutton Press		
3 rd Pushbutton Press		
4 th Pushbutton Press		
5 th Pushbutton Press		
6 th Pushbutton Press		
...		

What kind of pattern do you notice in the values?

What happens for pushbutton presses after the 13th and 14th ones?

UNDERSTANDING | TASK 5

Change your SLOWCLOCK to a 12 Hz clock. What do you notice when the pushbutton is pressed for the counter?

Change your SLOWCLOCK to a 25 MHz clock? What do you notice when the pushbutton is pressed for the counter?

GRADED POST-LAB ASSIGNMENT

Complete as much as possible, **in one working bitstream**, within the given deadline. It is much better to have a working program with some completed functionalities, instead of submitting a program without a working bitstream.

You may need a few of the operators listed below for the assignment (as well as for the upcoming EE2026 project):

Bitwise Operators		
~	~m	invert each bit of m
&	m & n	AND each bit of m with each bit of n
	m n	OR each bit of m with each bit of n
^	m ^ n	exclusive-OR each bit of m with n
~^ or ^~	m ~^ n	exclusive-NOR each bit of m with n
<<	m << n	shift m left n-times and fill with zeros
>>	m >> n	shift m right n-times and fill with zeros
Unary Reduction Operators		
&	&m	AND all bits in m together (1-bit result)
~&	~&m	NAND all bits in m together (1-bit result)
	m	OR all bits in m together (1-bit result)
~	~ m	NOR all bits in m together (1-bit result)
^	^m	exclusive-OR all bits in m (1-bit result)
~^ or ^~	~^m	exclusive-NOR all bits in m (1-bit result)
Logical Operators		
!	!m	is m not true? (1-bit True/False result)
&&	m && n	are both m and n true? (1-bit True/False result)
	m n	are either m or n true? (1-bit True/False result)
Equality and Relational Operators (return X if an operand has X or Z)		
==	m == n	is m equal to n? (1-bit True/False result)
!=	m != n	is m not equal to n? (1-bit True/False result)
<	m < n	is m less than n? (1-bit True/False result)
>	m > n	is m greater than n? (1-bit True/False result)
<=	m <= n	is m less than or equal to n? (1-bit True/False result)
>=	m >= n	is m greater than or equal to n? (1-bit True/False result)
Identity Operators (compare logic values 0, 1, X, and Z)		
===	m === n	is m identical to n? (1-bit True/False results)
!==	m !== n	is m not identical to n? (1-bit True/False result)
Miscellaneous Operators		
? :	sel?m:n	conditional operator; if sel is true, return m; else return n
{ }	{m, n}	concatenate m to n, creating a larger vector
{ { }	{n { }	replicate inner concatenation n-times
->	-> m	trigger an event on an event data type

Arithmetic Operators		
+	m + n	add n to m
-	m - n	subtract n from m
-	-m	negate m (2's complement)
*	m * n	multiply m by n
/	m / n	divide m by n
%	m % n	modulus of m / n
**	m ** n	m to the power n (new in Verilog-2001)
<<<	m <<< n	shift m left n-times, filling with 0 (new in Verilog-2001)
>>>	m >>> n	shift m right n-times; fill with value of sign bit if expression is signed, otherwise fill with 0 (Verilog-2001)

It is required to complete and fully understand all the five UNDERSTANDING | TASK before starting this assignment. **The accuracy and responsiveness of the pushbuttons will be tested. High accuracy and high responsiveness are required.**

SUB-SYSTEM A [Secured Access Fingerprint Entry]

Before the start of your program, switches SW0 to SW15 are OFF. When the program starts, LD0 to LD15 are OFF, and the seven segment displays do not show any characters (All 7 segments and decimal point segment are off).

The user is then allowed to scan a fingerprint by pressing and holding the centre pushbutton (BTNC) on the Basys 3 development board. While BTNC is being held, it is required to light up the 16 LEDs in increasing order (from LD0 to LD15), with each additional LED turning ON at a time interval, t_{on} . The latter is dependent on the 4th rightmost numerical value of your student matriculation number, and as indicated in Table A.

4 th (Fourth) rightmost numerical value of your student matriculation number	Time interval to turn ON additional led, t_{on} (A max error of ± 0.01 second is acceptable)
0 or 3 or 6 or 9	0.168 second
1 or 4 or 7	0.336 second
2 or 5 or 8	0.671 second

Table A

If the user releases BTNC before LD15 is turned ON, all leds should turn OFF, and the user can restart the fingerprint scanning process again from beginning.

When LD0 to LD15 are all ON, but the user does not release BTNC, nothing else should happen. Following that, when the user releases BTNC, it is required to clearly observe the following sequence of 4 characters on specific seven-segment displays at the specified time steps (Each time step is 1.342 seconds long):

	AN3	AN2	AN1	AN0
Time Step 01	S			
Time Step 02		A		
Time Step 03			F	
Time Step 04				E

Each time step is 1.342 seconds long
(An error of ± 0.005 second is acceptable)

After Time Step 04 has shown the character “E”, it is required to be able to clearly observe the following:

	AN3	AN2	AN1	AN0
Observation	S	A	F	E

Hint: Repeat Time Step 01 to 04 at a frequency of 381 Hz
(Maximum error of $\pm 1\%$ for frequency is acceptable)

The word “SAFE” indicates that the fingerprint scan is successful. For the next 5.37 seconds, “SAFE” will remain being display. After that 5.37 seconds are over, the seven segment displays should be replaced with the four rightmost numerical value of your student matriculation number. For example, if a student has matriculation number A0123456Y, then the following should be seen:

AN3	AN2	AN1	AN0
3	4	5	6

When that 4 digits number is being displayed, the user can now physically open the doors to the rooms of a certain Digital Electronics Lab. This is done by manually turning ON SW3, SW2, SW1 and SW0 on the Basys 3 development board. Assume that the user will not turn ON/OFF the switches before that 4 digits number is being displayed on the seven segment displays.

Switching ON/OFF these switches (SW3 to SW0) has another effect in this SAFE sub-system only, as described below:

- Turning ON SW3 will turn off the segments of AN3
- Turning ON SW2 will turn off the segments of AN2
- Turning ON SW1 will turn off the segments of AN1
- Turning ON SW0 will turn off the segments of AN0
- Turning OFF SW3 will show the 4th rightmost numerical value of your student matriculation number
- Turning OFF SW2 will show the 3rd rightmost numerical value of your student matriculation number
- Turning OFF SW1 will show the 2nd rightmost numerical value of your student matriculation number
- Turning OFF SW0 will show the 1st rightmost numerical value of your student matriculation number

The DISTANCE sub-system is triggered when the four switches from SW0 to SW3 are simultaneously ON. The user will not toggle any of these switches in the DISTANCE sub-system.

SUB-SYSTEM B [Digital Integrated System for Transgression in Admittance and Notifications for Crowded Environments]

At the start of this DISTANCE sub-system, AN3 to AN1 will not show anything.

AN0 must show $n_{chances}$, which is dependent on the **1st rightmost numerical value** of your student matriculation number, and as indicated in **Table B**.

1 st (First) rightmost numerical value of your student matriculation number	$n_{chances}$ at beginning of DISTANCE (Hexadecimal value)	$penalty_{crowding}$ (Decimal value. If rule (4) is broken)
0	6	2
1	7	4
2	8	3
3	9	6
4	A	6
5	b	8
6	C	7
7	d	9
8	E	8
9	F	9

Table B

Throughout this DISTANCE sub-system, it is **ALWAYS** possible to fully reset the state to the very beginning of this DISTANCE sub-system by pressing and immediately releasing the **up pushbutton (BTNU)** on the Basys 3 development board.

In this DISTANCE sub-system, AN3 to AN1 represent separate rooms in the Digital Electronics Lab. Whenever a person enters the room, one additional horizontal bar is to be lit up, up to a maximum of 3 horizontal bars. The following actions indicate that a person is entering a room:

BTNL (Left pushbutton):	One additional person is entering room AN3
BTNC (Centre pushbutton):	One additional person is entering room AN2
BTNR (Right pushbutton):	One additional person is entering room AN1

An example is shown below, with 2 persons inside room AN3, 3 persons inside room AN2, and 2 persons inside room AN1:

AN3	AN2	AN1	AN0
:	:	:	9

AN0 is the $n_{chances}$ value indicated previously in **Table B**

Following the law regarding the COVID-19 safe management practices in preventing overcrowding, and to distribute the amount of people inside the rooms evenly, this DISTANCE subsystem must work based on the following rules:

- (1) A person can only enter a room if the difference in number of persons inside the room will not be more than 1 (Difference can be 1) after entering the room, when compared to the other rooms
- (2) No two persons can enter the same room one after the other
- (3) The safe capacity of any room is 3 persons. If an additional person is trying to enter, it should be counted as breaching the rule, and the person will automatically be removed from the room immediately (This extra person will not be shown on the seven segments)
- (4) People must be able to enter the rooms quickly. The worst scenario of having to fill in 9 people within 2.68 seconds to prevent overcrowding outside the rooms is required. Therefore, as soon as this DISTANCE sub-system is entered, if 9 persons have not entered the rooms within 3.00 seconds (An error of ± 0.25 second is acceptable), the value of AN0 must decrease by *penalty_{crowding}*. This rule only happens once each time this DISTANCE sub-system is entered or reset (When BTNU is pressed and released). This rule is even active during the cooldown period if the latter is currently in progress

Each time any of the above rules numbered (1), (2) and (3) are broken, AN0 must decrease its current value by 1, to indicate the amount of chances left before severe action is taken. Also, whenever any of the rules (1), (2) and (3) are broken, there is a cooldown period of 10.74 seconds (An error of ± 0.25 second is acceptable). During the cooldown period, the following happens:

- The room where the person was trying to enter should create a notification. This will be in the form of the horizontal bars(s) in that specific room blinking. The blinking frequency should be 1.49 Hz
- No persons will be allowed in any of the rooms until the blinking notification has stopped. In other words, none of these pushbuttons should work: BTNL, BTNC, BTNR

If AN0 reaches a value of 0 (The value of 0 will not be seen), the following message appears on the seven segments display:

AN3	AN2	AN1	AN0
F	A	I	L

No further observations are required when "FAIL" is shown on the seven segments, as the program ends there. However, remember that throughout this DISTANCE sub-system, including after seeing the word "FAIL", it is ALWAYS possible to fully reset the state to the very beginning of this DISTANCE sub-system by pressing and immediately releasing the up pushbutton (BTNU).

Be reminded to turn OFF switches SW15 to SW0 if you need to reload the bitstream for this SAFE-DISTANCE.

LUMINUS SUBMISSION INSTRUCTIONS

- Complete as much required functionalities **as possible within the given deadline**, and ensure that your bitstream has been successfully generated and tested on your Basys 3 development board **BEFORE** archiving your Vivado workspace for LumiNUS upload. No working bitstream is equivalent to no marks (It is best to have some working functionalities / requirements, instead of not having any bitstream at all while trying all requirements)
- It is compulsory to archive your project in a compressed form without any simulation waveforms. In the uploaded archive, the codes (.v files) are important, not the waveforms (.wdb files). **The archive size should not exceed 4 MB in size for lab 4.** Follow the instructions given in the pdf: "Archive Project in Vivado 2018.02"
- **After** following the instructions in "Archive Project in Vivado 2018.02", rename your project archive as indicated in the appendix of this lab manual
- There are no report submissions for this lab assignment
- Upload to LumiNUS EE2026 -> Files -> Lab and Project - Materials and Submissions -> Lab 4 Submission
- Download your LumiNUS archive after uploading. **Click and drag the single folder within that archive to desktop, and then open the Vivado project in that extracted folder to see if it can be opened. Check if you can also run your bitstream correctly.** No project files and no working bitstream is equivalent to losing all marks
- The LumiNUS upload must be completed by **Monday 15th March 2021, 12:00 P.M. (Noon)**. Do not plan to upload during the grace period of 2 hours
- **Late submissions for lab 4 are not accepted.** Complete as much required functionalities as possible within the given deadline and in one working program

Plagiarism is penalised with a 100% penalty for all SOURCES and RECIPIENTS

All past and future submissions, and marks, will be reviewed in greater detail, for any person found to have plagiarised

REMEMBER TO NAME YOUR SUBMISSION IN THE REQUIRED FORMAT

ALL THE SUBMISSION INSTRUCTIONS LISTED ABOVE WILL AFFECT YOUR GRADES!

APPENDIX (COMPULSORY renaming before just LumiNUS upload):

It is **compulsory to rename your project archive**, just before the LumiNUS upload, as listed in the table below. Do not change any other part of the naming. Simply **copy** the naming from the table below, and **paste** it while renaming your project archive. Penalties will be incurred if your submission cannot be found according to the exact naming template below.

Name	Archive Naming
Aaron Chan Siang Joo	L4 Tue PM Aaron Chan Siang Joo 426 Archive
Aditi Chadha	L4 Tue AM Aditi Chadha 898 Archive
Aiden Thaw @ Aung Kham Thaw	L4 Tue PM Aiden Thaw Aung Kham Th 186 Archive
Alvin Lim Jun	L4 Tue AM Alvin Lim Jun 284 Archive
Alvin Pang Zi Xiong	L4 Mon PM Alvin Pang Zi Xiong 475 Archive
Ameer Khalid	L4 Tue PM Ameer Khalid 328 Archive
Anderson Leong Ke Sheng	L4 Tue PM Anderson Leong Ke Sheng 152 Archive
Andy Chua Xun Ze	L4 Tue PM Andy Chua Xun Ze 384 Archive
ANG JIA JUN, DARYL	L4 Tue PM ANG JIA JUN DARYL 485 Archive
Ang Qi Xuan	L4 Mon PM Ang Qi Xuan 052 Archive
Ang Yong Siang Alwin	L4 Tue AM Ang Yong Siang Alwin 771 Archive
Anna Zhang Runyu	L4 Tue PM Anna Zhang Runyu 999 Archive
Antriksh Verma	L4 Tue AM Antriksh Verma 149 Archive
Anvitha Rajaram	L4 Tue AM Anvitha Rajaram 434 Archive
Ariel Ong Xing Er	L4 Tue PM Ariel Ong Xing Er 560 Archive
Bellakka Krishnamurthy Prajwal	L4 Tue AM Bellakka Krishnamurthy Pr 862 Archive
Boo Qian Wei, Adeline	L4 Tue AM Boo Qian Wei Adeline 207 Archive
Braden Teo Wei Ren	L4 Tue AM Braden Teo Wei Ren 238 Archive
Brendan Lau Siew Zhi	L4 Tue AM Brendan Lau Siew Zhi 596 Archive
Bryan Elmer Mulijono	L4 Tue AM Bryan Elmer Mulijono 447 Archive
Bryan Wong Hong Liang	L4 Tue AM Bryan Wong Hong Liang 051 Archive
Bui Quang Huy	L4 Tue PM Bui Quang Huy 362 Archive
Chai Zong Lun	L4 Tue AM Chai Zong Lun 784 Archive
Chan Keng Jit	L4 Tue AM Chan Keng Jit 501 Archive
Chan Yew Kun	L4 Tue PM Chan Yew Kun 985 Archive
Chan Zhao Yong	L4 Thu PM Chan Zhao Yong 518 Archive
Chan Zhi Jie Ryan	L4 Tue PM Chan Zhi Jie Ryan 415 Archive
Chen Hsin	L4 Tue PM Chen Hsin 602 Archive
CHEN SILIN	L4 Tue AM CHEN SILIN 445 Archive
CHEN YUHAN	L4 Tue PM CHEN YUHAN 520 Archive
Cheng Siyuan	L4 Tue AM Cheng Siyuan 728 Archive
Chew Yi Jie	L4 Tue AM Chew Yi Jie 632 Archive
Chia Shao Xian	L4 Wed PM Chia Shao Xian 447 Archive
Chong Jia An	L4 Tue PM Chong Jia An 190 Archive
Chong Xuan Liang	L4 Thu AM Chong Xuan Liang 171 Archive
Christopher Nge Jing Qi	L4 Thu AM Christopher Nge Jing Qi 145 Archive
Christopher Tze-Wen Langton	L4 Thu AM Christopher TzeWen Langt 265 Archive
CHUA WAN NING	L4 Tue PM CHUA WAN NING 189 Archive
Chua Xiong Wei	L4 Thu AM Chua Xiong Wei 484 Archive
Chun Min Gyu	L4 Wed PM Chun Min Gyu 249 Archive
Chung Ying Qiao Winnie	L4 Tue PM Chung Ying Qiao Winnie 324 Archive
Conrad Ephraim Wee Cher Jae	L4 Thu AM Conrad Ephraim Wee Cher J 123 Archive
Cordell Chan Yi Hng	L4 Tue PM Cordell Chan Yi Hng 253 Archive
CUI MINJING	L4 Thu AM CUI MINJING 441 Archive
Cui Xinyu	L4 Tue PM Cui Xinyu 116 Archive
Damien Lim Yu Hao	L4 Thu AM Damien Lim Yu Hao 933 Archive
Darren Khoo Kah Weng	L4 Thu AM Darren Khoo Kah Weng 516 Archive
Darryl See	L4 Tue PM Darryl See 317 Archive
Desmond Eng Kian Wee	L4 Wed PM Desmond Eng Kian Wee 095 Archive
Donovan Sim Jing Yi	L4 Tue PM Donovan Sim Jing Yi 402 Archive
Du Yantang	L4 Tue PM Du Yantang 744 Archive
Edly Irsyad B Elham	L4 Thu AM Edly Irsyad B Elham 555 Archive
Elumalai Oviya Dharshini	L4 Thu AM Elumalai Oviya Dharshini 353 Archive
Eric Bryan	L4 Thu AM Eric Bryan 789 Archive
Eugene Chong Zhi Liang	L4 Thu AM Eugene Chong Zhi Liang 525 Archive
Fan Shixi	L4 Thu AM Fan Shixi 848 Archive
FOONG XIN YU	L4 Thu AM FOONG XIN YU 018 Archive
Fu Zhehui	L4 Tue PM Fu Zhehui 218 Archive
Gavien Pat Wei Zhuo	L4 Thu AM Gavien Pat Wei Zhuo 185 Archive
GOH KAI YAO BRYAN	L4 Tue AM GOH KAI YAO BRYAN 690 Archive
Goh Shao Quan	L4 Tue PM Goh Shao Quan 422 Archive
GOH SHAU HUI GEORGE	L4 Tue PM GOH SHAU HUI GEORGE 353 Archive
Goh Wei Yang	L4 Tue PM Goh Wei Yang 254 Archive
Gu Jianqiang	L4 Tue PM Gu Jianqiang 514 Archive
Guan Dinghe	L4 Tue PM Guan Dinghe 736 Archive
Han Si Yuan	L4 Wed PM Han Si Yuan 050 Archive
Hemanth Bangalore Srinivas Murthy	L4 Tue PM Hemanth Bangalore Sriniva 135 Archive
Ho Shu Jun	L4 Tue PM Ho Shu Jun 198 Archive
Ho Zhen Hong	L4 Thu AM Ho Zhen Hong 014 Archive
Hoang Trong Tan	L4 Thu AM Hoang Trong Tan 425 Archive
HOE JUN LEONG	L4 Thu AM HOE JUN LEONG 182 Archive
Hong Xingwen	L4 Tue PM Hong Xingwen 861 Archive
Hossan Goh Xuan Rong	L4 Thu AM Hossan Goh Xuan Rong 833 Archive

How Teck Wei	L4 Tue PM How Teck Wei 391 Archive
HU JIALUN	L4 Thu AM HU JIALUN 521 Archive
Hu Xuefei	L4 Thu AM Hu Xuefei 885 Archive
Huang Che Yen	L4 Thu AM Huang Che Yen 597 Archive
HUANG HAOFENG	L4 Mon PM HUANG HAOFENG 936 Archive
Huang Shanshan	L4 Tue PM Huang Shanshan 622 Archive
HUANG YUJING	L4 Tue PM HUANG YUJING 485 Archive
Ian Wang Ee En	L4 Thu AM Ian Wang Ee En 227 Archive
Imperial Edward Justin Javier	L4 Tue PM Imperial Edward Justin Ja 356 Archive
Ishaan Maunil Vyas	L4 Thu AM Ishaan Maunil Vyas 479 Archive
Izdiya Farhan B Zuri	L4 Thu AM Izdiya Farhan B Zuri 407 Archive
Jared Cheang	L4 Mon PM Jared Cheang 192 Archive
Jareth Tan Eu Quan	L4 Tue PM Jareth Tan Eu Quan 240 Archive
Jason Ong Meng Lee	L4 Tue PM Jason Ong Meng Lee 174 Archive
Jasshan Kumeresh	L4 Tue PM Jasshan Kumeresh 503 Archive
Jeremiah Jiang	L4 Tue PM Jeremiah Jiang 139 Archive
Jeremiah Ong Ray	L4 Tue PM Jeremiah Ong Ray 551 Archive
Jeremy Goh Liang Yi	L4 Tue PM Jeremy Goh Liang Yi 393 Archive
JIANG QIXIONG	L4 Mon PM JIANG QIXIONG 698 Archive
Jiang Xing Kai	L4 Thu AM Jiang Xing Kai 564 Archive
Jin Minyue	L4 Tue AM Jin Minyue 069 Archive
JIN YIXUAN	L4 Wed PM JIN YIXUAN 976 Archive
Joanne Wong Wei Yin	L4 Thu AM Joanne Wong Wei Yin 527 Archive
Joel Matthew Chiam Zhi Qiang	L4 Thu AM Joel Matthew Chiam Zhi Qi 250 Archive
Jon Lim Yong Kiat	L4 Thu AM Jon Lim Yong Kiat 782 Archive
Jonathan Mui Koy Kit	L4 Thu AM Jonathan Mui Koy Kit 534 Archive
Joshua Harsha Dass	L4 Thu AM Joshua Harsha Dass 714 Archive
Justin Fidelis Wong Jun Wen	L4 Thu AM Justin Fidelis Wong Jun W 326 Archive
Kairos Koh Jia Jun	L4 Thu AM Kairos Koh Jia Jun 149 Archive
Keh Wen Yang, Rachel	L4 Thu AM Keh Wen Yang Rachel 249 Archive
Kevinaldi Dwiastajulio Hunto	L4 Thu PM Kevinaldi Dwiastajulio Hu 912 Archive
Khoo Jia Le Isaac	L4 Thu AM Khoo Jia Le Isaac 733 Archive
Khor Sheng Hou	L4 Thu PM Khor Sheng Hou 443 Archive
Kishor Kumar Haribaskar	L4 Thu AM Kishor Kumar Haribaskar 481 Archive
Koh Meng Kiat, Kenneth	L4 Tue AM Koh Meng Kiat Kenneth 512 Archive
Koh Qiangqi	L4 Thu AM Koh Qiangqi 746 Archive
Koh Qin Ruo	L4 Thu PM Koh Qin Ruo 055 Archive
Koh Ruizhe Jerome	L4 Thu PM Koh Ruizhe Jerome 429 Archive
Kom Xing Yuan	L4 Thu AM Kom Xing Yuan 993 Archive
Kong Dak Nam	L4 Thu AM Kong Dak Nam 171 Archive
Koo Wei De	L4 Tue PM Koo Wei De 133 Archive
Krishna R R	L4 Thu PM Krishna R R 900 Archive
Kum Wing Ho	L4 Thu AM Kum Wing Ho 725 Archive
Kumaravel Vignesh	L4 Thu AM Kumaravel Vignesh 585 Archive
Kwok Xiu Sheng Theodore	L4 Thu AM Kwok Xiu Sheng Theodore 118 Archive
Kwong Zhi Qian	L4 Thu AM Kwong Zhi Qian 569 Archive
Lam Junyu William	L4 Thu AM Lam Junyu William 903 Archive
LAM KAI WEN JONATHAN	L4 Thu AM LAM KAI WEN JONATHAN 213 Archive
Lau Miang Puang, Glennard	L4 Thu PM Lau Miang Puang Glennard 207 Archive
Lee An Sheng	L4 Tue AM Lee An Sheng 263 Archive
Lee Cheok Feng	L4 Tue AM Lee Cheok Feng 743 Archive
Lee Hung Tien	L4 Thu PM Lee Hung Tien 965 Archive
Lee Jia Jun	L4 Thu PM Lee Jia Jun 423 Archive
Lee Jing Rui, Evan	L4 Thu PM Lee Jing Rui Evan 399 Archive
Lee Jun Wen	L4 Wed PM Lee Jun Wen 466 Archive
LEE KENG YONG JOSHUA	L4 Tue AM LEE KENG YONG JOSHUA 644 Archive
Lee Qi An	L4 Tue AM Lee Qi An 644 Archive
Lee Shi-An, Matthew	L4 Thu PM Lee ShiAn Matthew 324 Archive
Lee Sungmin	L4 Tue AM Lee Sungmin 490 Archive
Lee Sze Ern, Jeremy	L4 Tue PM Lee Sze Ern Jeremy 510 Archive
Lee Yi Kai	L4 Tue AM Lee Yi Kai 550 Archive
Lee Yu-Hsueh	L4 Thu PM Lee YuHsueh 639 Archive
LEONARD CHUA ZHONG QI	L4 Tue PM LEONARD CHUA ZHONG QI 873 Archive
Leong Kah Choong	L4 Thu PM Leong Kah Choong 455 Archive
Leow Yuan Yang	L4 Tue AM Leow Yuan Yang 574 Archive
Leroy Ong Nai Kiat	L4 Thu PM Leroy Ong Nai Kiat 506 Archive
Li Huanda	L4 Thu PM Li Huanda 101 Archive
Li Xi Yuan	L4 Tue AM Li Xi Yuan 926 Archive
Liang Yuzhao	L4 Tue AM Liang Yuzhao 802 Archive
LIM BING SEN	L4 Wed PM LIM BING SEN 580 Archive
LIM CHANG QUAN THADDEUS	L4 Thu AM LIM CHANG QUAN THADDEUS 210 Archive
Lim Jia Sheng Jackson	L4 Thu PM Lim Jia Sheng Jackson 596 Archive
Lim Kay Yun	L4 Tue AM Lim Kay Yun 244 Archive
Lim Shyun Yin	L4 Tue AM Lim Shyun Yin 063 Archive
Lim Wen Jie	L4 Thu PM Lim Wen Jie 382 Archive
Liu Danfeng	L4 Thu PM Liu Danfeng 777 Archive
Liu Ruijun	L4 Thu PM Liu Ruijun 371 Archive
LIU ZEHANG	L4 Tue AM LIU ZEHANG 491 Archive
LIU ZHIYANG	L4 Wed PM LIU ZHIYANG 653 Archive
Loo Keng Leong	L4 Thu PM Loo Keng Leong 408 Archive
LOW ZHEN WEI JERRELL	L4 Tue AM LOW ZHEN WEI JERRELL 516 Archive
Lu Jingguang	L4 Thu PM Lu Jingguang 319 Archive
Lu Sicheng	L4 Tue AM Lu Sicheng 634 Archive
LU ZONGHAN	L4 Tue PM LU ZONGHAN 452 Archive

MA XUDONG	L4 Tue PM MA XUDONG 493 Archive
Ma Zijian	L4 Tue AM Ma Zijian 828 Archive
Madhan Selvapandian	L4 Tue AM Madhan Selvapandian 482 Archive
Madheswaran Niveytha	L4 Thu PM Madheswaran Niveytha 465 Archive
Mah Yuan Jie Alvin	L4 Tue AM Mah Yuan Jie Alvin 500 Archive
Mahadevan Svetha	L4 Tue AM Mahadevan Svetha 108 Archive
Mahadevan Swati	L4 Tue AM Mahadevan Swati 107 Archive
Marcus Goh Xuan De	L4 Thu PM Marcus Goh Xuan De 355 Archive
Marcus Lim Sheng Jie	L4 Thu PM Marcus Lim Sheng Jie 408 Archive
Marcus Ong Yih	L4 Tue AM Marcus Ong Yih 404 Archive
Mathur Aayush	L4 Tue AM Mathur Aayush 581 Archive
Mayank Panjiyara	L4 Tue AM Mayank Panjiyara 763 Archive
Mehedi Hasan Salim	L4 Thu PM Mehedi Hasan Salim 436 Archive
Mohamed Faez Bin Shahlan	L4 Thu PM Mohamed Faez Bin Shahlan 297 Archive
Mohammad Shoib Memon Loya	L4 Tue AM Mohammad Shoib Memon Loya 487 Archive
Muhammad Aizat Bin Rahim	L4 Thu PM Muhammad Aizat Bin Rahim 437 Archive
Muhammad Ashraf B Mohamad J	L4 Tue AM Muhammad Ashraf B Mohamad 432 Archive
MUHAMMAD HAZIM BIN ABDULLAH	L4 Thu PM MUHAMMAD HAZIM BIN ABDULL 633 Archive
Muhammad Jaish Bin Jamalun Nasir	L4 Wed PM Muhammad Jaish Bin Jamalun 287 Archive
Mun Le Zong	L4 Tue AM Mun Le Zong 172 Archive
Nan Song	L4 Thu PM Nan Song 102 Archive
Ng Andre	L4 Tue AM Ng Andre 973 Archive
Ng Cheng Yang, Titus	L4 Tue AM Ng Cheng Yang Titus 478 Archive
Ng Jin Loong, Jeremy	L4 Thu PM Ng Jin Loong Jeremy 395 Archive
Ng Qi Hao	L4 Thu PM Ng Qi Hao 420 Archive
Ng Xinyi	L4 Thu PM Ng Xinyi 545 Archive
Ngoi Hui Wen, Vanessa	L4 Tue AM Ngoi Hui Wen Vanessa 471 Archive
Nguyen Minh Tuan	L4 Tue AM Nguyen Minh Tuan 389 Archive
Nguyen Van Binh	L4 Mon PM Nguyen Van Binh 453 Archive
Nigel Loh Weien	L4 Thu PM Nigel Loh Weien 416 Archive
Nigel Ng	L4 Mon PM Nigel Ng 444 Archive
Nishant Rai	L4 Mon PM Nishant Rai 182 Archive
Oh Qi Ren	L4 Thu PM Oh Qi Ren 441 Archive
Ong Chor Yew	L4 Tue PM Ong Chor Yew 460 Archive
Ong Jun Giat	L4 Thu PM Ong Jun Giat 205 Archive
Ong Siying Falicia	L4 Thu AM Ong Siying Falicia 566 Archive
Ong Yew Yong, Adrian	L4 Thu PM Ong Yew Yong Adrian 401 Archive
Owng Kai Leng Sally	L4 Thu PM Owng Kai Leng Sally 331 Archive
Pang Kai Lin	L4 Thu PM Pang Kai Lin 036 Archive
Pang Kai Yi	L4 Thu PM Pang Kai Yi 236 Archive
Pang Qi Wei, Jenna	L4 Wed PM Pang Qi Wei Jenna 685 Archive
Paramita Tejasvi	L4 Mon PM Paramita Tejasvi 194 Archive
Peh Li Yan	L4 Thu PM Peh Li Yan 267 Archive
PENG FEI	L4 Mon PM PENG FEI 518 Archive
Peng Yanjia	L4 Tue AM Peng Yanjia 877 Archive
Phoon Pei Zhen	L4 Thu PM Phoon Pei Zhen 744 Archive
Phua Keng Wee	L4 Thu PM Phua Keng Wee 706 Archive
Phuah Yong Chen Keith	L4 Thu PM Phuah Yong Chen Keith 360 Archive
Pichanon Rattanadilok Na Phuket	L4 Tue AM Pichanon Rattanadilok Na 545 Archive
Pojcharapol Leenukiat	L4 Wed PM Pojcharapol Leenukiat 642 Archive
Poon Jeun Lek	L4 Wed PM Poon Jeun Lek 202 Archive
Pow Zhi Xiang	L4 Tue AM Pow Zhi Xiang 942 Archive
Pradhan Rachit Manish	L4 Wed PM Pradhan Rachit Manish 230 Archive
Pranav Venkatram	L4 Tue AM Pranav Venkatram 200 Archive
Qi Tian Cong	L4 Wed PM Qi Tian Cong 442 Archive
Ramalingam Saravanamani	L4 Tue AM Ramalingam Saravanamani 586 Archive
Ravindiran Rakesh	L4 Tue AM Ravindiran Rakesh 010 Archive
Rebecca Chua	L4 Thu AM Rebecca Chua 171 Archive
REN TIANLE	L4 Mon PM REN TIANLE 446 Archive
Renzo Rivera Canare	L4 Thu AM Renzo Rivera Canare 502 Archive
Reuel Teo Lu Wei	L4 Wed PM Reuel Teo Lu Wei 435 Archive
Richard Willie	L4 Thu AM Richard Willie 368 Archive
Roycius Lim Yuanwei	L4 Thu AM Roycius Lim Yuanwei 060 Archive
Samuel Ong Wei Chuan	L4 Tue PM Samuel Ong Wei Chuan 462 Archive
Se Sean	L4 Wed PM Se Sean 140 Archive
See Jian Hui	L4 Thu AM See Jian Hui 737 Archive
Seet Ting Yang Irvin	L4 Mon PM Seet Ting Yang Irvin 608 Archive
Seetoh Yit Ching	L4 Mon PM Seetoh Yit Ching 154 Archive
Seo Gimin	L4 Mon PM Seo Gimin 442 Archive
Seth Teng Shann	L4 Wed PM Seth Teng Shann 419 Archive
Shao Yurui	L4 Mon PM Shao Yurui 111 Archive
Shawn Chang	L4 Wed PM Shawn Chang 151 Archive
Shreshth Sarda	L4 Wed PM Shreshth Sarda 424 Archive
Shyam Ganesh Jayagopi	L4 Mon PM Shyam Ganesh Jayagopi 484 Archive
Sidharth Premnath	L4 Wed PM Sidharth Premnath 502 Archive
Siew Yang Zhi	L4 Thu AM Siew Yang Zhi 331 Archive
Sim Le Yee Beatrice	L4 Wed PM Sim Le Yee Beatrice 769 Archive
Sin Ren Xiang	L4 Thu PM Sin Ren Xiang 865 Archive
Sivakumar Yogarajan	L4 Wed PM Sivakumar Yogarajan 505 Archive
Song Chenan	L4 Wed PM Song Chenan 797 Archive
Song Min Kyu	L4 Wed PM Song Min Kyu 226 Archive
Sridharan Arvind Srinivasan	L4 Mon PM Sridharan Arvind Srinivas 477 Archive
Sthitipragyan Samal	L4 Mon PM Sthitipragyan Samal 664 Archive
Sun Jiale	L4 Mon PM Sun Jiale 853 Archive

SUN JIAWEI	L4 Thu PM SUN JIAWEI 496 Archive
SWAMINATHAN VARUN	L4 Mon PM SWAMINATHAN VARUN 281 Archive
Swann Tet Aung	L4 Mon PM Swann Tet Aung 552 Archive
Tan Haoxuan	L4 Wed PM Tan Haoxuan 934 Archive
Tan Hui En	L4 Mon PM Tan Hui En 373 Archive
Tan Jun Heng Daren Justin	L4 Mon PM Tan Jun Heng Daren Justin 331 Archive
Tan Kah Heng	L4 Mon PM Tan Kah Heng 677 Archive
Tan Le Yi	L4 Mon PM Tan Le Yi 071 Archive
Tan Lindsey	L4 Wed PM Tan Lindsey 197 Archive
Tan Qi Xian, Keith	L4 Wed PM Tan Qi Xian Keith 397 Archive
Tan Rui Yang	L4 Mon PM Tan Rui Yang 472 Archive
Tan Tze Yeong	L4 Wed PM Tan Tze Yeong 970 Archive
Tan Wei Li	L4 Wed PM Tan Wei Li 336 Archive
Tan Xing Jie	L4 Mon PM Tan Xing Jie 747 Archive
Tan Yong Zheng	L4 Wed PM Tan Yong Zheng 261 Archive
Tang Zehou	L4 Mon PM Tang Zehou 210 Archive
Tay Weida	L4 Mon PM Tay Weida 027 Archive
Tay Yi Heng, Atticus	L4 Mon PM Tay Yi Heng Atticus 994 Archive
Teh Jiewen	L4 Mon PM Teh Jiewen 520 Archive
Teh Zi-Chun	L4 Wed PM Teh ZiChun 328 Archive
Teng Yi Shiong	L4 Mon PM Teng Yi Shiong 647 Archive
Teo Ziyi Ivy	L4 Mon PM Teo Ziyi Ivy 117 Archive
Tham Yang Tze Xavier	L4 Wed PM Tham Yang Tze Xavier 256 Archive
TIAN ZHENYU	L4 Thu PM TIAN ZHENYU 467 Archive
Tiang Zhang Quan Xavier	L4 Wed PM Tiang Zhang Quan Xavier 446 Archive
Tie Zhou Peng	L4 Wed PM Tie Zhou Peng 264 Archive
Toh Yi Cheng	L4 Wed PM Toh Yi Cheng 421 Archive
Toh Yi Zhi	L4 Mon PM Toh Yi Zhi 086 Archive
Tran Nhan Duc Anh	L4 Mon PM Tran Nhan Duc Anh 358 Archive
Tran Thi Phuong Thao	L4 Wed PM Tran Thi Phuong Thao 438 Archive
Varun Agarwal	L4 Wed PM Varun Agarwal 605 Archive
VIKAS HARLANI	L4 Mon PM VIKAS HARLANI 376 Archive
Vishal Jeyaram	L4 Mon PM Vishal Jeyaram 224 Archive
Wan Haocheng	L4 Wed PM Wan Haocheng 780 Archive
Wang Wenxuan	L4 Wed PM Wang Wenxuan 649 Archive
WANG YUDA	L4 Thu PM WANG YUDA 443 Archive
Wang Zhao Yu, Edward	L4 Mon PM Wang Zhao Yu Edward 953 Archive
Wang Zhihuang	L4 Mon PM Wang Zhihuang 682 Archive
Wang Zichen	L4 Wed PM Wang Zichen 951 Archive
Wang Zihan	L4 Wed PM Wang Zihan 361 Archive
Wang Zixi	L4 Wed PM Wang Zixi 445 Archive
William Wahyudi	L4 Mon PM William Wahyudi 230 Archive
Wong Jun Lin	L4 Tue AM Wong Jun Lin 077 Archive
Wong Tze Shan Samantha	L4 Mon PM Wong Tze Shan Samantha 672 Archive
Wong Zi Xin, Avellin	L4 Mon PM Wong Zi Xin Avellin 073 Archive
Woo Bo Tuan	L4 Mon PM Woo Bo Tuan 153 Archive
WU HAO HSUAN	L4 Thu PM WU HAO HSUAN 635 Archive
Wu Luoyu	L4 Mon PM Wu Luoyu 894 Archive
WU YUWEI	L4 Wed PM WU YUWEI 472 Archive
XIAO JUNTIAN	L4 Wed PM XIAO JUNTIAN 497 Archive
Xu Yuxing	L4 Wed PM Xu Yuxing 183 Archive
Xue Yuxuan	L4 Wed PM Xue Yuxuan 250 Archive
Yam Jin Ee Dmitri	L4 Mon PM Yam Jin Ee Dmitri 974 Archive
Yang Zikun	L4 Tue AM Yang Zikun 313 Archive
Yap Joon Siong	L4 Mon PM Yap Joon Siong 925 Archive
YAP WEI XUAN	L4 Mon PM YAP WEI XUAN 997 Archive
Yap Zhan Wei	L4 Thu PM Yap Zhan Wei 455 Archive
Yeat Nai Jie	L4 Mon PM Yeat Nai Jie 613 Archive
Yeo Shi Heng	L4 Wed PM Yeo Shi Heng 390 Archive
Yeo Wei Hng	L4 Mon PM Yeo Wei Hng 075 Archive
Yeo Zi Hao, Edwin	L4 Mon PM Yeo Zi Hao Edwin 710 Archive
YIP WAYNE	L4 Mon PM YIP WAYNE 998 Archive
YU HAIHONG	L4 Wed PM YU HAIHONG 470 Archive
Yue Junfeng	L4 Thu AM Yue Junfeng 802 Archive
Yuk Yeon Soo	L4 Wed PM Yuk Yeon Soo 243 Archive
Zeng Jiexiong	L4 Mon PM Zeng Jiexiong 052 Archive
ZHANG HAOYU	L4 Thu AM ZHANG HAOYU 783 Archive
ZHAO LUOYUANG	L4 Mon PM ZHAO LUOYUANG 466 Archive
Zhao Yibo	L4 Wed PM Zhao Yibo 863 Archive
Zhao Ziqi	L4 Wed PM Zhao Ziqi 275 Archive
ZHONG XINGHAN	L4 Mon PM ZHONG XINGHAN 468 Archive
ZHOU CHENGXU	L4 Mon PM ZHOU CHENGXU 492 Archive
ZHOU YUHAN	L4 Wed PM ZHOU YUHAN 530 Archive
Zhu Shaohan Steven	L4 Wed PM Zhu Shaohan Steven 193 Archive
Zhuang Jianning	L4 Mon PM Zhuang Jianning 277 Archive
Zubin Jain	L4 Tue PM Zubin Jain 990 Archive