

Date: 5/17/2021

## Assignment 5: GPIO

The following will document completion of the fifth assignment for ECE-40291, with the stated goals of:

1. Use STM32CubeIDE to generate the default code for the STM32 Discovery Board.
2. Edit, build, run, and debug the code that uses the HAL\_GPIO API to toggle the LED2 On/Off when the blue button is pressed. The on/off toggle should happen in an interrupt service routine that runs when the blue button is pressed.
3. The STM32 IOT Discovery board has an Arduino Connector. On that connector, connect pin D8 to the +(positive ) side of an LED (the longer LED pin), then connect the - (negative) of the LED (the short LED pin) to a small (say 330 ohm) resistor, and then connect the resistor to the Arduino GND pin. Write code to blink the LED connected to D8 at a 1 second rate.

### 1. Use STM32CubeIDE to generate the default code for the STM32 Discovery Board

To begin, open the IDE and create a new project as per the methods documented in previous assignments. As we will be using the HAL in this example, there are no extra software packages to enable under the project configurator beyond the defaults, but we will want to confirm our IO config is what we expect for good measure. We can open the GPIO config and check LED2 that will be toggled by the blue pushbutton:

GPIO	Pin	Mode	Output Type	Pull-up/Pull-down	Speed	IOVDD	IOVDD2	IOVDD3	IOVDD4	IOVDD5	IOVDD6	IOVDD7	IOVDD8	IOVDD9	IOVDD10	IOVDD11	IOVDD12	IOVDD13	IOVDD14	IOVDD15	IOVDD16	IOVDD17	IOVDD18	IOVDD19	IOVDD20	IOVDD21	IOVDD22	IOVDD23	IOVDD24	IOVDD25	IOVDD26	IOVDD27	IOVDD28	IOVDD29	IOVDD30	IOVDD31	IOVDD32	IOVDD33	IOVDD34	IOVDD35	IOVDD36	IOVDD37	IOVDD38	IOVDD39	IOVDD40	IOVDD41	IOVDD42	IOVDD43	IOVDD44	IOVDD45	IOVDD46	IOVDD47	IOVDD48	IOVDD49	IOVDD50	IOVDD51	IOVDD52	IOVDD53	IOVDD54	IOVDD55	IOVDD56	IOVDD57	IOVDD58	IOVDD59	IOVDD60	IOVDD61	IOVDD62	IOVDD63	IOVDD64	IOVDD65	IOVDD66	IOVDD67	IOVDD68	IOVDD69	IOVDD70	IOVDD71	IOVDD72	IOVDD73	IOVDD74	IOVDD75	IOVDD76	IOVDD77	IOVDD78	IOVDD79	IOVDD80	IOVDD81	IOVDD82	IOVDD83	IOVDD84	IOVDD85	IOVDD86	IOVDD87	IOVDD88	IOVDD89	IOVDD90	IOVDD91	IOVDD92	IOVDD93	IOVDD94	IOVDD95	IOVDD96	IOVDD97	IOVDD98	IOVDD99	IOVDD100	IOVDD101	IOVDD102	IOVDD103	IOVDD104	IOVDD105	IOVDD106	IOVDD107	IOVDD108	IOVDD109	IOVDD110	IOVDD111	IOVDD112	IOVDD113	IOVDD114	IOVDD115	IOVDD116	IOVDD117	IOVDD118	IOVDD119	IOVDD120	IOVDD121	IOVDD122	IOVDD123	IOVDD124	IOVDD125	IOVDD126	IOVDD127	IOVDD128	IOVDD129	IOVDD130	IOVDD131	IOVDD132	IOVDD133	IOVDD134	IOVDD135	IOVDD136	IOVDD137	IOVDD138	IOVDD139	IOVDD140	IOVDD141	IOVDD142	IOVDD143	IOVDD144	IOVDD145	IOVDD146	IOVDD147	IOVDD148	IOVDD149	IOVDD150	IOVDD151	IOVDD152	IOVDD153	IOVDD154	IOVDD155	IOVDD156	IOVDD157	IOVDD158	IOVDD159	IOVDD160	IOVDD161	IOVDD162	IOVDD163	IOVDD164	IOVDD165	IOVDD166	IOVDD167	IOVDD168	IOVDD169	IOVDD170	IOVDD171	IOVDD172	IOVDD173	IOVDD174	IOVDD175	IOVDD176	IOVDD177	IOVDD178	IOVDD179	IOVDD180	IOVDD181	IOVDD182	IOVDD183	IOVDD184	IOVDD185	IOVDD186	IOVDD187	IOVDD188	IOVDD189	IOVDD190	IOVDD191	IOVDD192	IOVDD193	IOVDD194	IOVDD195	IOVDD196	IOVDD197	IOVDD198	IOVDD199	IOVDD200	IOVDD201	IOVDD202	IOVDD203	IOVDD204	IOVDD205	IOVDD206	IOVDD207	IOVDD208	IOVDD209	IOVDD210	IOVDD211	IOVDD212	IOVDD213	IOVDD214	IOVDD215	IOVDD216	IOVDD217	IOVDD218	IOVDD219	IOVDD220	IOVDD221	IOVDD222	IOVDD223	IOVDD224	IOVDD225	IOVDD226	IOVDD227	IOVDD228	IOVDD229	IOVDD230	IOVDD231	IOVDD232	IOVDD233	IOVDD234	IOVDD235	IOVDD236	IOVDD237	IOVDD238	IOVDD239	IOVDD240	IOVDD241	IOVDD242	IOVDD243	IOVDD244	IOVDD245	IOVDD246	IOVDD247	IOVDD248	IOVDD249	IOVDD250	IOVDD251	IOVDD252	IOVDD253	IOVDD254	IOVDD255	IOVDD256	IOVDD257	IOVDD258	IOVDD259	IOVDD260	IOVDD261	IOVDD262	IOVDD263	IOVDD264	IOVDD265	IOVDD266	IOVDD267	IOVDD268	IOVDD269	IOVDD270	IOVDD271	IOVDD272	IOVDD273	IOVDD274	IOVDD275	IOVDD276	IOVDD277	IOVDD278	IOVDD279	IOVDD280	IOVDD281	IOVDD282	IOVDD283	IOVDD284	IOVDD285	IOVDD286	IOVDD287	IOVDD288	IOVDD289	IOVDD290	IOVDD291	IOVDD292	IOVDD293	IOVDD294	IOVDD295	IOVDD296	IOVDD297	IOVDD298	IOVDD299	IOVDD300	IOVDD301	IOVDD302	IOVDD303	IOVDD304	IOVDD305	IOVDD306	IOVDD307	IOVDD308	IOVDD309	IOVDD310	IOVDD311	IOVDD312	IOVDD313	IOVDD314	IOVDD315	IOVDD316	IOVDD317	IOVDD318	IOVDD319	IOVDD320	IOVDD321	IOVDD322	IOVDD323	IOVDD324	IOVDD325	IOVDD326	IOVDD327	IOVDD328	IOVDD329	IOVDD330	IOVDD331	IOVDD332	IOVDD333	IOVDD334	IOVDD335	IOVDD336	IOVDD337	IOVDD338	IOVDD339	IOVDD340	IOVDD341	IOVDD342	IOVDD343	IOVDD344	IOVDD345	IOVDD346	IOVDD347	IOVDD348	IOVDD349	IOVDD350	IOVDD351	IOVDD352	IOVDD353	IOVDD354	IOVDD355	IOVDD356	IOVDD357	IOVDD358	IOVDD359	IOVDD360	IOVDD361	IOVDD362	IOVDD363	IOVDD364	IOVDD365	IOVDD366	IOVDD367	IOVDD368	IOVDD369	IOVDD370	IOVDD371	IOVDD372	IOVDD373	IOVDD374	IOVDD375	IOVDD376	IOVDD377	IOVDD378	IOVDD379	IOVDD380	IOVDD381	IOVDD382	IOVDD383	IOVDD384	IOVDD385	IOVDD386	IOVDD387	IOVDD388	IOVDD389	IOVDD390	IOVDD391	IOVDD392	IOVDD393	IOVDD394	IOVDD395	IOVDD396	IOVDD397	IOVDD398	IOVDD399	IOVDD400	IOVDD401	IOVDD402	IOVDD403	IOVDD404	IOVDD405	IOVDD406	IOVDD407	IOVDD408	IOVDD409	IOVDD410	IOVDD411	IOVDD412	IOVDD413	IOVDD414	IOVDD415	IOVDD416	IOVDD417	IOVDD418	IOVDD419	IOVDD420	IOVDD421	IOVDD422	IOVDD423	IOVDD424	IOVDD425	IOVDD426	IOVDD427	IOVDD428	IOVDD429	IOVDD430	IOVDD431	IOVDD432	IOVDD433	IOVDD434	IOVDD435	IOVDD436	IOVDD437	IOVDD438	IOVDD439	IOVDD440	IOVDD441	IOVDD442	IOVDD443	IOVDD444	IOVDD445	IOVDD446	IOVDD447	IOVDD448	IOVDD449	IOVDD450	IOVDD451	IOVDD452	IOVDD453	IOVDD454	IOVDD455	IOVDD456	IOVDD457	IOVDD458	IOVDD459	IOVDD460	IOVDD461	IOVDD462	IOVDD463	IOVDD464	IOVDD465	IOVDD466	IOVDD467	IOVDD468	IOVDD469	IOVDD470	IOVDD471	IOVDD472	IOVDD473	IOVDD474	IOVDD475	IOVDD476	IOVDD477	IOVDD478	IOVDD479	IOVDD480	IOVDD481	IOVDD482	IOVDD483	IOVDD484	IOVDD485	IOVDD486	IOVDD487	IOVDD488	IOVDD489	IOVDD490	IOVDD491	IOVDD492	IOVDD493	IOVDD494	IOVDD495	IOVDD496	IOVDD497	IOVDD498	IOVDD499	IOVDD500	IOVDD501	IOVDD502	IOVDD503	IOVDD504	IOVDD505	IOVDD506	IOVDD507	IOVDD508	IOVDD509	IOVDD510	IOVDD511	IOVDD512	IOVDD513	IOVDD514	IOVDD515	IOVDD516	IOVDD517	IOVDD518	IOVDD519	IOVDD520	IOVDD521	IOVDD522	IOVDD523	IOVDD524	IOVDD525	IOVDD526	IOVDD527	IOVDD528	IOVDD529	IOVDD530	IOVDD531	IOVDD532	IOVDD533	IOVDD534	IOVDD535	IOVDD536	IOVDD537	IOVDD538	IOVDD539	IOVDD540	IOVDD541	IOVDD542	IOVDD543	IOVDD544	IOVDD545	IOVDD546	IOVDD547	IOVDD548	IOVDD549	IOVDD550	IOVDD551	IOVDD552	IOVDD553	IOVDD554	IOVDD555	IOVDD556	IOVDD557	IOVDD558	IOVDD559	IOVDD560	IOVDD561	IOVDD562	IOVDD563	IOVDD564	IOVDD565	IOVDD566	IOVDD567	IOVDD568	IOVDD569	IOVDD570	IOVDD571	IOVDD572	IOVDD573	IOVDD574	IOVDD575	IOVDD576	IOVDD577	IOVDD578	IOVDD579	IOVDD580	IOVDD581	IOVDD582	IOVDD583	IOVDD584	IOVDD585	IOVDD586	IOVDD587	IOVDD588	IOVDD589	IOVDD590	IOVDD591	IOVDD592	IOVDD593	IOVDD594	IOVDD595	IOVDD596	IOVDD597	IOVDD598	IOVDD599	IOVDD600	IOVDD601	IOVDD602	IOVDD603	IOVDD604	IOVDD605	IOVDD606	IOVDD607	IOVDD608	IOVDD609	IOVDD610	IOVDD611	IOVDD612	IOVDD613	IOVDD614	IOVDD615	IOVDD616	IOVDD617	IOVDD618	IOVDD619	IOVDD620	IOVDD621	IOVDD622	IOVDD623	IOVDD624	IOVDD625	IOVDD626	IOVDD627	IOVDD628	IOVDD629	IOVDD630	IOVDD631	IOVDD632	IOVDD633	IOVDD634	IOVDD635	IOVDD636	IOVDD637	IOVDD638	IOVDD639	IOVDD640	IOVDD641	IOVDD642	IOVDD643	IOVDD644	IOVDD645	IOVDD646	IOVDD647	IOVDD648	IOVDD649	IOVDD650	IOVDD651	IOVDD652	IOVDD653	IOVDD654	IOVDD655	IOVDD656	IOVDD657	IOVDD658	IOVDD659	IOVDD660	IOVDD661	IOVDD662	IOVDD663	IOVDD664	IOVDD665	IOVDD666	IOVDD667	IOVDD668	IOVDD669	IOVDD670	IOVDD671	IOVDD672	IOVDD673	IOVDD674	IOVDD675	IOVDD676	IOVDD677	IOVDD678	IOVDD679	IOVDD680	IOVDD681	IOVDD682	IOVDD683	IOVDD684	IOVDD685	IOVDD686	IOVDD687	IOVDD688	IOVDD689	IOVDD690	IOVDD691	IOVDD692	IOVDD693	IOVDD694	IOVDD695	IOVDD696	IOVDD697	IOVDD698	IOVDD699	IOVDD700	IOVDD701	IOVDD702	IOVDD703	IOVDD704	IOVDD705	IOVDD706	IOVDD707	IOVDD708	IOVDD709	IOVDD710	IOVDD711	IOVDD712	IOVDD713	IOVDD714	IOVDD715	IOVDD716	IOVDD717	IOVDD718	IOVDD719	IOVDD720	IOVDD721	IOVDD722	IOVDD723	IOVDD724	IOVDD725	IOVDD726	IOVDD727	IOVDD728	IOVDD729	IOVDD730	IOVDD731	IOVDD732	IOVDD733	IOVDD734	IOVDD735	IOVDD736	IOVDD737	IOVDD738	IOVDD739	IOVDD740	IOVDD741	IOVDD742	IOVDD743	IOVDD744	IOVDD745	IOVDD746	IOVDD747	IOVDD748	IOVDD749	IOVDD750	IOVDD751	IOVDD752	IOVDD753	IOVDD754	IOVDD755	IOVDD756	IOVDD757	IOVDD758	IOVDD759	IOVDD760	IOVDD761	IOVDD762	IOVDD763	IOVDD764	IOVDD765	IOVDD766	IOVDD767	IOVDD768	IOVDD769	IOVDD770	IOVDD771	IOVDD772	IOVDD773	IOVDD774	IOVDD775	IOVDD776	IOVDD777	IOVDD778	IOVDD779	IOVDD780	IOVDD781	IOVDD782	IOVDD783	IOVDD784	IOVDD785	IOVDD786	IOVDD787	IOVDD788	IOVDD789	IOVDD790	IOVDD791	IOVDD792	IOVDD793	IOVDD794	IOVDD795	IOVDD796	IOVDD797	IOVDD798	IOVDD799	IOVDD800	IOVDD801	IOVDD802	IOVDD803	IOVDD804	IOVDD805	IOVDD806	IOVDD807	IOVDD808	IOVDD809	IOVDD810	IOVDD811	IOVDD812	IOVDD813	IOVDD814	IOVDD815	IOVDD816	IOVDD817	IOVDD818	IOVDD819	IOVDD820	IOVDD821	IOVDD822	IOVDD823	IOVDD824	IOVDD825	IOVDD826	IOVDD827	IOVDD828	IOVDD829	IOVDD830	IOVDD831	IOVDD832	IOVDD833	IOVDD834	IOVDD835	IOVDD836	IOVDD837	IOVDD838	IOVDD839	IOVDD840	IOVDD841	IOVDD842	IOVDD843	IOVDD844	IOVDD845	IOVDD846	IOVDD847	IOVDD848	IOVDD849	IOVDD850	IOVDD851	IOVDD852	IOVDD853	IOVDD854	IOVDD855	IOVDD856	IOVDD857	IOVDD858	IOVDD859	IOVDD860	IOVDD861	IOVDD862	IOVDD863	IOVDD864	IOVDD865	IOVDD866	IOVDD867	IOVDD868	IOVDD869	IOVDD870	IOVDD871	IOVDD872	IOVDD873	IOVDD874	IOVDD875	IOVDD876	IOVDD877	IOVDD878	IOVDD879	IOVDD880	IOVDD881	IOVDD882	IOVDD883	IOVDD884	IOVDD885	IOVDD886	IOVDD887	IOVDD888	IOVDD889	IOVDD890	IOVDD891	IOVDD892	IOVDD893	IOVDD894	IOVDD895	IOVDD896	IOVDD897	IOVDD898	IOVDD899	IOVDD900	IOVDD901	IOVDD902	IOVDD903	IOVDD904	IOVDD905	IOVDD906	IOVDD907	IOVDD908	IOVDD909	IOVDD910	IOVDD911	IOVDD912	IOVDD913	IOVDD914	IOVDD915	IOVDD916	IOVDD917	IOVDD918	IOVDD919	IOVDD920	IOVDD921	IOVDD922	IOVDD923	IOVDD924	IOVDD925	IOVDD926	IOVDD927	IOVDD928	IOVDD929	IOVDD930	IOVDD931	IOVDD932	IOVDD933	IOVDD934	IOVDD935	IOVDD936	IOVDD937	IOVDD938	IOVDD939	IOVDD940	IOVDD941	IOVDD942	IOVDD943	IOVDD944	IOVDD945	IOVDD946	IOVDD947	IOVDD948	IOVDD949	IOVDD950	IOVDD951	IOVDD952	IOVDD953	IOVDD954	IOVDD955	IOVDD956	IOVDD957	IOVDD958	IOVDD959	IOVDD960	IOVDD961	IOVDD962	IOVDD963	IOVDD964	IOVDD965	IOVDD966	IOVDD967	IOVDD968	IOVDD969	IOVDD970	IOVDD971	IOVDD972	IOVDD973	IOVDD974	IOVDD975	IOVDD976	IOVDD977	IOVDD978	IOVDD979	IOVDD980	IOVDD981	IOVDD982	IOVDD983	IOVDD984	IOVDD985	IOVDD986	IOVDD987	IOVDD988	IOVDD989	IOVDD990	IOVDD991	IOVDD992	IOVDD993	IOVDD994	IOVDD995	IOVDD996	IOVDD997	IOVDD998	IOVDD999	IOVDD1000	IOVDD1001	IOVDD1002	IOVDD1003	IOVDD1004	IOVDD1005	IOVDD1006	IOVDD1007	IOVDD1008	IOVDD1009	IOVDD1010	IOVDD1011	IOVDD1012	IOVDD1013	IOVDD1014	IOVDD1015	IOVDD1016	IOVDD1017	IOVDD1018	IOVDD1019	IOVDD1020	IOVDD1021	IOVDD1022	IOVDD1023	IOVDD1024	IOVDD1025	IOVDD1026	IOVDD1027	IOVDD1028	IOVDD1029	IOVDD1030	IOVDD1031	IOVDD1032	IOVDD1033	IOVDD1034	IOVDD1035	IOVDD1036	IOVDD1037	IOVDD1038	IOVDD1039	IOVDD1040	IOVDD1041	IOVDD1042	IOVDD1043	IOVDD1044	IOVDD1045	IOVDD1046	IOVDD1047	IOVDD1048	IOVDD1049	IOVDD1050	IOVDD1051	IOVDD1052	IOVDD1053	IOVDD1054	IOVDD1055	IOVDD1056	IOVDD1057	IOVDD1058	IOVDD1059	IOVDD1060	IOVDD1061	IOVDD1062	IOVDD1063	IOVDD1064	IOVDD1065	IOVDD1066	IOVDD1067</
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Date: 5/17/2021

As well as D8 on the Arduino connector, which will be tied to our blinking LED:

PB2	n/a	Low	Output Push Pull	No pull-up and n...	Low	n/a	ARD_D8	✓
PB4 (NTRST)	n/a	Low	Output Push Pull	No pull-up and n...	Low	n/a	ARD_D5	✓
PB5	n/a	High	Output Push Pull	No pull-up and n...	Low	n/a	SPSGRF_915_S...	✓
PB12	n/a	Low	Output Push Pull	No pull-up and n...	Low	n/a	ISM43362_BOO...	✓
PB13	n/a	Low	Output Push Pull	No pull-up and n...	Low	n/a	ISM43362_WAK...	✓
PB14	n/a	Low	Output Push Pull	No pull-up and n...	Low	n/a	LED2 [LED_GR...	✓
PB15	n/a	Low	Output Push Pull	No pull-up and n...	Low	n/a	SPSGRF_915_S...	✓
PC6	n/a	Low	Output Push Pull	No pull-up and n...	Low	n/a	VL53L0X_XSHUT...	✓
PC7	n/a	n/a	External Interru...	No pull-up and n...	n/a	n/a	VL53L0X_GPIO1...	✓
PC8	n/a	n/a	External Interru...	No pull-up and n...	n/a	n/a	LSM3MDL_DRD...	✓
PC9	n/a	Low	Output Push Pull	No pull-up and n...	Low	n/a	LED3 [WIFI_LF...	✓

PB2 Configuration :

GPIO output level: Low

GPIO mode: Output Push Pull

GPIO Pull-up/Pull-down: No pull-up and no pull-down

Maximum output speed: Low

User Label: ARD\_D8

And finally, the blue pushbutton, which connects to EXTI13:

PC13	n/a	n/a	External Interru...	No pull-up and n...	n/a	n/a	BUTTON_EXTI13...	✓
PD0	n/a	Low	Output Push Pull	No pull-up and n...	Low	n/a	PMOD_RESET	✓
PD2	n/a	n/a	External Interru...	No pull-up and n...	n/a	n/a	PMOD_IRQ_EXT	✓

PC13 Configuration :

GPIO mode: External Interrupt Mode with Falling edge trigger detection

GPIO Pull-up/Pull-down: No pull-up and no pull-down

User Label: BUTTON\_EXTI13 [B2]

- Edit, build, run, and debug the code that uses the HAL\_GPIO API to toggle the LED2 On/Off when the blue button is pressed. The on/off toggle should happen in an interrupt service routine that runs when the blue button pressed.**

With the configuration verified and default project code built, the on/off toggle is trivial to implement with the skills we've previously developed in this course. We will define a callback routine associated with the GPIO EXTI interface that is mapped to the specific pin, in this case PC13. Within the project's main.c Private user code section, we place the below function definition:

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```
74  /* Private user code -----*/
75  /* USER CODE BEGIN 0 */
76
77  void HAL_GPIO_EXTI_Callback(uint16_t GPIO_Pin)
78  {
79      if (GPIO_Pin == GPIO_PIN_13)
80      {
81          HAL_GPIO_TogglePin(LED2_GPIO_Port, LED2_Pin);
82      }
83  }
84
85
86  /* USER CODE END 0 */
87
```

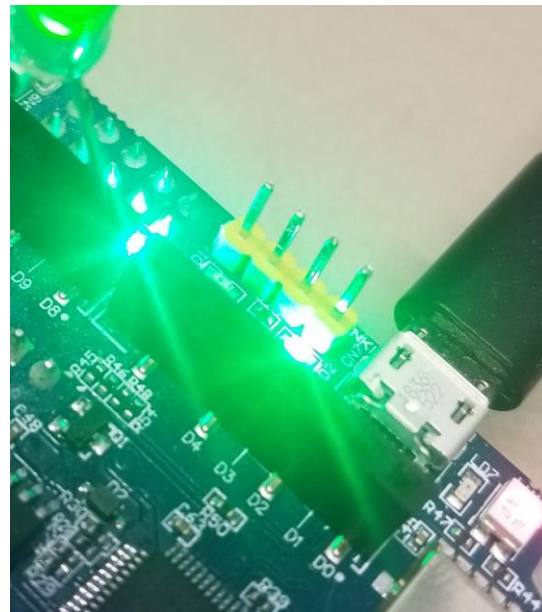
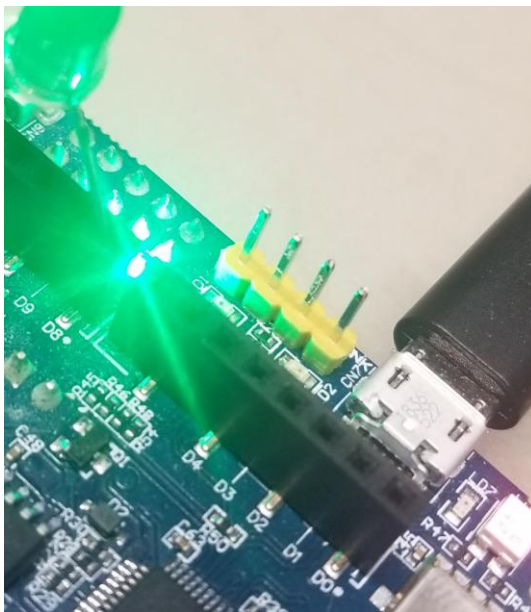
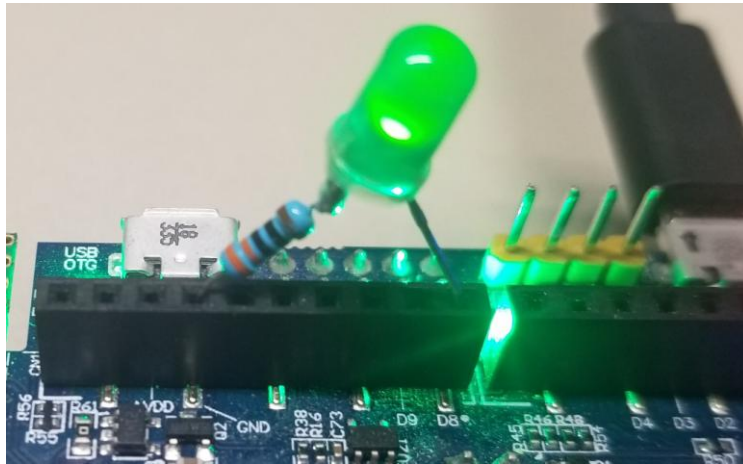
3. The STM32 IOT Discovery board has an Arduino Connector. On that connector, connect pin D8 to the +(positive ) side of an LED (the longer LED pin), then connect the - (negative) of the LED (the short LED pin) to a small (say 330 ohm) resistor, and then connect the resistor to the Arduino GND pin. Write code to blink the LED connected to D8 at a 1 second rate.

From here, the blink feature is even easier to implement, and can be accomplished as in previous assignments by calling the *HAL\_Delay()* and *HAL\_GPIO\_TogglePin()* functions on the appropriate port and pin, which would be PB2 or ARD\_D8 if using the macros as seen below:

```
126
127  /* Infinite loop */
128  /* USER CODE BEGIN WHILE */
129  while (1)
130  {
131      /* USER CODE END WHILE */
132
133      /* USER CODE BEGIN 3 */
134
135      HAL_GPIO_TogglePin(ARD_D8_GPIO_Port, ARD_D8_Pin);
136      HAL_Delay(1000);
137  }
138  /* USER CODE END 3 */
139  }
```

With the code successfully compiled and downloaded, we can observe that the LED connected to D8 will toggle on and off at the expected rate, and that the LED2 will also toggle when the blue push button is pressed.

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### Closing Thoughts

This assignment was straightforward to complete, especially so considering that the project default configuration set up the necessary GPIO to the functional modes we were targeting. In hindsight, I should have used a different colored LED to connect to the Arduino headers as there ended up being a lot of green on the board and it makes the images a bit confusing on what is the actual light source. Otherwise, it was extremely simple to reimplement code previously developed to accomplish the assignment goals.