Fingerpick Blood-Based Nucleic Acid Testing on A USB Interfaced Device Towards HIV Self-Testing

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Supplementary Figure

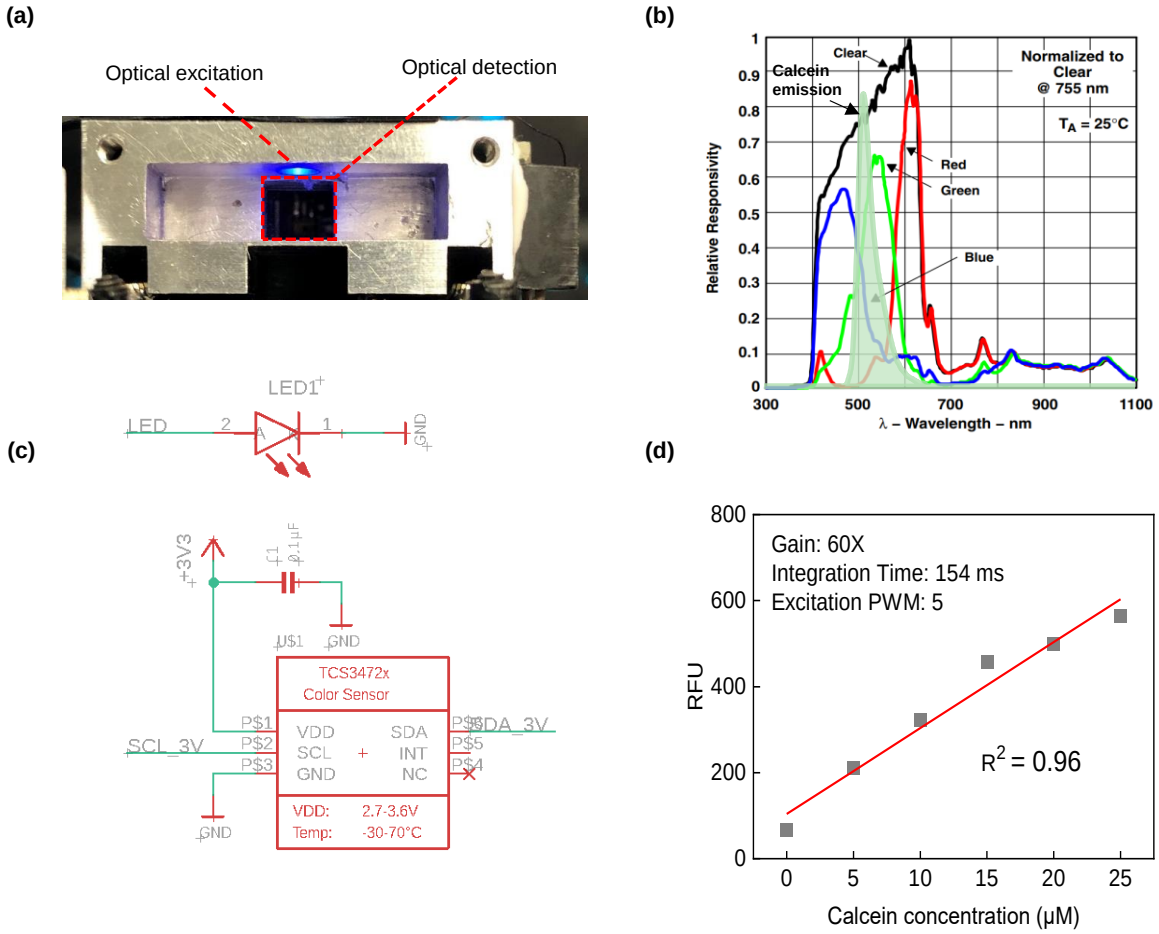


Figure S1 (a) Photo image of the optical module. On the excitation side, an LED light source (λ = 488 nm) illuminates the LAMP reaction chamber. On the detection side, the emitted light from the LAMP reaction chamber is guided to the optical sensor through PMMA. The incident direction of the excitation LED light is perpendicular to the optical sensor to minimize the diffracted excitation light entering the optical sensor, thereby improving the signal-to-noise ratio. (b) Optical responsibility of the optical sensor as well as the calcein emission profile. The optical sensor can collect the signals from the red, green, and blue channels. The analyzer uses the red channel of the optical sensor to monitor the emission signal. (c) The circuit schematic diagram of the excitation and emission sensing module. (d) Characterization of the optical sensor with calcein. The optical sensor showed a linear response to the concentration of Calcein from 0 to 25 µM. The test is performed with gain 60x, the integration time 154 ms, and PWM of the excitation LED control is 5.

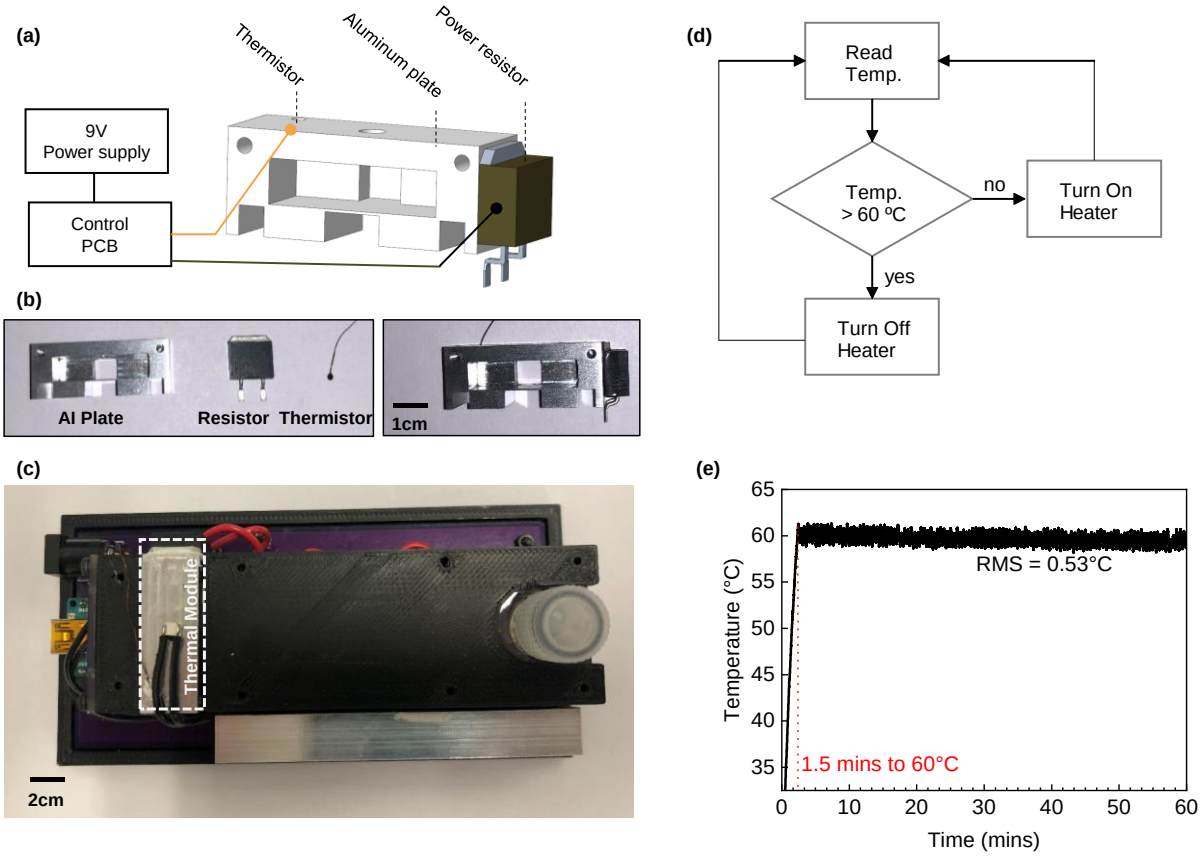


Figure S2 (a) The thermal module is composed of a power resistor as a heating source, a thermistor as a temperature feedback sensor, and a CNC aluminum plate. (b) Photo image of each component in the heating module (left) and the assembled heating module (right). (c) Photo image of the thermal module assembled on the analyzer (top view). (d) Flow chart of the thermal control algorithm. (e) The thermal module can reach the required 60°C within 1.5 minutes, and the root mean square (RMS) value of the temperature after stabilization is 0.53°C, which can meet the temperature requirements of LAMP detection.

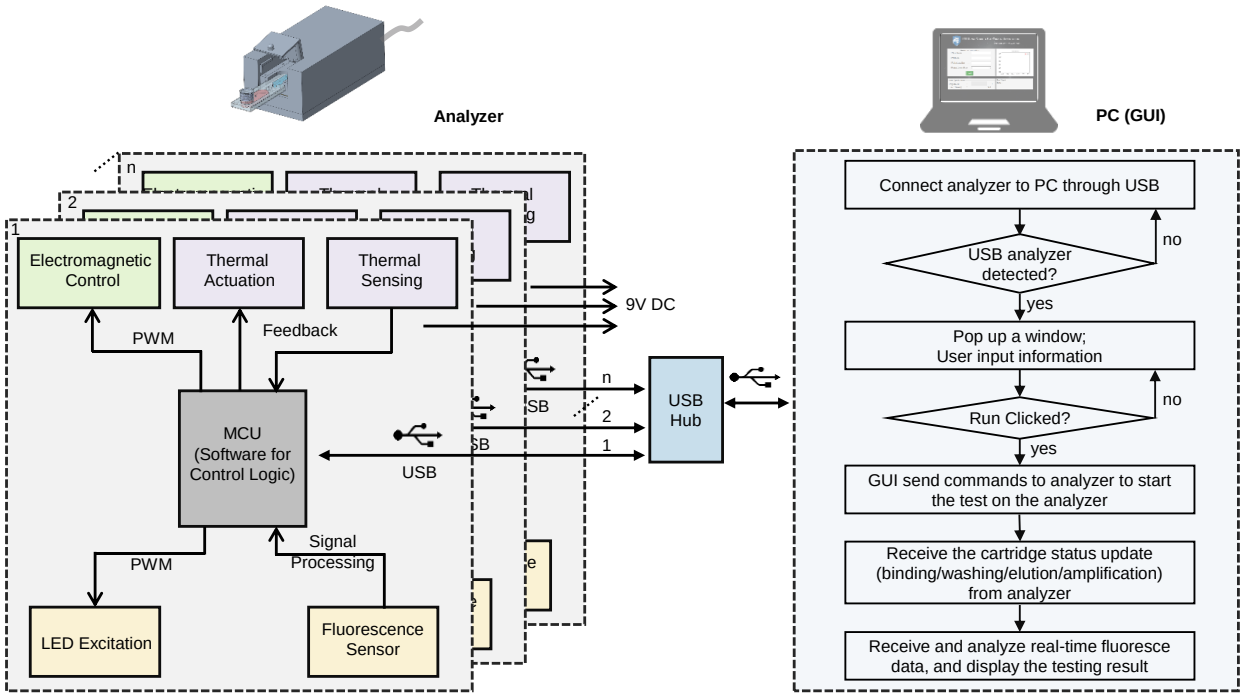


Figure S3 Schematic diagram of the device software and hardware. On the analyzer side, the optical, thermal, and electromagnetic modules are seamlessly integrated and controlled by an MCU for automated nucleic acid testing. The analyzer is designed to be USB-interfaced for data connection. Multiple analyzers can be used concurrently through a single USB hub. On the PC side, a graphic user interface (GUI) is designed to automatically recognize and administrate the analyzer inserted through the USB port. The device status, real-time amplification data, and the final positive/negative results will be displayed on GUI to the end-user.

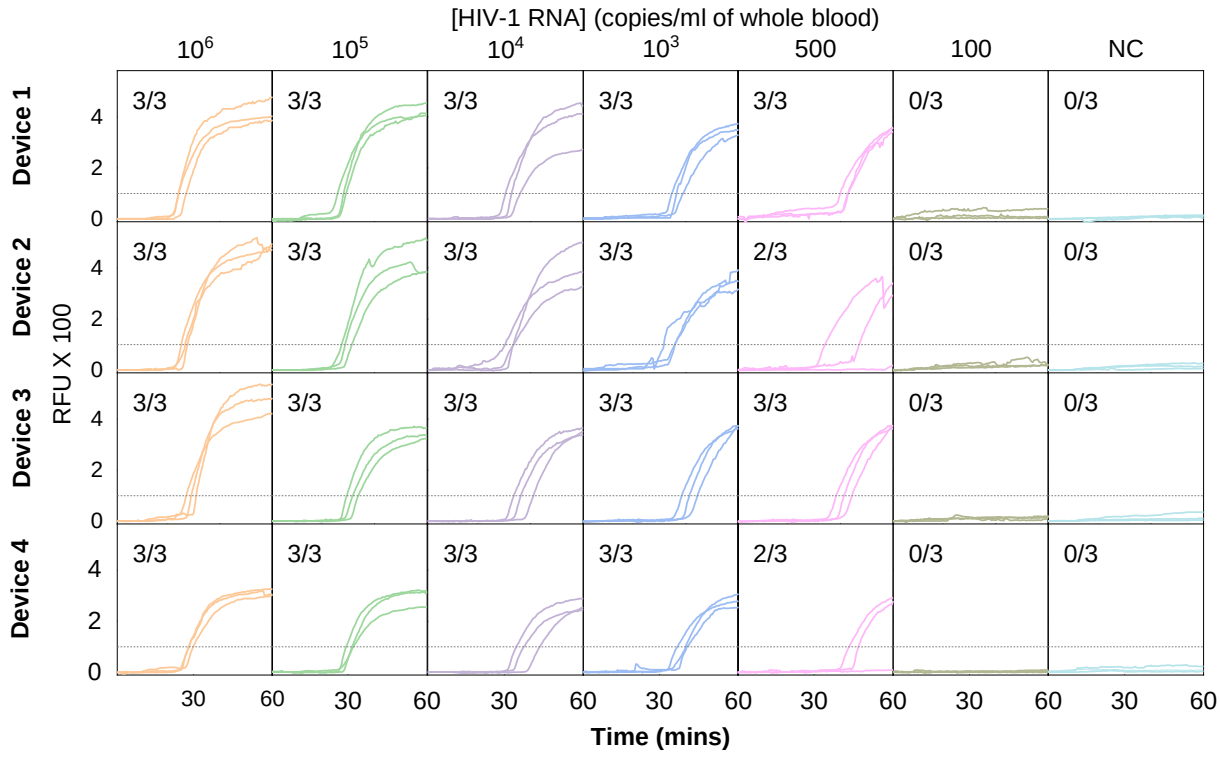


Figure S4 The real-time RT-LAMP curves for the inter-device test (4 devices) at different HIV-1 RNA concentrations in whole blood. The hit rate for RNA concentrations above 1000 copies/mL is 100% for all devices tested. The hit rate dropped to 83% (10/12) with samples of 500 copies/mL. No amplification curves were observed for samples at 100 copies/mL and negative control samples.

Supplementary Table

Supplementary Table S1 Bill of materials of the analyzer

System	Description	Part#	Function	Unit Cost ($)	Unit Qty.	Ext. Cost ($)
Electronics	Arduino Nano	7630049200173	Microcontroller	22	1	22.00
Electronics	36-pin stripe male header	392	Headpins	4.95	0.1	0.50
Electronics	DC Barrel Power Jack/Connector	PRT-00119	Power Connector	1.25	1	1.25
Electronics	Stacking Headers for Arduino	85	Wire Sockets	1.95	0.83	1.62
Electronics	Male/Male Jumper Wires	758	Wires	3.95	0.1	0.40
Electronics	Power Resistor, 3Ω	MP930-3.00F	Power stabilizing	5.2	1	5.20
Electronics	Capacitor 10uF	P10425CT	Power stabilizing	0.147	1	0.147
Electronics	IC 16-channel I/O Expander	SX1509BIULCT	EM control	2.06	1	2.06
Electromagnetic	SMD Resistor, 1kΩ	311-1.00KHRCT	Temperature/EM control	0.0072	24	0.17
Electromagnetic	N Channel Power MOSFET	DMN1019USN-7DICT	Switch for PCB coils	0.354	24	8.50
Magnet	Neodymium Disc Magnet Nickel	58605K33	Holding magnetic beads	2.69	1	2.69
Thermal	Cold Plate	CP-0.91-0.91	Heating Stage	5.75	0.25	1.44
Thermal	2Ω Power Resistor	MP725-2.00-FCT	Heater	7.01	1	7.01
Thermal	SMD Resistor, 1kΩ	311-1.00KHRCT	Temperature/EM control	0.0072	1	0.01
Thermal	Thermistor	235-1057	Temperature sensing	7.94	1	7.94
Thermal	SMD Resistor, 10kΩ	RNCP0603FTD10K0CT	Temperature control	0.1	1	0.10
Thermal	N Channel Power MOSFET	DMN1019USN-7DICT	Switch for heater	0.354	1	0.35
Optics	SMD Resistor, 10kΩ	RNCP0805FTD10K0CT	Optical module	0.0277	3	0.08
Optics	IC Color Sensor	TCS34725FNCT	Optical detection	2.6	1	2.60
Optics	SMD LED, Blue	1497-1138-1	Fluorescence excitation	0.528	1	0.53
Enclosure	ABS Filament (Black)	-	3D platform material	69	0.05	3.45
Enclosure	Screws (M2 cap screw)	91290A015	Assembly	0.14	10	1.40
			Total Cost			**$69.43**

Supplementary Table S2 Microfluidic cartridge and reagent cost per test

Reagents	Vendor	Function	Stock Vol. (mL)	Unit Cost ($)	Vol. (µL)	Ext. Cost ($)
PCR Grade Water	VWR	LAMP master mix	20	91.88	1	0.0046
F3	IDT	LAMP master mix	4.8	9.4	0.15	0.0003
B3	IDT	LAMP master mix	4.3	8.46	0.15	0.0003
FIP	IDT	LAMP master mix	0.9	62.68	1.2	0.0836
BIP	IDT	LAMP master mix	0.9	64.56	1.2	0.0861
LF	IDT	LAMP master mix	4.6	9.4	0.6	0.0012
LB-HEX	IDT	LAMP master mix	4.3	75.34	0.6	0.0105
Betaine	Sigma-Aldrich	LAMP master mix	1.5	24.25	2.4	0.0388
dNTP Mix	Thermo Fisher	LAMP master mix	3.2	107	2.1	0.0702
Bst polymerase	NEB	LAMP master mix	1	264	1	0.5280
WarmStart RT	NEB	LAMP master mix	1	292	0.3	0.0876
NEB Isothermal Buffer	NEB	LAMP master mix	6	24	1.5	0.0060
$MgSO_4$	NEB	LAMP master mix	6	20	1.2	0.0040
Lysis Buffer	Invitrogen	Sample Prep.	100	12.68	1000	0.1268
Purification Buffer	Invitrogen	Sample Prep.	20	2.54	200	0.0254
Wash Buffer	Invitrogen	Sample Prep.	100	12.68	500	0.0634
Proteinase K	Invitrogen	Sample Prep.	1	33.20	10	0.3320
Magnetic Beads	Invitrogen	Sample Prep.	2	356.00	10	1.7800
Acrylic Adhesive	Inventables	Compact disc	118	9.69	1.5	0.0001
1/32” Acrylic Sheet	Inventables	Compact disc	-	14.98	-	0.0250
1/16” Acrylic Sheet	Inventables	Compact disc	-	17.72	-	0.03
					Total Cost	**$ 3.38**